1907999

# Phase 3 Vapor Intrusion Pathway Monitoring Work Plan

RACER Eckles Road Off-Site Residential AOI 31
Wayne County
Livonia, MI, 48150

**PREPARED BY:**
HAMP, MATHEWS & ASSOCIATES, INC.
BATH, MICHIGAN

**PREPARED FOR:**
GRANT TRIGGER/PAM BARNETT
RACER TRUST

**SUBMITTED TO:**
JENNIFER STANHOPE, P.E.
RCRA CORRECTIVE ACTION PROJECT MANAGER
U.S. EPA REGION 5

**May 31, 2024**

HAMP MATHEWS & ASSOCIATES, INC.

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# 1.0 INTRODUCTION

This work plan describes a sampling strategy to evaluate vapor intrusion (VI) pathway conditions associated with recent trichloroethene (TCE) detections in groundwater and soil vapor at the most downgradient portion of the shallow groundwater TCE plume at the RACER Eckles Road Off-Site Residential Area of Interest-31 (AOI 31/Site). This work plan provides the framework for collecting data to guide further decisions regarding the VI pathway conditions at a specific portion of the Newburgh Village senior living residential complex (Subject Property). The location of the Site and the Subject Property are shown on **Figure 1**. A Subject Property map is provided on **Figure 2**. The details provided on **Figure 2** were obtained from as-built drawings of Newburg Village utility plan from City of Livonia (**Appendix A**).

## 2.0 WORK PLAN OBJECTIVES

The physical/chemical nature of the contaminant of concern (COC), TCE, is such that it is a volatile organic compound (VOC) that can/will volatilize (evaporate) from groundwater into soil vapor. TCE in soil vapor phase has the potential to migrate into building structures, which may present an inhalation exposure risk. TCE is included as a subset of VOCs known as chlorinated volatile organic compounds (CVOCs) because they contain chlorine atoms.

The following statement outlines the need for data at the Subject Property:

- It is unknown if, or the extent that, TCE in groundwater and/or soil vapor has migrated onto the Subject Property.

Additional information is needed to make decisions regarding the shallow groundwater TCE plume and potential associated VI pathway condition. The primary source of information/inputs will be groundwater sample analytical data and soil vapor sample analytical data in the study area, which will then facilitate decisions for where to collect subsequent samples to further assess conditions of the shallow groundwater TCE plume and potential associated VI pathway condition.

The study area boundaries for this evaluation are shown on **Figure 2** with Subject Property roadways, and utilities.

Information obtained from the work activities proposed in this work plan (groundwater sample analytical data and soil vapor sample analytical data) will be evaluated in consultation with EPA to determine the next steps for assessment.

The remainder of this work plan outlines the sample collection design that will be used to obtain groundwater concentration data and soil vapor concentration data to assess groundwater and soil vapor conditions at the Subject Property.

## 3.0 PROPOSED GEOPROBE GROUNDWATER SAMPLING

HMA proposes to install a total of five new shallow groundwater monitoring borings (SB-510 through SB-514) located in the North Capitol Court roadway, and shown on **Figure 3**.

Pending results from the initial discrete groundwater sample analytical results and geologic information documented for each boring, HMA and RACER will consult with EPA to determine the next steps for evaluation (see **Section 3.2**).

### 3.1 Geoprobe Boring Details

At each proposed location (i.e., SB-510 through SB-514), a direct-push soil boring will be advanced to a depth that is at least 10 feet deeper than the first encountered groundwater (total depth approximately 15 to 25 feet bgs). A least one soil boring will be advanced until native clay is encountered (total depth approximately 20 to 30 feet bgs). Soils will be logged to document soil type, moisture/saturation, and color, and screened with a photo-ionization detector (PID) for the potential presence of VOCs.

After the primary soil boring is completed, the direct-push tooling will be removed from the ground and a second soil boring will be advanced in the immediate vicinity. The second soil boring will be used to collect up to three groundwater samples, using the geoprobe screen point sampler, from discrete intervals based upon the likelihood for groundwater flow and/or contaminant presence. See **Appendix B** for Geoprobe Screen Point Groundwater Sampling standard operating procedures (SOPs) and **Section 3.4** for groundwater sampling procedures. If site conditions prevent the geoprobe screen point sampler from effectively collecting a groundwater sample, then temporary one-inch diameter polyvinyl chloride (PVC) wells will be installed to the defined discrete intervals for groundwater sample collection. Temporary monitoring wells will be installed and sampled in accordance with monitoring well installation procedures and direct push sampling procedures provided within the GHD Field Training Manual (**Appendix C**), and the procedures listed below. Procedures for installation of temporary monitoring wells are based upon ASTM method D6001 and are the same as procedures for permanent monitoring wells (**Appendix C**) with the exception that they are removed after sampling.

Geoprobe groundwater samples and field Quality Assurance/Quality Control QA/QC samples will be collected in general accordance with the 2019 GHD QAPP[1]. Field QA/QC samples will include one trip blank for each sample cooler, one co-located field duplicate sample for every 10 field samples, and one geoprobe screen point sampler equipment rinsate blank for every 20 uses of the sampler.

All samples (field samples and QA/QC samples) will be submitted using Chain-of-Custody protocol to an independent laboratory[2] for analysis of CVOCs using EPA method 8260. Samples will be submitted to the independent laboratory[2] with rush turn-around-time (TAT) so that evaluation and next steps may be quickly completed in consultation with EPA.

[1] Quality Assurance Project Plan (QAPP) for the Resource Conservation and Recovery Act (RCRA) Area 1 Corrective Action Operations, Maintenance and Monitoring (OM&M) Plan Eckles Road Site Livonia, Michigan. Revitalizing Auto Communities Environmental Response Trust (RACER) Site, GHD, July 2019.
[2] Metiri Group (formerly Fibertec), 1914 Holloway Drive, Holt, MI 48842

## 3.2 Monitoring Well Installation

Pending results from the discrete groundwater sampling and geologic information documented for each boring, HMA will consult with EPA to determine the necessity, number, and locations of permanent monitoring wells to install. It is anticipated that installation of at least one permanent monitoring well will be necessary to monitor the leading edge of the plume. Permanent monitoring wells will be installed in accordance with monitoring well installation GHD SOPs (**Appendix C**). New monitoring wells will be sampled, per procedures in **Section 3.3**.

## 3.3 Groundwater Sampling Procedures

Groundwater sampling will be conducted in general accordance with EGLE and EPA guidance for low-flow sampling of groundwater with CVOC impacts. These procedures will apply to groundwater samples collected from both geoprobe borings and/or permanent monitoring wells. Unless otherwise specified, all groundwater sampling procedures, analyses, QA/QC, groundwater data management, and other protocol listed within this section (e.g., Sections 3.3.1 through Section 3.3.7) will be completed in general accordance with the 2019 GHD QAPP. See **Appendix C** for low-flow groundwater sampling SOP.

Groundwater samples from the Geoprobe groundwater soil borings will be submitted to one of two independent laboratories[2,3], and/or field measured to provide lines of evidence for natural attenuation and to collect data for potential groundwater mitigation activities. Groundwater samples will be analyzed for the following parameters:

- Primary (laboratory[2]): CVOCs using EPA method 8260 per 2024 HMA QAPP[4].
- Secondary (field measured): pH, DO, ORP, conductivity, turbidity, and temperature.
- Tertiary (laboratory[3]): total organic carbon (TOC), alkalinity, nitrate, sulfate, total and dissolved iron, and total and dissolved manganese.
- Quaternary (laboratory[3] saturated soil analysis): fraction organic carbon (FOC).

Groundwater samples from SB-510 through SB-514 will be analyzed for the primary and secondary parameters. Groundwater samples from soil borings SB-510, SB-512, and SB-514 will be analyzed for the tertiary and quaternary parameters. For permanent monitoring wells installed per **Section 3.2**, groundwater samples will be analyzed for the primary and secondary parameters using Eurofins as the independent laboratory[3] for analysis.

Groundwater static water level measurements from each sample location will be obtained prior to sampling to determine approximate groundwater elevations and to estimate groundwater flow direction.

[3] Eurofins TestAmerica 4101 Shuffel Street NW, North Canton, Ohio
[4] Quality Assurance Project Plan (QAPP) RACER Eckles Road Off-Site Residential AOI 31, Wayne County, Livonia, Michigan 48150, April 2024, Hamp Mathews & Associates, Inc.

### 3.3.1 Determination of Static Water Level

Static water level measurements will be recorded using an electronic water level indicator, accurate to 0.01 inch, from each monitoring well prior to purging and sampling activities. To avoid the potential for cross-contamination, the water level indicator will be decontaminated by washing and rinsing between each use. Measurements for geoprobe groundwater sample borings will be made from the ground surface, which may be surveyed at a later date. Measurements for permanent monitoring wells will be made from the top of well casing, which may be surveyed at a later date.

### 3.3.2 Sample Collection

Groundwater samples will be collected by personnel who have thoroughly reviewed this work plan, the 2019 GHD QAPP, the 2024 HMA QAPP[4] and are familiar with the sampling procedures. Care will be taken to avoid the potential for cross-contamination between samples and to prevent loss of volatiles to the atmosphere. The groundwater samples will be collected using low-flow sampling methods and protocols in general accordance with EGLE and EPA guidance.

Water samples for laboratory analyses of CVOCs will be transferred directly from the sample pump discharge line into appropriate sample containers with preservatives.

### 3.3.3 Sample Preservation

Groundwater samples will be collected in the designated size and type of containers required for specific parameters. Sample containers will be filled in such a manner as not to lose any preservative chemicals from the containers.

### 3.3.4 Sample Shipment

The samples will be stored in an ice-packed cooler and transported, with appropriate trip blanks and chain-of-custody forms, to the laboratory for chemical analysis within the appropriate holding times.

### 3.3.5 Chain-of-Custody

Chain-of-custody procedures from the 2019 GHD QAPP will be used to allow for the tracing of possession and handling of samples from the time of collection to the completion of laboratory analysis. A chain-of-custody form will accompany each set of samples transported to the laboratory.

### 3.3.6 Detection Limits

Laboratory analysis of all test parameters listed as part of the monitoring program will meet or exceed the target method detection limits (MDLs) and Estimated Quantitation Limit (EQLs) in accordance with the 2019 GHD QAPP. **Table 1** contains groundwater, soil, soil vapor, and indoor air detection limits with EPA and EGLE screening levels for the vapor intrusion pathway.

### 3.3.7 Quality Assurance/Quality Control

QA/QC samples will be submitted for analysis for each sampling event to establish confidence in the quality of the laboratory results in accordance with the 2019 GHD QAPP for soil and groundwater sampling provided by GHD in July 2019.

- Trip blanks of distilled water will accompany the shipment for each sample cooler with water samples for CVOC analysis to the laboratory to evaluate possible contamination of containers/samples from the time the sample containers are prepared through the field event to the time the samples are received and analyzed at the laboratory. The trip blanks will be analyzed for CVOCs using EPA method 8260.
- Equipment blanks will be used to evaluate field decontamination procedures for the geoprobe screen point sampler (if used) to determine the likelihood of cross-contamination during groundwater monitoring. If temporary, one-inch, PVC wells are used due to site conditions (**Section 3.1**) then equipment blanks will not be necessary because new, disposable equipment will be used for each sample location preventing the possibility for cross-contamination.
- Co-located (i.e., duplicate) samples of groundwater will be submitted to the laboratory for analysis of CVOCs using EPA method 8260. In general accordance with the 2019 GHD QAPP, one duplicate sample will be collected for each of the 10 field groundwater samples to evaluate sampling and analysis reproducibility and estimate the overall precision of the data collection activity. Sampling personnel will record the actual well number of the duplicate on the field data collection sheets. The duplicate location and sample results will be reported in the VI monitoring report.

## 4.0 PROPOSED SOIL VAPOR SAMPLING

Soil vapor sampling is included within the initial sampling activities for this work plan. HMA proposes to install a total of five new soil vapor implants co-located with the geoprobe groundwater monitoring borings (SB-510 through SB-514) shown in **Figure 3** located in the North Capitol Court roadway. The soil vapor implants will be installed and sampled in accordance with SOPs included in **Appendix D** and procedures listed below. If EPA, RACER, and HMA concur that additional soil vapor implant locations are necessary, then additional soil vapor implants will be installed and sampled at locations selected in concurrence with all parties.

Soil vapor sampling will be conducted in general accordance with EGLE and EPA guidance. See **Appendix D** for SOPs for exterior soil vapor monitoring point installation and sampling as well as interior sub-slab soil Vapor Pin® installation and sampling. Soil vapor samples will be submitted to an independent laboratory[2], for analysis of CVOCs using EPA method TO-15. Soil vapor data will be collected and managed in accordance with the 2024 HMA QAPP.

### 4.1 Proposed New Soil Vapor Implant Monitoring Points

Soil vapor implants will be installed with the following procedures in general accordance with EPA and EGLE guidance (Appendix F.1 of 2013 EGLE Guidance Document for the Vapor Intrusion Pathway) and the installation SOPs included within **Appendix D**. Installation, sampling, and data management procedures are provided in the 2024 HMA QAPP.

Soil vapor implants will be installed with a direct push (e.g., geoprobe) type drill rig using 3¼-inch tooling. Depending on the depth to water, soil vapor implants will be installed to a depth approximately four to five feet below grade with at least a one-foot separation above the top of the groundwater table. Vapor implants will be constructed with a ceramic or stainless-steel screen connected to ¼-inch (or smaller) tubing constructed of nylon, Teflon®, polyethylene, or equivalent material. The vapor implant screen will be installed at the target depth and surrounded with a #4 sand, or equivalent coarse aggregate material (sand pack). The sand pack will extend from the bottom of the sample interval to approximately six inches above the top of the vapor implant screen (one foot total height). Six inches of uncoated bentonite will be placed on top of the sand pack and hydrated with 0.5 liter of clean water. The bentonite will be allowed to hydrate for a minimum of one hour prior to finishing the vapor implant installation with backfill of native material and/or prepared well grout. The bottom eight inches of the final 12 inches bgs) will be filled with sand. The top four inches bgs will be a void space to house the end of the vapor implant tubing and associated brass valve. The vapor implants will be finished at the ground surface with four-inch diameter, flush mount manholes.

### 4.2 Soil Vapor Sampling Procedures

If soil vapor sampling is warranted, then soil vapor samples will be collected in electropolished, passivated glass or stainless steel vacuum sampling devices (i.e., SUMMA® Canister, Bottle Vac™, and/or 1.4 L vacuum canisters) supplied by the laboratory[2].

### 4.2.1 Leak Testing

Prior to collecting a soil vapor sample, the complete sampling apparatus will be evaluated for leaks utilizing a chamber encompassing the sample device, flow regulator, sample tubing, and associated connections. The sampling apparatus will be leak tested utilizing a chamber (i.e., helium/argon shroud) which encompasses the sample tubing and associated connections and the sampling point. The chamber will be charged with helium (or argon) prior to purging the sampling point of a maximum of three volumes. A helium (or argon) detector will be utilized to ensure no leaks are present.

The chamber will be charged with helium, or equivalent gas. Sample tubing will be tested to document the presence, or lack thereof, of helium in the sample tubing. If helium is detected, then the sample setup connections within the chamber will be disassembled and the sample procedures at the sample point will be reevaluated and restarted to ensure/document that no leaks are present during sample collection.

### 4.2.2 Sample Collection

Following sample container, regulator, and chamber setup, the sample will be collected using sample devices and flow-regulators pre-set by the laboratory to a maximum flow rate of 200 ml/minute. Sample collection time will be approximately five to seven minutes.

### 4.2.3 Chain-of-Custody

After sample collection, the soil vapor sample devices will be placed in appropriate shipping containers and transported under chain-of-custody procedures for laboratory analysis within applicable holding times. Soil vapor samples will be submitted to an independent laboratory, for analysis of CVOCs using EPA method TO-15.

### 4.2.4 Laboratory and Reporting Limits

Laboratory information, including SOPs, reference data, and audit information, is included in the 2024 HMA QAPP. The laboratory soil vapor reporting limits are less than the EPA VISLs obtained via the EPA VISL calculator and are included in **Table 1** and the 2024 HMA QAPP.

### 4.2.5 Quality Assurance/Quality Control

QA/QC samples will be submitted for analysis for each sampling event to establish confidence in the quality of the laboratory results in accordance with the 2024 HMA QAPP.

- One co-located duplicate sample will be collected from a soil vapor monitoring point using a sample tee for every 20 vapor samples collected for quality assurance.

# 5.0 REPORTING AND DATA EVALUATION

The initial sample result data will be emailed to EPA for collaborative review with HMA and RACER. If decisions are necessary after collaborative review and prior to completing an interim data package, then those decisions will be communicated in written form via email. Interim data packages summarizing the geoprobe groundwater sampling and soil vapor sample results with text, tables, and figures will be provided to EPA within three weeks of receiving all laboratory analytical results to collaboratively process the data in consultation with EPA. All data will be validated in general accordance with the 2019 GHD QAPP and/or 2024 HMA QAPP before the interim data packages are completed.

Pending results from the discrete groundwater sampling, soil vapor sampling, and geologic information documented for each boring, HMA and RACER will consult with EPA to decide on next steps for evaluation. Next steps could include some/all/none of the following assessment activities:

- Additional geoprobe groundwater sample borings
- Permanent monitoring well installation and sampling
- Additional soil vapor implant installation and sampling
- Utility evaluation
- Passive soil gas (PSG) assessment
- Other environmental site assessment activities

Additional assessment activities will not be planned or completed without first consulting with EPA to obtain input and concur on assessment details.

If EPA, RACER, and HMA concur that additional geoprobe groundwater sample borings should be installed, then they will be installed in accordance with procedures listed in **Section 3.1**.

If EPA, RACER, and HMA concur that permanent monitoring wells should be installed, then they will be installed in accordance with monitoring well installation procedures in **Section 3.2** and sampled, per procedures in **Section 3.3**. SOPs for well installation and sampling are included in **Appendix C**.

If EPA, RACER, and HMA concur that additional soil vapor implants should be installed and sampled, then they will be installed and sampled in accordance with the procedures listed in **Section 4.0**.

If EPA, RACER, and HMA concur that utility evaluation, PSG assessment, and/or other types of assessment activities are warranted, then a supplement to this work plan will be developed in concurrence with EPA to document the procedures and assessment details for those activities.

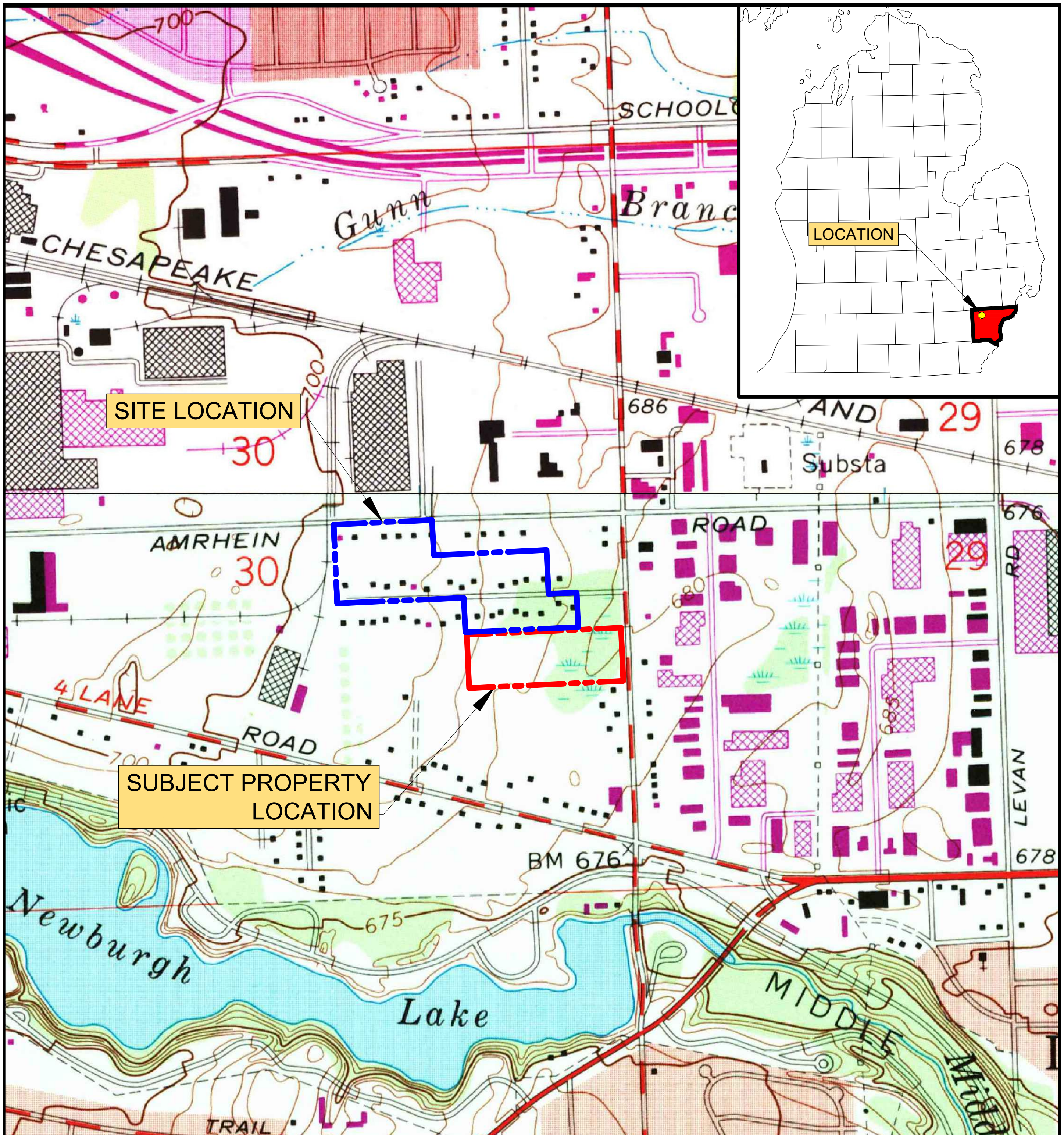
## 6.0 SUMMARY AND SCHEDULE

This work plan proposes a sampling strategy to assess conditions of the shallow groundwater TCE plume and potential associated VI pathway condition.

The following schedule is proposed for completion of activities presented within this work plan.

| Proposed Field Activity | Start Date |
|---|---|
| Five geoprobe groundwater sample and co-located soil vapor borings | June 6-7, 2024 |
| Obtain groundwater sample results and evaluate with EPA | June 11-12 2024 |
| Sample five co-located soil vapor implants | June 11-12 2024 |
| Additional geoprobe groundwater sample borings, if necessary | June 13-14, 2024 |
| Obtain soil vapor sample results and evaluate with EPA | June 18-19 2024 |
| If necessary, obtain additional groundwater sample results and evaluate with EPA | June 18-19 2024 |
| Initiate next steps for evaluation | Week of June 24, 2024 |

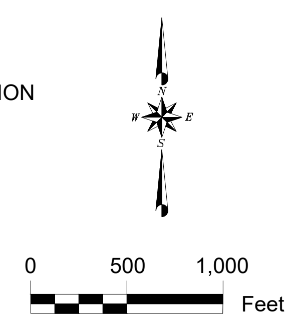
# FIGURES




LEGEND

SUBJECT PROPERTY LOCATION

SITE LOCATION

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**RACER TRUST**

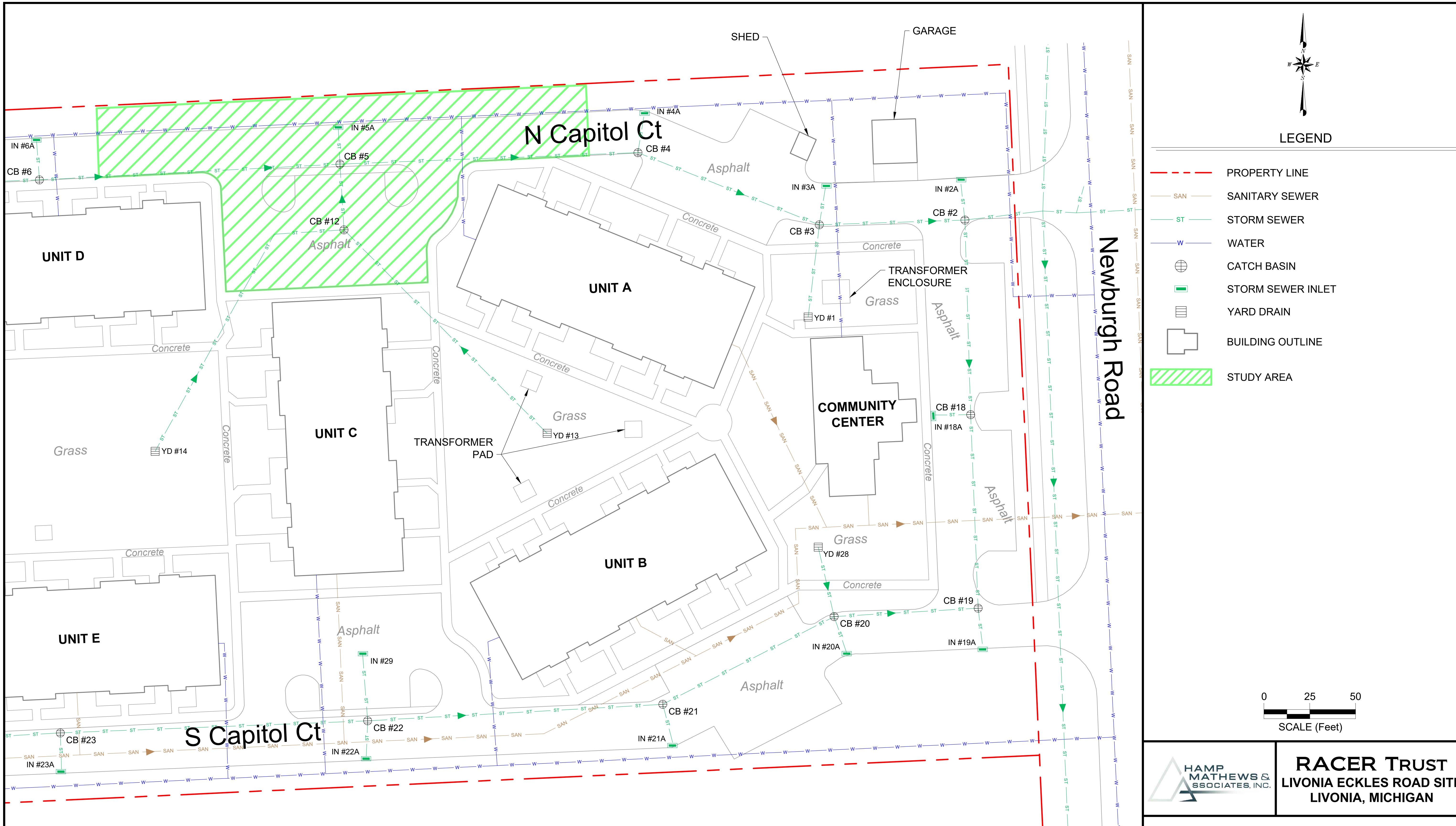
**LIVONIA ECKLES ROAD SITE**

**LIVONIA, MICHIGAN**

FIGURE 1

SITE AND SUBJECT PROPERTY LOCATION MAP

| DRAWN BY: | DATE: | PROJECT: | DRAWING ID: |
|---|---|---|---|
| KS | 5/29/2024 | 41-4 | Soil Vapor-GW Plume 2024 PII_2.dwg |

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**RACER TRUST**
**LIVONIA ECKLES ROAD SITE**
**LIVONIA, MICHIGAN**

FIGURE 2
SUBJECT PROPERTY MAP

| DRAWN BY: | DATE: | PROJECT: | DRAWING ID: |
|---|---|---|---|
| TRF/DJR/KS | July 2021 rev. 4/25/2024 | 41-4 | Soil Vapor-GW Plume 2024 PII_2.dwg |


N
W E
S

LEGEND

PROPERTY LINE
SAN — SANITARY SEWER
ST — STORM SEWER
W — WATER
CATCH BASIN
STORM SEWER INLET
YARD DRAIN
BUILDING OUTLINE
PROPOSED GEOPROBE GROUNDWATER SAMPLE LOCATION
PROPOSED SOIL VAPOR SAMPLE LOCATION
STUDY AREA

0 25 50
SCALE (Feet)

HAMP MATHEWS & ASSOCIATES, INC.

**RACER TRUST**
**LIVONIA ECKLES ROAD SITE**
**LIVONIA, MICHIGAN**

FIGURE 3
PROPOSED GEOPROBE GROUNDWATER SAMPLE LOCATIONS

| DRAWN BY: | DATE: | PROJECT: | DRAWING ID: |
|---|---|---|---|
| TRF/DJR/KS | July 2021 rev. 5/14/2024 | 41-4 | Soil Vapor-GW Plume 2024 PII_2.dwg |

# TABLES

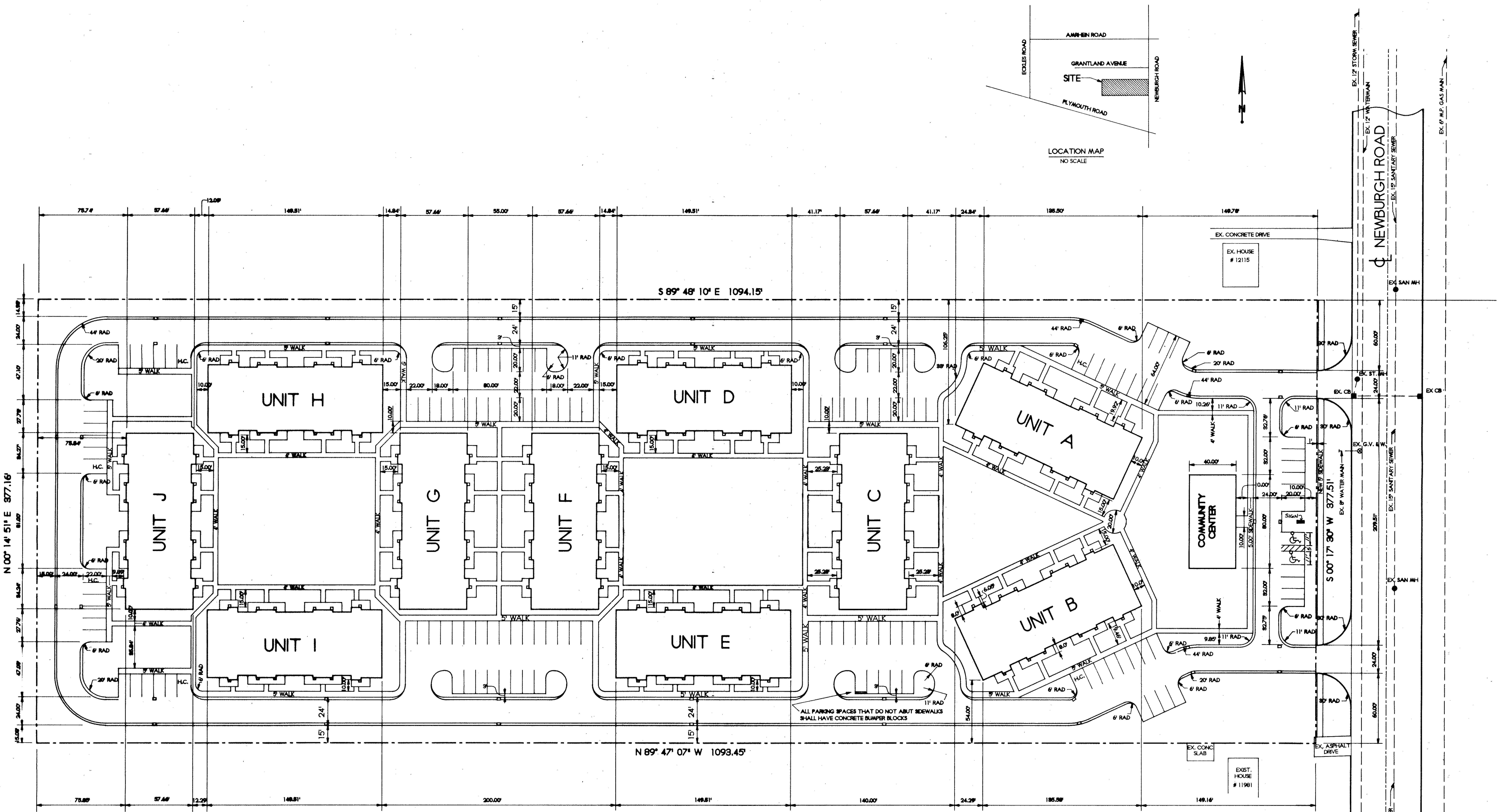
**Table 1**
**Chlorinated Volatile Organic Compounds (CVOCs)**
**Screening Levels and Laboratory Limits**
**RACER Trust - AOI 31 Eckles Road Site, Livonia, Michigan**

| Screening Level Information | | Chlorinated Volatile Organic Compounds CVOCs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Media | Chemical of Concern COC Screening Level / Reporting Limits | Chloroethane | 1,1-Dichloroethane | 1,1-Dichloroethene | cis-1,2-Dichloroethene | trans-1,2-Dichloroethene | 1,1,1-Trichloroethane | Trichloroethene | Vinyl Chloride |
| Groundwater | USEPA Residential Vapor Intrusion Screening Levels µg/L* | 14,800 | 140 | 330 | 480 | 200 | 14,000 | 10 | 2.1 |
| | EGLE Residential Groundwater Not In Contact VIAP Screening Levels µg/L | 15,000 | 130 | 330 | 95 | 390 | 14,000 | 10 | 2.1 |
| | Laboratory Reporting Limit RL µg/L | 5.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | Laboratory Estimated Quantitation Limit EQL µg/L | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | Laboratory Method Detection Limit MDL µg/L | 0.83 | 0.17 | 0.19 | 0.16 | 0.19 | 0.24 | 0.10 | 0.20 |
| | EGLE Target Detection Limit TDL µg/L | 5.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Soil | USEPA Residential Vapor Intrusion Screening Levels µg/kg* | NA | NA | NA | NA | NA | NA | NA | NA |
| | EGLE Residential Soil VIAP Screening Levels µg/kg | 330 | 2.6 (M) 50 | 12 (M) 50 | 2.1 (M) 50 | 12 (M) 50 | 450 | 0.33 (M) 50 | 0.082 (M) 50 |
| | Laboratory Method Detection Limit MDL µg/kg | 24 | 25 | 2.6 | 3.6 | 2.9 | 25 | 3.6 | 25 |
| | Laboratory Reporting Limit RL µg/kg | 250 | 50 | 50 | 50 | 50 | 50 | 50 | 40 |
| | EGLE Target Detection Limit TDL µg/kg | 250 | 50 | 50 | 50 | 50 | 50 | 50 | 40 |
| Soil Vapor | USEPA Residential Vapor Intrusion Screening Levels µg/m$^3$* | 140,000 | 590 | 7,000 | 1,400 | 1,400 | 170,000 | 70 | 56 |
| | EGLE Residential Soil Vapor VIAP Screening Levels µg/m$^3$ | 140,000 | 530 | 7,000 | 280 | 2,800 | 170,000 | 67 | 54 |
| | Laboratory Method Detection Limit MDL µg/m$^3$ | 0.20 | 0.12 | 0.33 | 0.40 | 0.31 | 0.45 | 0.23 | 0.49 |
| | Laboratory Reporting Limit RL µg/m$^3$ | 16 | 24 | 24 | 24 | 24 | 33 | 1.6 | 15.0 |
| | EGLE Target Detection Limit TDL µg/m3** | 340,000 | 16,600 | 6,700 | 230 | 2,300 | 196,000 | 64 | 54 |
| Indoor Air | USEPA Residential Target Indoor Air Concentrations µg/m$^3$* | 4,200 | 18 | 210 | 42 | 42 | 5,200 | 2.0 | 1.68 |
| | EGLE Residential Recommended Interim Action Screening Levels RIASLs for indoor air µg/m$^3$ | 4,200 | 16 | 210 | 8.3 | 83 | 5,000 | 2.0 | 1.6 |
| | Laboratory Method Detection Limit MDL µg/m$^3$ | 0.045 | 1.20 | 0.95 | 0.80 | 1.20 | 1.50 | 0.055 | 0.032 |
| | Laboratory Reporting Limit RL µg/m$^3$ | 4.0 | 6.1 | 5.9 | 5.9 | 5.9 | 8.2 | 0.160 | 0.77 |
| | EGLE Target Detection Limit TDL µg/m$^{3**}$ | 10,000 | 490 | 200 | 6.7 | 67 | 6,000 | 2.0 | 1.6 |

(M) = VIAP screening level is below TDL. TDL is used to evaluate the risk posed from the pathway.
* Calculated in February 2024 using November 2023 USEPA VISL Calculator generic inputs, a Hazard Quotient of 1.0, a Cancer Risk Screening Level of 1E-5 and a site-specific groundwater temperature of 10°C
**Converted from EGLE Target Detection Limit (TDL) published in units of ppbv using the equation ug/m$^3$ = ppb$_v$ * MW/24.45 where MW is the molecular weight of the chemical,

# APPENDIX A

## CITY OF LIVONIA NEWBURGH VILLAGE SITE PLANS




## SHEET INDEX

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GRAPHIC SCALE

0 25 50 100

1" = 40'

SOUTHEAST CORNER
SECTION 30
TOWN 1 SOUTH, RANGE 9 EAST
CITY OF LIVONIA
WAYNE COUNTY, MICHIGAN

| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
| A | 10-17-90 | TDR | ROS | PRELIMINARY REVIEW |
| B | 10-24-90 | JEE | ROS | ISSUED FOR CITY OF LIVONIA REVIEW |
| C | 11-05-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| D | 11-16-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |


R. O. SCRAMSTAD AND ASSOCIATES, INC.
9957 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170
PHONE (313) 459-9160
CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING


PROJECT: NEWBURGH VILLAGE

TITLE: SITE PLAN

CLIENT: CITY OF LIVONIA
19300 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

DRAWING NUMBER: 1 of 11

PROJECT NUMBER: 90045

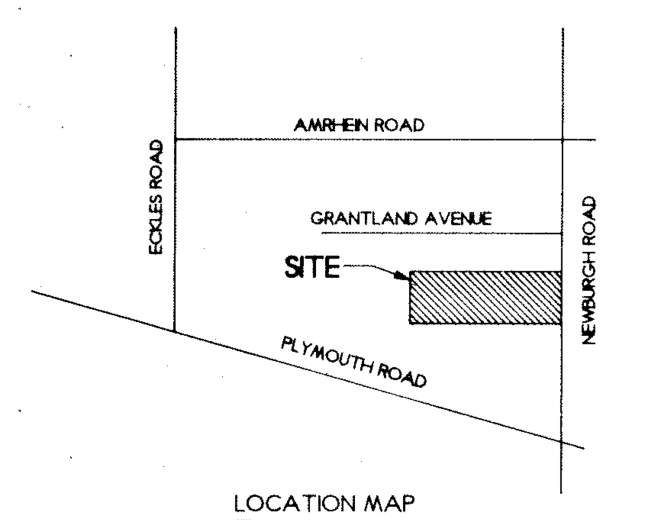
SCALE: 1" = 40'

## CITY OF LIVONIA GENERAL NOTES:

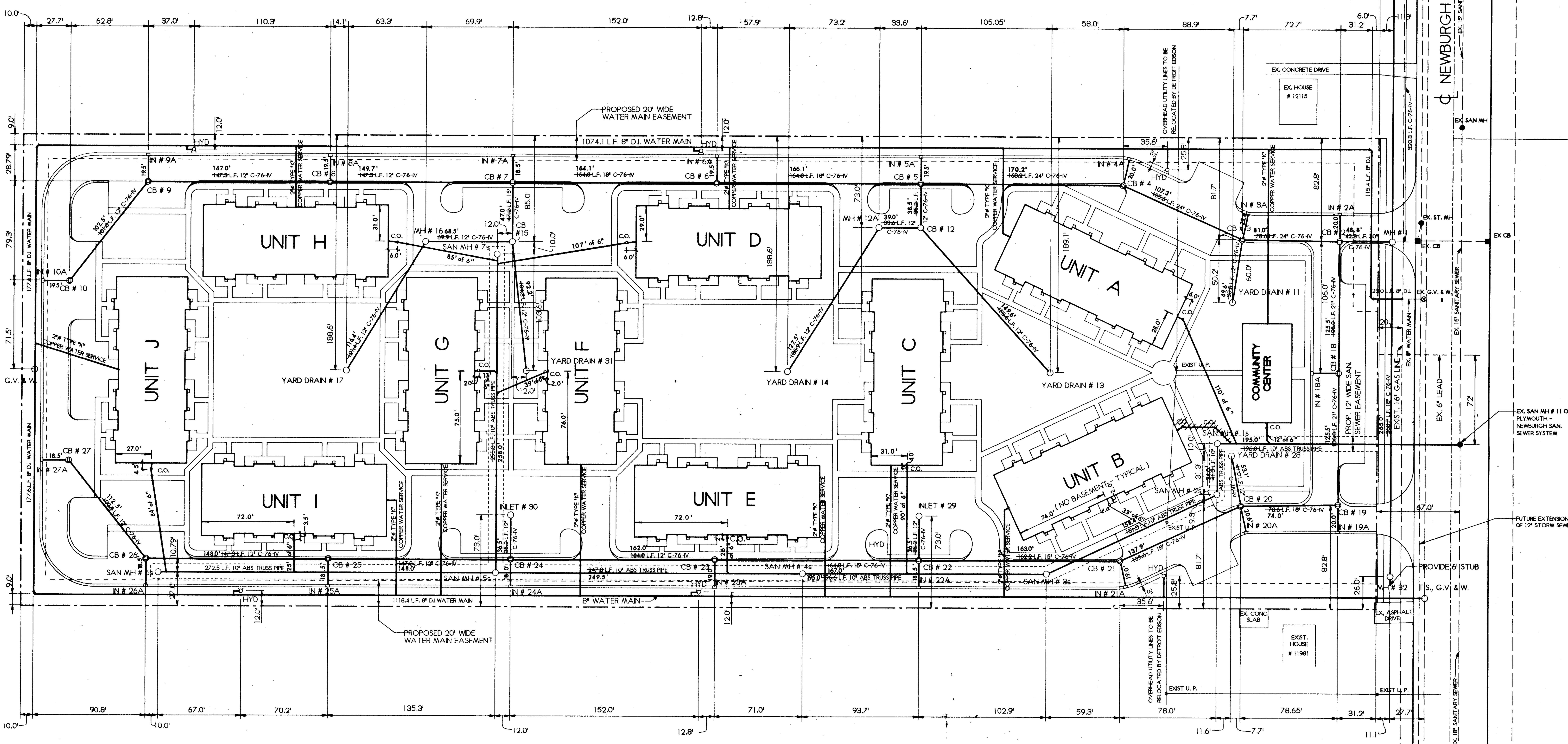
1. ALL WORK AND MATERIALS SHALL BE IN ACCORDANCE WITH THE CURRENT STANDARDS AND SPECIFICATIONS OF THE CITY OF LIVONIA.
2. THE CONTRACTOR SHALL NOTIFY THE CITY OF LIVONIA ENGINEERING DEPARTMENT AND MISS DIG IN ACCORDANCE WITH ACT 53, P.A. 1974, PRIOR TO STARTING CONSTRUCTION IN THE MEWBURGH ROAD RIGHT-OF-WAY.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY AND ALL DAMAGE TO EXISTING UNDERGROUND UTILITIES CAUSED BY HIS OPERATIONS.
4. TRENCHES UNDER OR WITHIN 3 FEET OF EXISTING OR PORPOSED PAVEMENTS, DRIVEWAYS AND/OR SIDEWALKS. SHALL BE BACKFILLED WITH APPROVED POROUS MATERIAL POWER-TAMPED IN 12 INCH LAYERS.
5. WHERE UTILITIES CROSS, PROVIDE POROUS BACKFILL TAMPED IN 12 INCH LAYERS TO THE UNDERSIDE OF THE HIGHER UTILITY. A 6 INCH MINIMUM SAND CUSHION SHALL BE PROVIDED BETWEEN UTILITIES.
6. ALL SEWER CONSTRUCTION SHALL HAVE CLASS "B" BEDDING UNLESS OTHERWISE SPECIFIED ON THE PROFILES.
7. ALL ELEVATIONS SHOWN ARE BASED ON WAYNE COUNTY PRECISE DATUM (U.S.C. & G.S.).
8. ALL DISTURBED AREAS OUTSIDE THE SHOULDERS WITHIN THE NEWBURGH ROAD FRONTAGE SHALL BE RESTORED BY PLACING 4 INCHES OF TOPSOIL AND SODDING IN ACCORDANCE WITH CITY STANDARDS.

## SANITARY SEWER NOTES

1. NO CONNECTIONS RECEIVING STORM WATER, SURFACE WATER, OR GROUND WATER SHALL BE MADE TO THE SANITARY SEWERS.
2. INFILTRATION FOR ANY SECTION OF SEWERS BETWEEN MANHOLES SHALL NOT EXCEED 200 GALS/INCH DIA/MILE/24 HOURS.
3. NO FOOTING DRAINS SHALL BE CONNECTED TO THE BUILDING SEWER.
4. DIFFERENTIAL OF EXCAVATION AROUND EXISTING MANHOLES SHALL NOT EXCEED 6 FEET.
5. ALL MENHOLES AND COVERS SHALL BE IN ACCORDANCE WITH CURRENT STANDARDS OF THE CITY OF LIVONIA AND THE WAYNE COUNTY DEPARTMENT OF PUBLIC WORKS.
6. TESTING METHODS IN ACCORDANCE WITH CURRENT SEWER USE REGULATIONS OF THE WAYNE COUNTY DEPARTMENT OF PUBLIC WORKS SHALL BE REQUIRED PRIOR TO APPROVAL BY THE CITY OF LIVONIA. (TELEVISION, AIR TESTS, ETC.)
7. SANITARY MANHOLES SHALL BE CONSTRUCTED IN ACCORDANCE WITH WAYNE COUNTY D.P.W. DETAIL W.C.D-1 (STANDARD MANHOLE FOR 8" THROUGH 24"). COVERS SHALL BE W.C.D-10 UNLESS WITHIN EASEMENT AREA WHERE COVER SHALL BE W.C.D-11 (E.J.H.I.W. 1040 PT.)
8. CONTRACTOR SHALL NOTIFY WAYNE COUNTY, Mr. PAT MEYERS, FIELD ENGINEERING (595-6507), 48 HOURS PRIOR TO START OF CONSTRUCTION.



LOCATION MAP
NO SCALE




## SCHEDULE OF QUANTITIES

| STORM SEWER | | SANITARY SEWER | | WATER MAIN | |
|---|---|---|---|---|---|
| 12" ø C-76-IV | 2020.1 L.F. | 10" ø ABS TRUSS | 1361.0 L.F. | 8" ø CLASS 54 DUCTILE IRON | 2686.1 L.F. |
| 15" ø C-76-IV | 539.0 L.F. | MANHOLE | 7 EA. | HYDRANT | 6 EA. |
| 18" ø C-76-IV | 782.6 L.F. | DROP CONNECTION TO EXIST MH | 1 EA. | T.S., G.V. & WELL | 1 EA. |
| 21" ø C-76-IV | 212.0 L.F. | | | G.V. & WELL | 1 EA. |
| 24" ø C-76-IV | 347.4 L.F. | | | | |
| 30" ø C-76-IV | 362.6 L.F. | | | | |
| MANHOLE | 4 EA. | | | | |
| CATCH BASIN | 20 EA. | | | | |
| YARD INLET | 27 EA. | | | | |

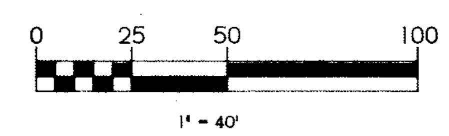
## SITE BENCHMARKS

NO. 1: BRONZE DISK IN CONCRETE POST AT THE S.W. CORNER OF NEWBURGH ROAD AND AMRHEIN ROAD LOCATED 56' WEST AND 56' SOUTH OF CENTERLINE.
ELEVATION: 683.248 (U.S.C. & G.S.).

NO. 2: NORTH RIM OF STORM MANHOLE LOCATED 66' SOUTH AND 35' EAST OF THE N.E. PROPERTY CORNER.
ELEVATION: 679.51 (U.S.C. & G.S.).

48 HOURS (3 WORKING DAYS)
BEFORE YOU DIG
CALL MISS DIG
800-482-7171
(TOLL FREE)

GRAPHIC SCALE




SOUTHEAST CORNER
SECTION 30
TOWN 1 SOUTH, RANGE 9 EAST
CITY OF LIVONIA
WAYNE COUNTY, MICHIGAN

| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
| A | 10-09-90 | TDR | ROS | PRELIMINARY REVIEW |
| B | 10-24-90 | JEE | ROS | ISSUED FOR CITY OF LIVONIA REVIEW |
| C | 11-05-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| D | 11-16-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| E | 12-27-90 | TDR | JEE | REVISED AS PER WAYNE COUNTY (12-12-90) |


R. O. SCRAMSTAD AND ASSOCIATES, INC.
9357 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170
PHONE (313) 459-9160
CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING

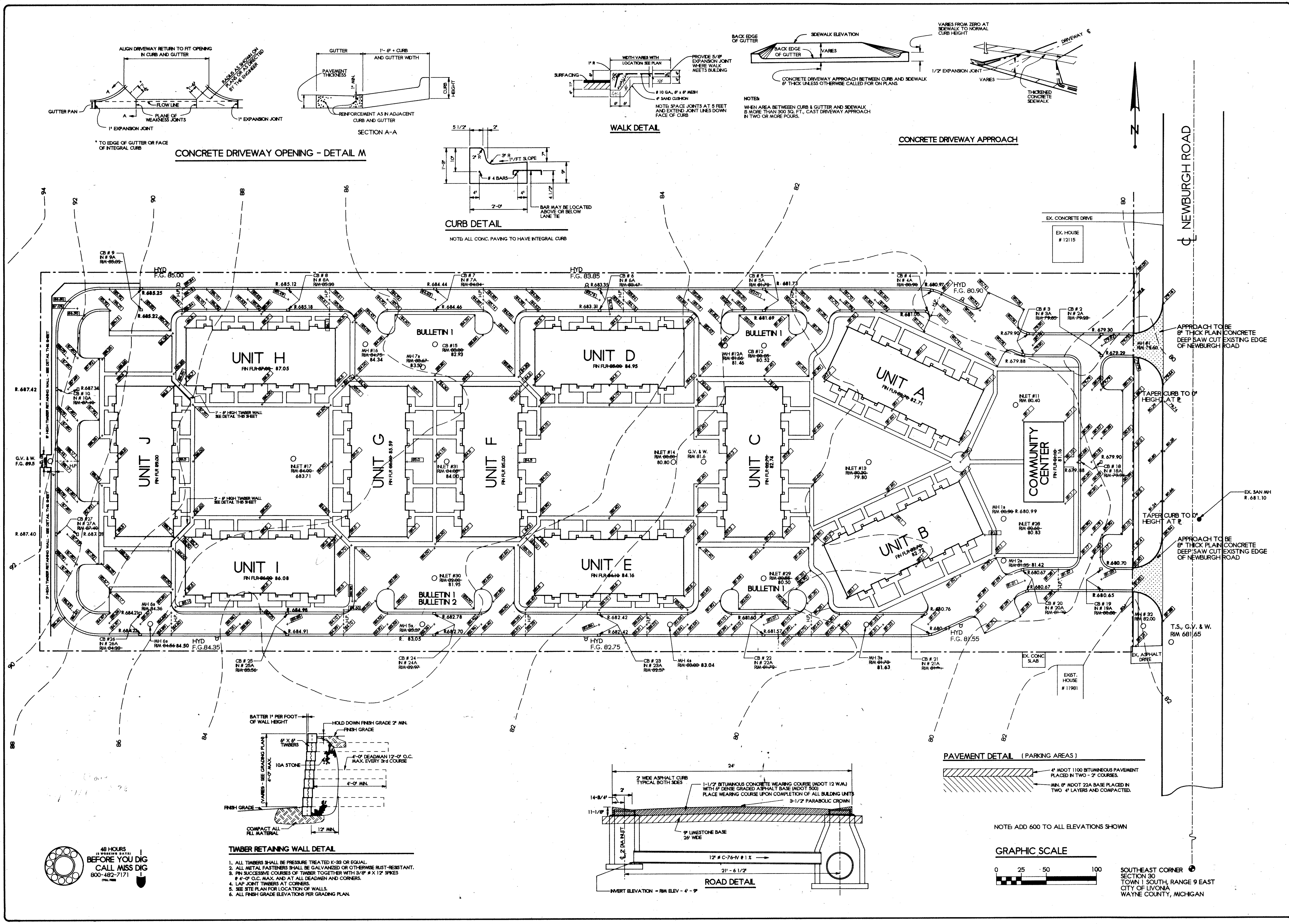

PROJECT: NEWBURGH VILLAGE

TITLE: UTILITY PLAN

CLIENT: CITY OF LIVONIA
19300 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

DRAWING NUMBER: 2 of 11
PROJECT NUMBER: 90045
SCALE: 1" = 40'

AS-BUILTS: 7-16-92




| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
| A | 10-17-90 | TDR | ROS | PRELIMINARY REVIEW |
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| C | 11-05-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| D | 11-16-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| E | 2-19-91 | TAD | FAP | REVISED PER BULLETIN 1 |
| F | 4-16-91 | TAD | FAP | REVISED PER BULLETIN 2 |

R. O. SCRAMSTAD AND ASSOCIATES, INC.
9357 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170
PHONE (313) 459-9160

CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING

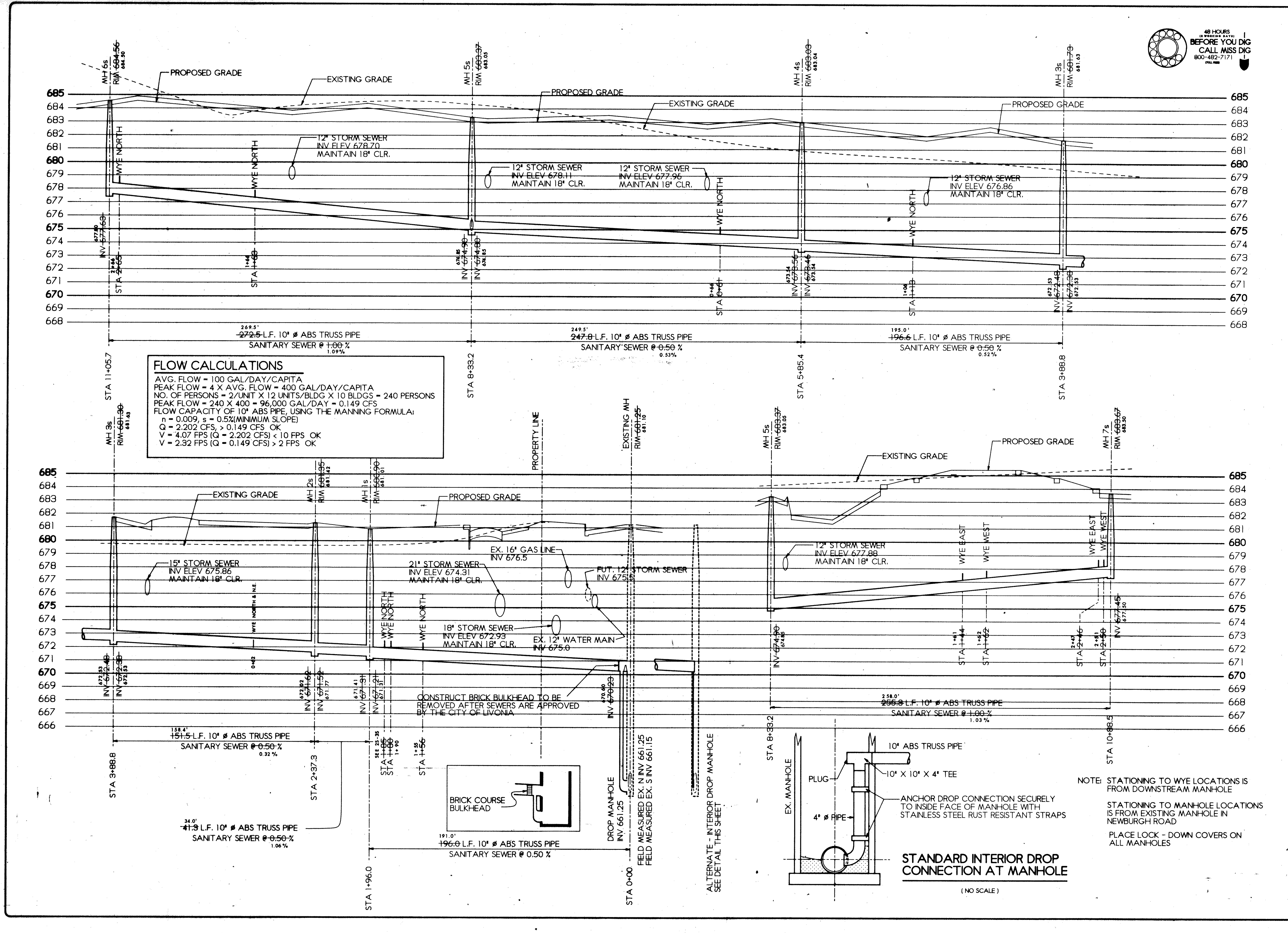
PROJECT: NEWBURGH VILLAGE

TITLE: GRADING PLAN

CLIENT: CITY OF LIVONIA
19300 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

DRAWING NUMBER: 3 of 11
PROJECT NUMBER: 90045
SCALE: 1" - 40'

AS-BUILTS: 7-13-92



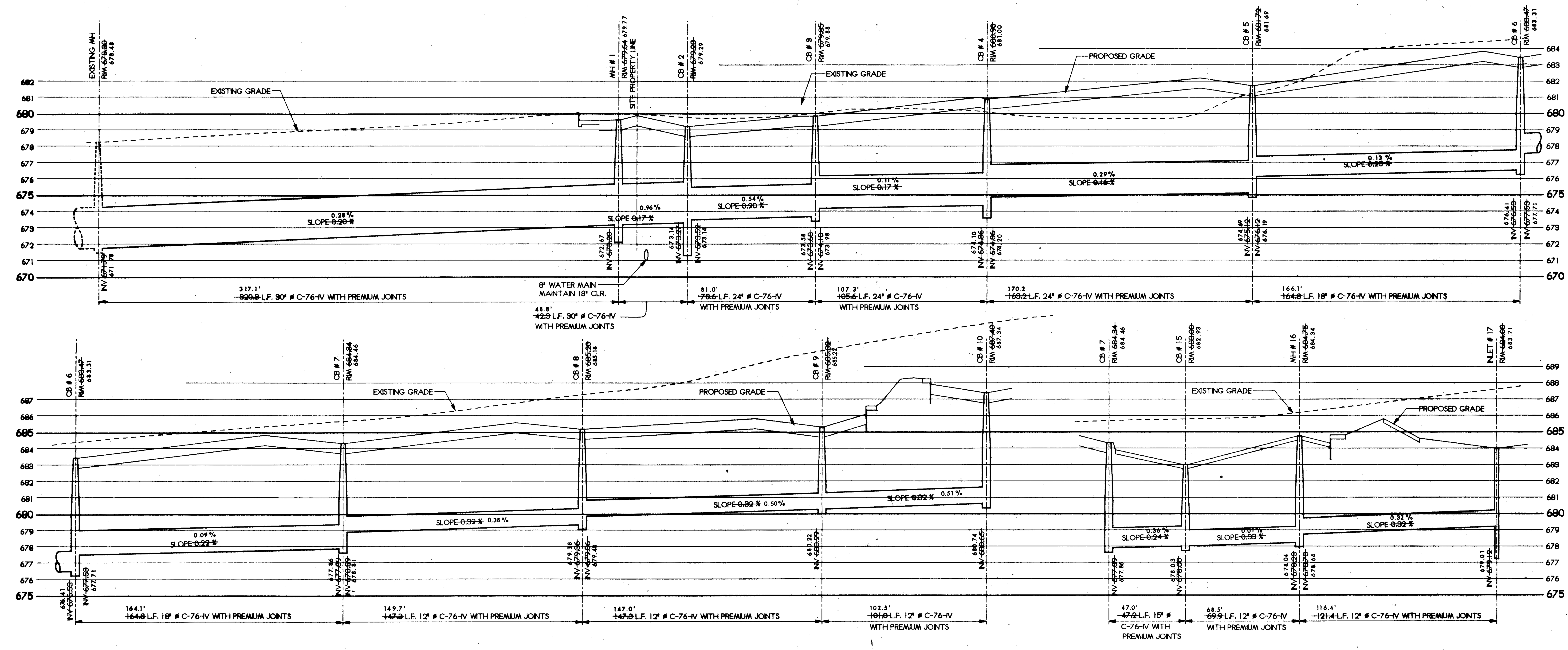

| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
| A | 10-24-90 | TDR | ROS | FOR CITY OF LIVONIA REVIEW |
| B | 11-05-90 | TDR | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| C | 11-16-90 | JEE | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| D | 12-27-90 | TDR | JEE | REVISED AS PER WAYNE COUNTY (12-12-90) |

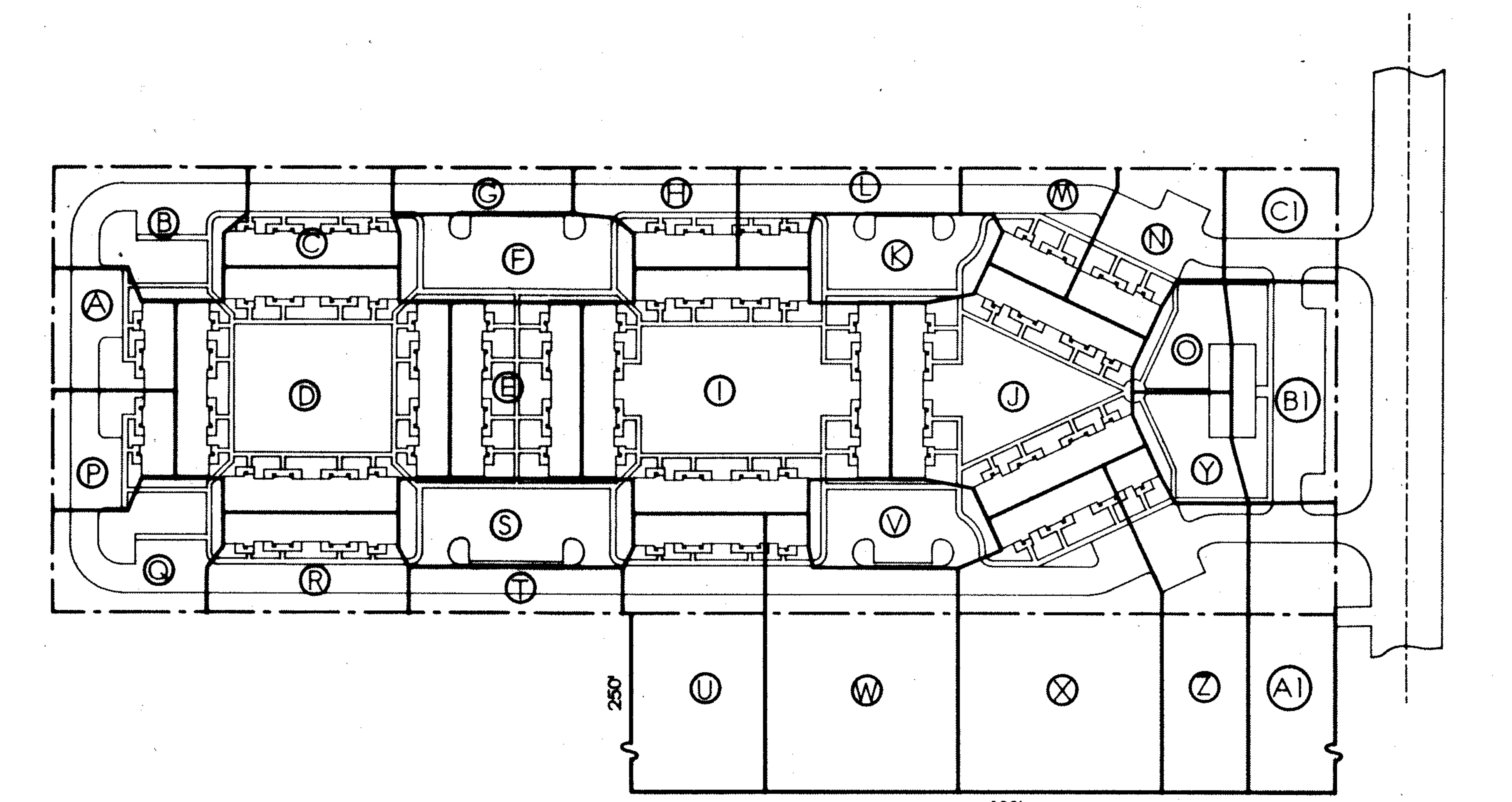
R. O. SCRAMSTAD AND ASSOCIATES, INC.
CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING

PROJECT: NEWBURGH VILLAGE
TITLE: SANITARY SEWER PROFILE
CLIENT: CITY OF LIVONIA

DRAWING NUMBER 4 of 11
PROJECT NUMBER 90045
SCALE HORZ 1" = 50' VERT 1" = 5'

AS-BUILTS: 7-13-92




48 HOURS (2 WORKING DAYS) BEFORE YOU DIG CALL MISS DIG 800-482-7171 (TOLL FREE)

## SITE AREAS (ACRES)

| AREA | BLDG | PVMT | GRASS | TOTAL | AVG 'C' |
|---|---|---|---|---|---|
| A | 0.056 | 0.084 | 0.084 | 0.224 | 0.569 |
| B | 0.000 | 0.130 | 0.228 | 0.358 | 0.372 |
| C | 0.112 | 0.068 | 0.082 | 0.262 | 0.615 |
| D | 0.449 | 0.000 | 0.555 | 1.004 | 0.435 |
| E | 0.224 | 0.000 | 0.162 | 0.386 | 0.535 |
| F | 0.000 | 0.216 | 0.123 | 0.339 | 0.578 |
| G | 0.000 | 0.085 | 0.053 | 0.138 | 0.562 |
| H | 0.058 | 0.079 | 0.080 | 0.217 | 0.574 |
| I | 0.449 | 0.000 | 0.655 | 1.104 | 0.405 |
| J | 0.336 | 0.000 | 0.426 | 0.762 | 0.431 |
| K | 0.000 | 0.161 | 0.097 | 0.258 | 0.568 |
| L | 0.047 | 0.105 | 0.083 | 0.235 | 0.585 |
| M | 0.055 | 0.070 | 0.098 | 0.223 | 0.520 |
| N | 0.058 | 0.115 | 0.123 | 0.296 | 0.538 |
| O | 0.018 | 0.000 | 0.131 | 0.149 | 0.191 |
| P | 0.056 | 0.084 | 0.084 | .0224 | 0.569 |
| Q | 0.000 | 0.111 | 0.210 | 0.321 | 0.359 |
| R | 0.112 | 0.095 | 0.109 | 0.316 | 0.591 |
| S | 0.000 | 0.218 | 0.122 | 0.340 | 0.581 |
| T | 0.100 | 0.000 | 0.063 | 0.163 | 0.560 |
| U | 0.085 | 0.067 | 0.732 | 0.884 | 0.229 |
| V | 0.000 | 0.159 | 0.094 | 0.252 | 0.571 |
| W | 0.027 | 0.091 | 1.014 | 1.132 | 0.178 |
| X | 0.082 | 0.110 | 1.208 | 1.336 | 0.213 |
| Y | 0.018 | 0.000 | 0.145 | 0.163 | 0.183 |
| Z | 0.030 | 0.089 | 0.538 | 0.652 | 0.238 |
| A1 | 0.000 | 0.048 | 0.537 | 0.585 | 0.162 |
| B1 | 0.037 | 0.168 | 0.174 | 0.379 | 0.506 |
| C1 | 0.000 | 0.060 | 0.149 | 0.209 | 0.315 |
| TOTAL | 2.409 | 2.413 | 8.089 | 12.911 | 0.380 |

## STORMWATER DRAINAGE CALCULATIONS

$I = 175 / (t + 25)$ $n = 0.013$

| LINE | FROM | TO | AREA | ACRES | C | A X C | Σ A X C | t | I | Q | DIA. | SLOPE | L | FLOW PROV'D | ACT VEL | Δ T | UPPER INVERT | LOWER INVERT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CB 10 | CB 9 | A | 0.224 | 0.569 | 0.127 | 0.127 | 20.00 | 3.889 | 0.494 | 12 | 0.32 | 101.0 | 2.015 | 2.57 | 0.65 | 680.65 | 680.33 |
| 2 | CB 9 | CB 8 | B | 0.358 | 0.372 | 0.133 | 0.260 | 20.65 | 3.834 | 0.997 | 12 | 0.32 | 147.3 | 2.015 | 2.57 | 0.96 | 680.3 | 679.86 |
| 3 | CB 8 | CB 7 | C | 0.262 | 0.615 | 0.161 | 0.421 | 21.61 | 3.755 | 1.581 | 12 | 0.32 | 147.3 | 2.015 | 2.57 | 0.96 | 679.36 | 678.89 |
| 4 | INLET 17 | MH 16 | D | 1.004 | 0.435 | 0.437 | 0.437 | 20.00 | 3.889 | 1.699 | 12 | 0.32 | 121.4 | 2.015 | 2.57 | 0.79 | 679.11 | 678.72 |
| 5 | MH 16 | CB 15 | | — | — | — | 0.437 | 20.79 | 3.822 | 1.670 | 12 | 0.33 | 69.9 | 2.047 | 2.61 | 0.45 | 678.22 | 677.99 |
| 6 | INLET 31 | CB 15 | E | 0.367 | 0.535 | 0.196 | 0.196 | 20.00 | 3.889 | 0.762 | 12 | 0.32 | 104.3 | 2.015 | 2.57 | 0.68 | 678.33 | 678.00 |
| 7 | CB 15 | CB 7 | F | 0.339 | 0.578 | 0.196 | 0.829 | 21.24 | 3.785 | 3.138 | 15 | 0.24 | 47.2 | 3.165 | 2.58 | 0.30 | 678.00 | 677.89 |
| 8 | CB 7 | CB 6 | G | 0.138 | 0.562 | 0.078 | 1.328 | 22.57 | 3.679 | 4.886 | 18 | 0.22 | 164.8 | 4.927 | 2.79 | 0.98 | 677.89 | 677.53 |
| 9 | CB 6 | CB 5 | H | 0.224 | 0.574 | 0.129 | 1.457 | 23.55 | 3.605 | 5.252 | 18 | 0.25 | 164.8 | 5.252 | 2.97 | 0.92 | 676.53 | 676.12 |
| 10 | INLET 14 | CB 12A | I | 1.104 | 0.405 | 0.447 | 0.447 | 20.00 | 3.889 | 1.738 | 12 | 0.32 | 136.9 | 2.015 | 2.57 | 0.89 | 676.31 | 675.87 |
| 11 | CB 12A | CB 12 | | — | — | — | 0.447 | 20.89 | 3.813 | 1.704 | 12 | 0.33 | 33.6 | 2.047 | 2.61 | 0.21 | 675.87 | 675.76 |
| 12 | INLET 13 | CB 12 | J | 0.762 | 0.431 | 0.329 | 0.328 | 20.00 | 3.889 | 1.276 | 12 | 0.32 | 156.6 | 2.015 | 2.57 | 1.02 | 675.76 | 675.26 |
| 13 | CB 12 | CB 5 | K | 0.258 | 0.568 | 0.147 | 0.922 | 21.10 | 3.796 | 3.500 | 15 | 0.30 | 35.2 | 3.538 | 2.88 | 0.20 | 675.26 | 675.12 |
| 14 | CB 5 | CB 4 | L | 0.235 | 0.585 | 0.137 | 2.516 | 24.47 | 3.537 | 8.899 | 24 | 0.16 | 163.2 | 9.049 | 2.88 | 0.94 | 675.12 | 674.86 |
| 15 | CB 4 | CB 3 | M | 0.223 | 0.520 | 0.116 | 2.632 | 25.41 | 3.472 | 9.138 | 24 | 0.17 | 105.6 | 9.327 | 2.97 | 0.59 | 674.36 | 674.18 |
| 16 | INLET 11 | CB 3 | N | 0.296 | 0.538 | 0.159 | 0.159 | 20.00 | 3.889 | 0.618 | 12 | 0.33 | 50.8 | 2.047 | 2.61 | 0.32 | 675.17 | 675.00 |
| 17 | CB 3 | CB 2 | O | 0.049 | 0.123 | 0.006 | 2.819 | 26.00 | 3.431 | 9.672 | 24 | 0.19 | 78.6 | 9.861 | 3.14 | 0.42 | 673.68 | 673.52 |
| 18 | CB 27 | CB 26 | P | 0.224 | 0.569 | 0.127 | 0.127 | 20.00 | 3.889 | 0.494 | 12 | 0.32 | 100.5 | 2.015 | 2.57 | 0.65 | 680.10 | 679.78 |
| 19 | CB 26 | CB 25 | Q | 0.321 | 0.359 | 0.115 | 0.242 | 20.65 | 3.834 | 0.928 | 12 | 0.32 | 147.3 | 2.015 | 2.57 | 0.96 | 678.78 | 678.31 |
| 20 | CB 25 | CB 24 | R | 0.316 | 0.591 | 0.187 | 0.429 | 21.61 | 3.755 | 1.611 | 12 | 0.32 | 147.3 | 2.015 | 2.57 | 0.96 | 678.31 | 677.84 |
| 21 | CB 30 | CB 24 | S | 0.340 | 0.581 | 0.198 | 0.198 | 20.00 | 3.889 | 0.770 | 12 | 0.33 | 35.2 | 2.047 | 2.61 | 0.22 | 677.61 | 677.46 |
| 22 | CB 24 | CB 23 | T | 0.163 | 0.560 | 0.091 | 0.718 | 22.57 | 3.679 | 2.642 | 12 | 0.55 | 164.8 | 2.642 | 3.36 | 0.82 | 677.84 | 676.93 |
| 23 | CB 23 | CB 22 | U | 0.884 | 0.229 | 0.202 | 0.920 | 23.39 | 3.616 | 3.327 | 15 | 0.27 | 164.8 | 3.357 | 2.74 | 1.00 | 676.93 | 676.49 |
| 24 | CB 29 | CB 22 | V | 0.252 | 0.571 | 0.144 | 0.144 | 20.00 | 3.889 | 0.560 | 12 | 0.33 | 35.2 | 2.047 | 2.61 | 0.22 | 676.64 | 676.49 |
| 25 | CB 22 | CB 21 | W | 1.132 | 0.178 | 0.201 | 1.265 | 24.39 | 3.543 | 4.482 | 15 | 0.48 | 162.2 | 4.475 | 3.65 | 0.74 | 676.49 | 675.69 |
| 26 | CB 21 | CB 20 | X | 1.336 | 0.213 | 0.285 | 1.550 | 25.13 | 3.491 | 5.411 | 18 | 0.27 | 105.6 | 5.458 | 3.09 | 0.57 | 675.69 | 675.40 |
| 27 | INLET 28 | CB 20 | Y | 0.163 | 0.183 | 0.030 | 0.030 | 20.00 | 3.889 | 0.177 | 12 | 0.33 | 41.0 | 2.470 | 2.61 | 0.26 | 675.53 | 675.40 |
| 28 | CB 20 | CB 19 | Z | 0.652 | 0.238 | 0.155 | 1.735 | 25.70 | 3.451 | 5.987 | 18 | 0.33 | 78.6 | 6.034 | 3.41 | 0.38 | 675.40 | 676.14 |
| 29 | CB 19 | CB 18 | A1 | 0.585 | 0.162 | 0.095 | 1.803 | 26.08 | 3.426 | 6.177 | 21 | 0.16 | 106.0 | 6.338 | 2.64 | 0.67 | 674.39 | 674.22 |
| 30 | CB 18 | CB 2 | B1 | 0.379 | 0.506 | 0.192 | 2.022 | 26.75 | 3.382 | 6.838 | 21 | 0.19 | 106.0 | 6.907 | 2.87 | 0.62 | 673.72 | 673.52 |
| 31 | CB 2 | MH 1 | C1 | 0.209 | 0.315 | 0.066 | 4.907 | 27.37 | 3.342 | 16.399 | 30 | 0.17 | 42.3 | 16.912 | 3.45 | 0.20 | 673.27 | 673.20 |
| 32 | MH 1 | EX MH | | | | | | | | | 30 | 0.44 | 320.3 | 27.208 | 5.54 | 0.96 | 673.20 | 671.79 |
| 33 | MH 32 | MH 1 | | | | | | | | | 18 | 0.31 | 268.7 | 5.849 | 3.31 | 1.35 | 674.04 | 673.20 |

| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
| A | 10-17-90 | TDR | ROS | FOR CITY OF LIVONIA REVIEW |
| B | 11-05-90 | TDR | ROS | REVISED PER CITY OF LIVONIA COMMENTS |
| C | 11-16-90 | TDR | ROS | REVISED PER CITY OF LIVONIA COMMENTS |

R. O. SCRAMSTAD AND ASSOCIATES, INC.
CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING
9857 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170 PHONE (313) 459-9160

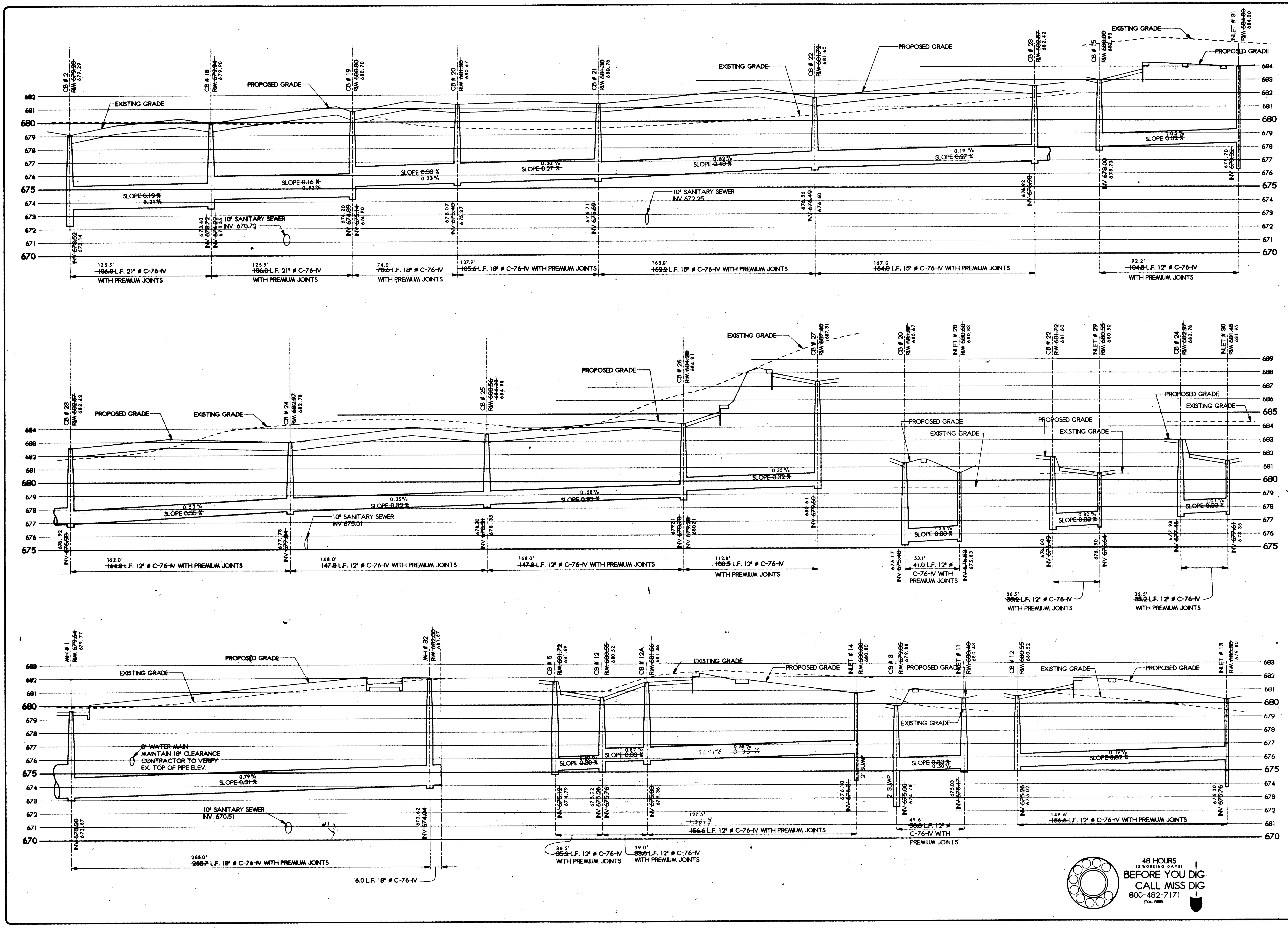
PROJECT: NEWBURGH VILLAGE

TITLE: STORM SEWER PROFILE

DRAWING NUMBER: 5 of 11 PROJECT NUMBER: 90045 SCALE: HORIZ 1" = 50' VERT 1" = 5'

CLIENT: CITY OF LIVONIA 19900 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

AS-BUILTS: 7-14-92

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R. O. SCRAMSTAD AND ASSOCIATES, INC.
9357 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170
PHONE (313) 459-9160

CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING

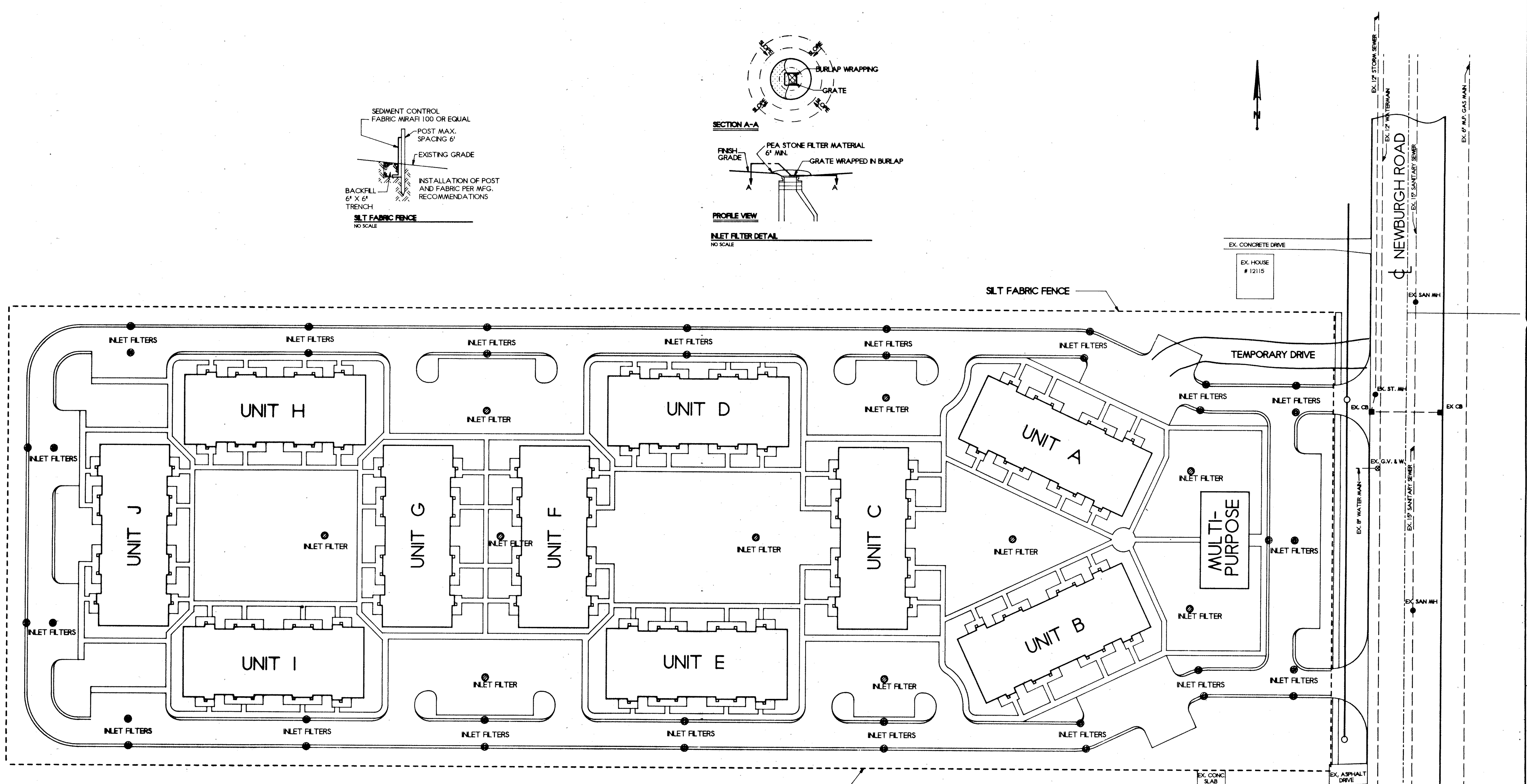
PROJECT
NEWBURGH VILLAGE

TITLE
STORM SEWER PROFILE

CLIENT
CITY OF LIVONIA
19300 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

DRAWING NUMBER 6 of 11
PROJECT NUMBER 90045
SCALE HORIZ 1" = 50' VERT 1" = 5'

AS-BUILTS: 7-14-92



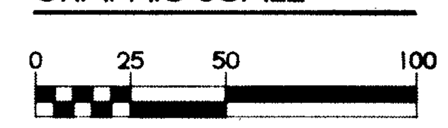

**CONSTRUCTION SEQUENCE**

1. CONSTRUCT 20' TEMPORARY DRIVE AS SHOWN ON PLAN.
2. INSTALL STRAW BALE BERM OR SILT FABRIC FENCE AROUND PERIMETER OF SITE.
3. INSTALL SANITARY SYSTEM.
4. INSTALL STORM DRAINAGE SYSTEM. INSTALL PAVEMENT INLET FILTERS.
5. ROUGH GRADE SITE, STORE TOPSOIL AND BEGIN BUILDING CONSTRUCTION.

NOTE: BUILDING CONSTRUCTION CAN BE DONE IN PHASES. A TEMPORARY ROAD CAN BE CONSTRUCTED WEST OF EACH GROUP OF UNITS IN A PHASE TO CONNECT THE NORTH AND SOUTH DRIVES AND PARKING AREAS. THE ENTIRE WATER MAIN SHOULD BE CONSTRUCTED, BUT THE SANITARY AND STORM SEWERS CAN BE CONSTRUCTED AS REQUIRED TO SERVICE THE UNITS IN A PHASE.

6. MAINTAIN EROSION AND SEDIMENT CONTROL MEASURES, AS REQIRED.
7. INSTALL WATER MAIN, SEWER AND WATER LEADS.
8. BRING PAVEMENT AREAS TO SUB-BASE; PLACE SUB-BASE. REMOVE PAVEMENT INLET FILTERS AND PLACE ASPHALT PAVEMENT.
9. INSTALL ALL UTILITIES (PHONE, GAS, ETC.).
10. FINISH GRADE, REDISTRIBUTE TOPSOIL, SEED AND MULCH ALL DISTURBED AREA.
11. COMPLETE CONSTRUCTION OF BUILDINGS.
12. REMOVE ALL EROSION AND SEDIMENT CONTROL MEASURES, SEED AND MULCH REMAINING UNSTABILIZED AREAS, INCLUDING OFF-SITE TRANSITION AREAS.
13. FOR APPROXIMATE DATES FOR GRADING, CONSULT THE OWNER/DEVELOPER.

GRAPHIC SCALE




SOUTHEAST CORNER
SECTION 30
TOWN 1 SOUTH, RANGE 9 EAST
CITY OF LIVONIA
WAYNE COUNTY, MICHIGAN

| REV | DATE | DRAWN BY | CHECKED BY | DESCRIPTION |
|---|---|---|---|---|
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9957 GENERAL DRIVE, SUITE 125, PLYMOUTH, MICHIGAN 48170
PHONE (313) 459-9160
CONSULTING ENGINEERS
ENGINEERING PLANNING SURVEYING


PROJECT
NEWBURGH VILLAGE

TITLE
SOIL EROSION CONTROL PLAN

CLIENT
CITY OF LIVONIA
19300 PURLINGBROOK, LIVONIA, MICHIGAN 48152 TELE (313) 477-7086

DRAWING NUMBER 7 of 11
PROJECT NUMBER 90045
SCALE 1" = 40'

# APPENDIX B

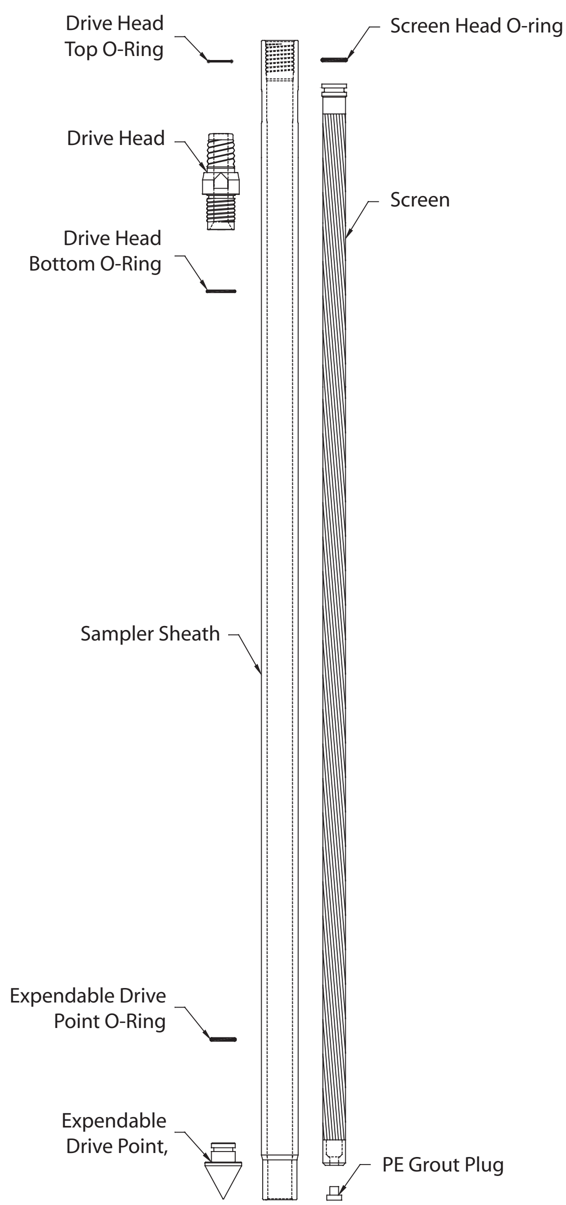
## GEOPROBE SCREEN POINT GROUNDWATER SAMPLING SOPS

# GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

## STANDARD OPERATING PROCEDURE

**Technical Bulletin No. MK3142**

**PREPARED: November, 2006**




**GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS**

**Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image® are Registered Trademarks of Kejr, Inc., Salina, Kansas**

**Screen Point 16 Groundwater Sampler is manufactured under U.S. Patent 5,612,498**

## 1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

## 2.0 BACKGROUND

### 2.1 Definitions

**Geoprobe®:** A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

**Screen Point 16 (SP16) Groundwater Sampler:** A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may chose to use this sampler in soils where driving is difficult.

**Rod Grip Pull System:** An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

### 2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of the these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

**(continued on following page)**

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

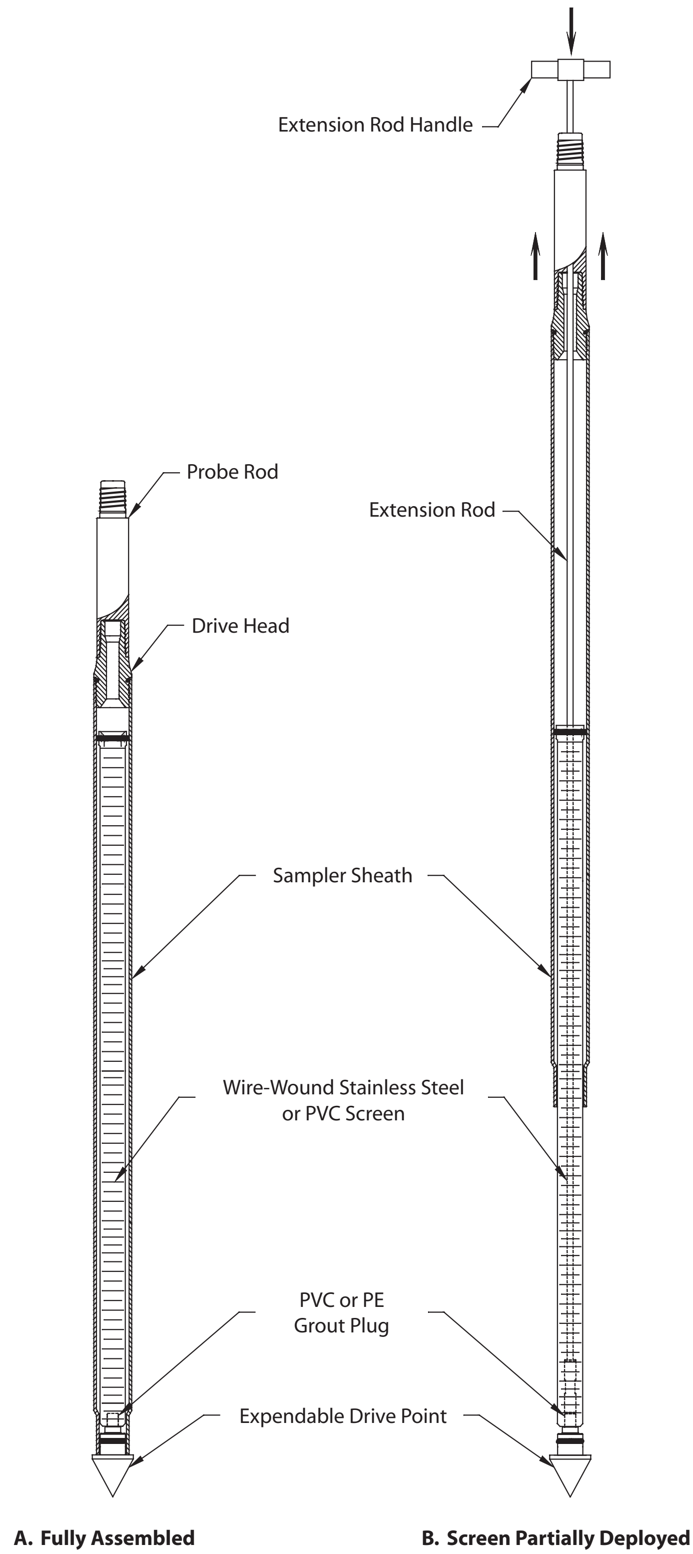



**FIGURE 2.1**
**Screen Point 16 Groundwater Sampler**

## 3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

| **SP16 Sampler Parts** | **Part Number** |
|---|---|
| SP16 Sampler Sheath | 15187 |
| SP16 Drive Head, 0.5-inch bore, 1.5-inch rods* | 18307 |
| SP16 O-ring Service Kit, 1.5-inch rods *(includes 4 each of the O-ring packets below)* | 15844 |
| *O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)* | *15389* |
| *O-rings for Bottom of SP16 Drive Head (Pkt. of 25)* | *13196* |
| *O-rings for GW1520 Screen Head (Pkt. of 25)* | *GW1520R* |
| *O-rings for SP16 Expendable Drive Point (Pkt. of 25)* | *GW1555R* |
| Screen, Wire-Wound Stainless Steel, 4-Slot* | GW1520 |
| Grout Plugs, PE (Pkg. of 25) | GW1552K |
| Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)* | GW1555K |
| Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods *(includes 1 each of: 15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K)* | 15770 |

| **Probe Rods and Probe Rod Accessories** | **Part Number** |
|---|---|
| Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer) | 12787 |
| Pull Cap, 1.5-inch probe rods | 15090 |
| Probe Rod, 1.5-inch x 60-inch* | 11121 |

| **Extension Rods and Extension Rod Accessories** | **Part Number** |
|---|---|
| Screen Push Adapter | GW1535 |
| Grout Plug Push Adapter | GW1540 |
| Extension Rod, 60-inch* | 10073 |
| Extension Rod Coupler | AT68 |
| Extension Rod Handle | AT69 |
| Extension Rod Jig | AT690 |
| Extension Rod Quick Link Coupler, pin | AT695 |
| Extension Rod Quick Link Coupler, box | AT696 |

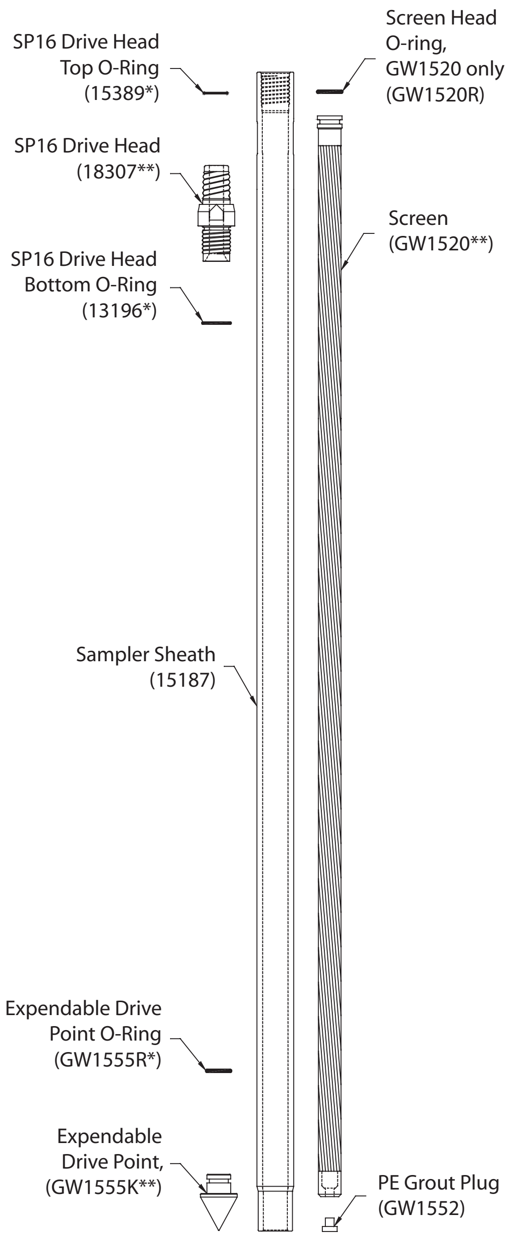
| **Grout Accessories** | **Part Number** |
|---|---|
| Grout Nozzle, for 0.375-inch OD tubing | GW1545 |
| High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m) | 11633 |
| Grout Machine, self-contained* | GS1000 |
| Grout System Accessories Package, 1.5-inch rods | GS1015 |

| **Groundwater Purging and Sampling Accessories** | **Part Number** |
|---|---|
| Polyethylene Tubing, 0.375-inch OD, 500 ft.* | TB25L |
| Check Valve Assembly, 0.375-inch OD Tubing* | GW4210 |
| Water Level Meter, 0.438-inch OD Probe, 100 ft. cable* | GW2000 |
| Mechanical Bladder Pump** | MB470 |
| Mini Bailer Assembly, stainless steel | GW41 |

| **Additional Tools** | **Part Number** |
|---|---|
| Adjustable Wrench, 6.0-inch | FA200 |
| Adjustable Wrench, 10.0-inch | FA201 |
| Pipe Wrenches | NA |

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.




* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration. See Appendix A for alternative parts.

**FIGURE 3.1**
**SP16 Sampler Parts**

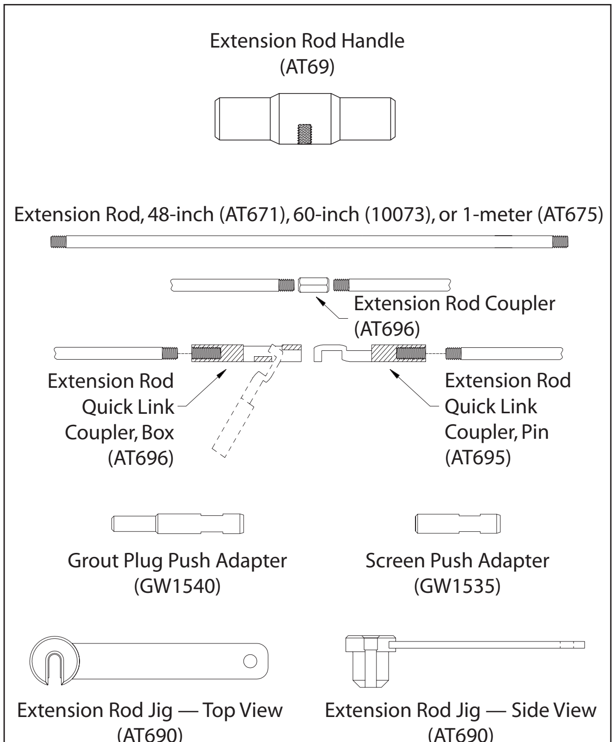



**FIGURE 3.2**
**Geoprobe® Extension Rods and Accessories**

# 4.0 OPERATION

## 4.1 Basic Operation

The SP16 sampler utilize a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

## 4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

## 4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

## 4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).

2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.

3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.

4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

   **NOTE:** The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

**Sampler assembly is complete.**

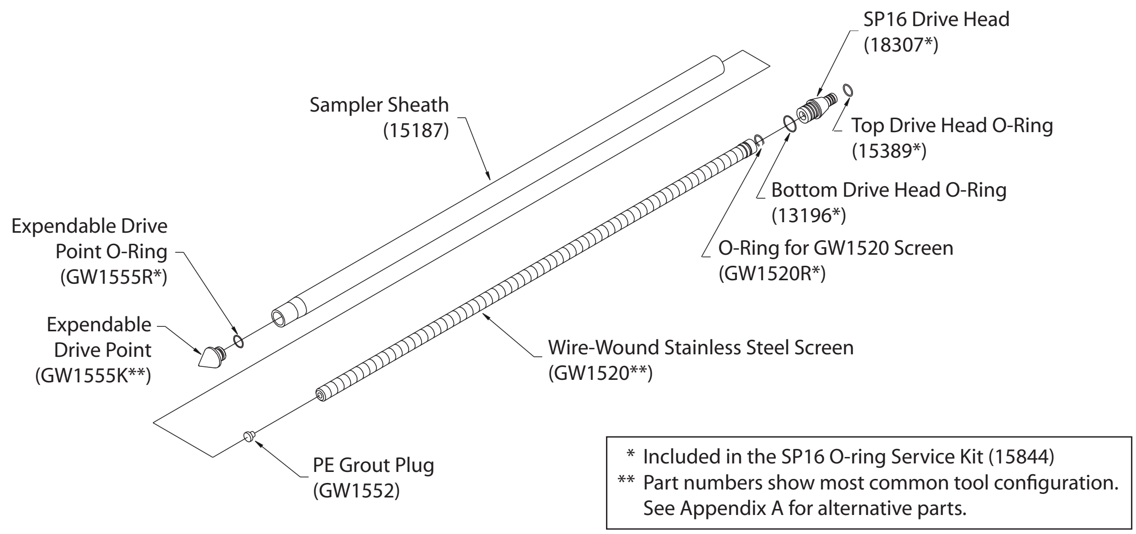



**FIGURE 4.1**
**Screen Point 16 Groundwater Sampler Assembly**

### 4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

**1.** Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.

**2.** Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.

**3.** Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.

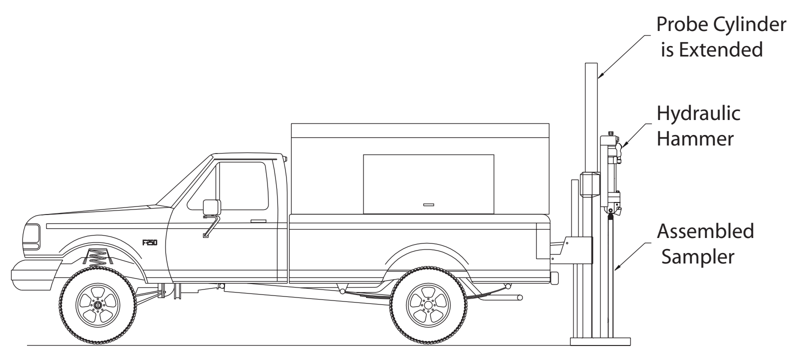



**FIGURE 4.2**
**Screen Point 16 Groundwater Sampler in Driving Position**

**4.** Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

**5.** Remove the drive cap and retract the probe derrick away from the tool string.

## 4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.

2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.

3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

   Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

   The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

   When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

## 4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.

2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.

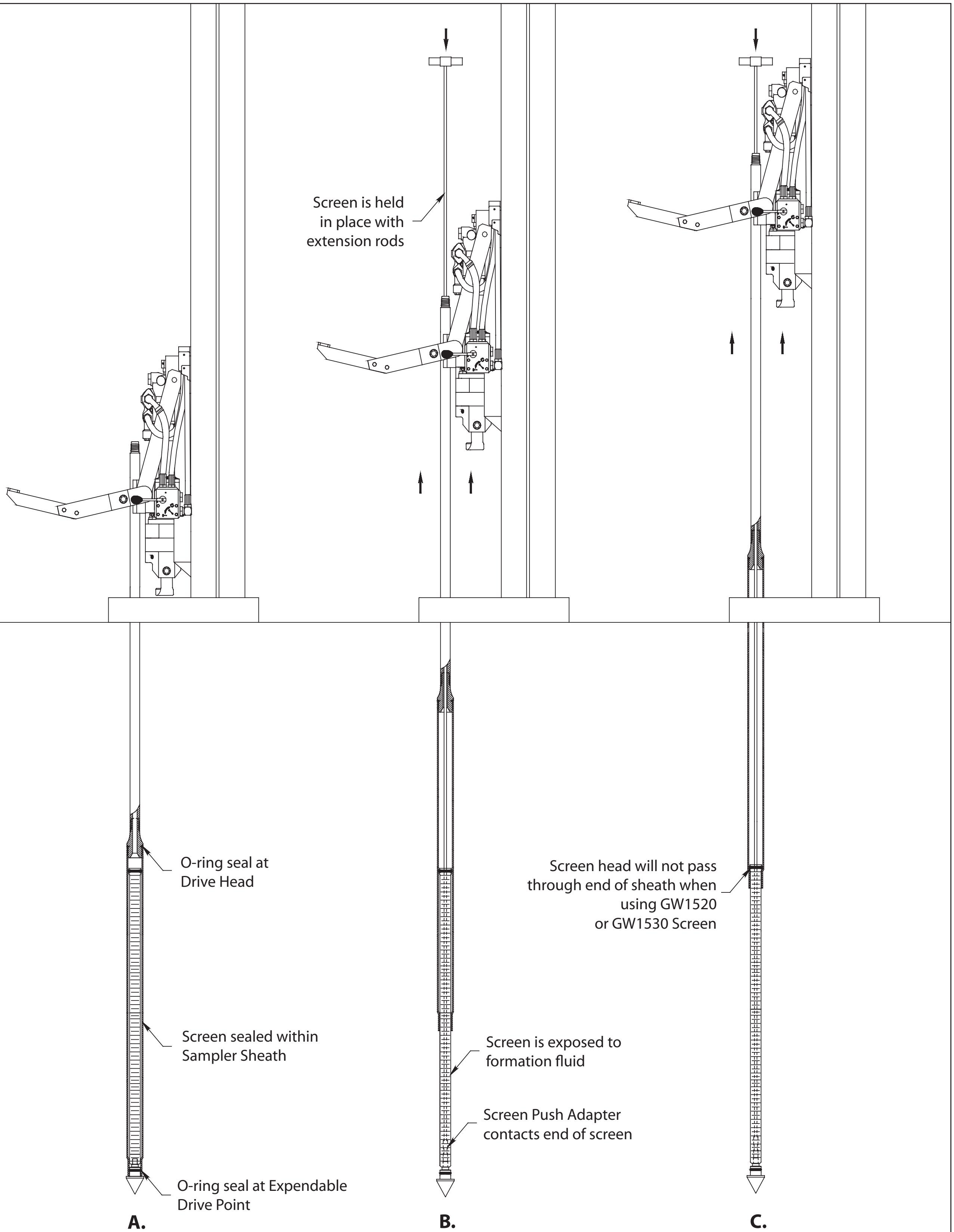



**FIGURE 4.3**
**Screen Deployment for SP16 Sampler**

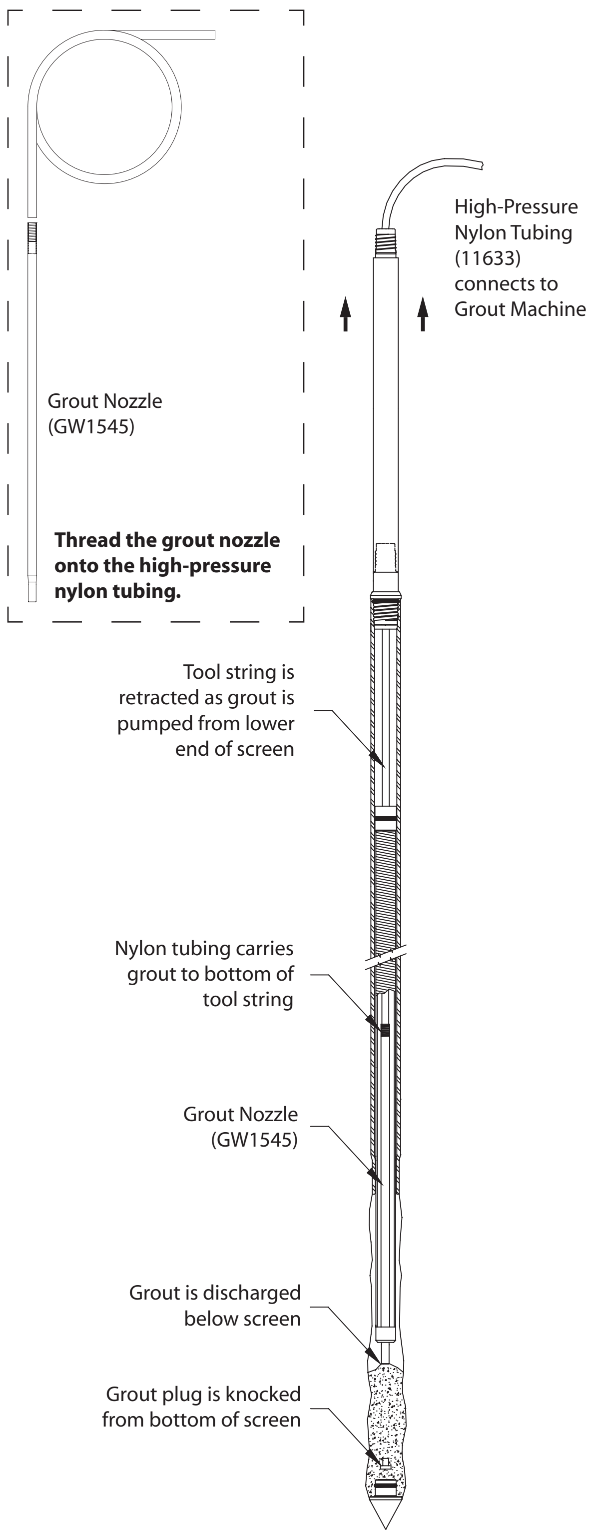



**FIGURE 4.4**

**Grouting the SP16 Sampler With a GW1520 or GW1530 Screen**

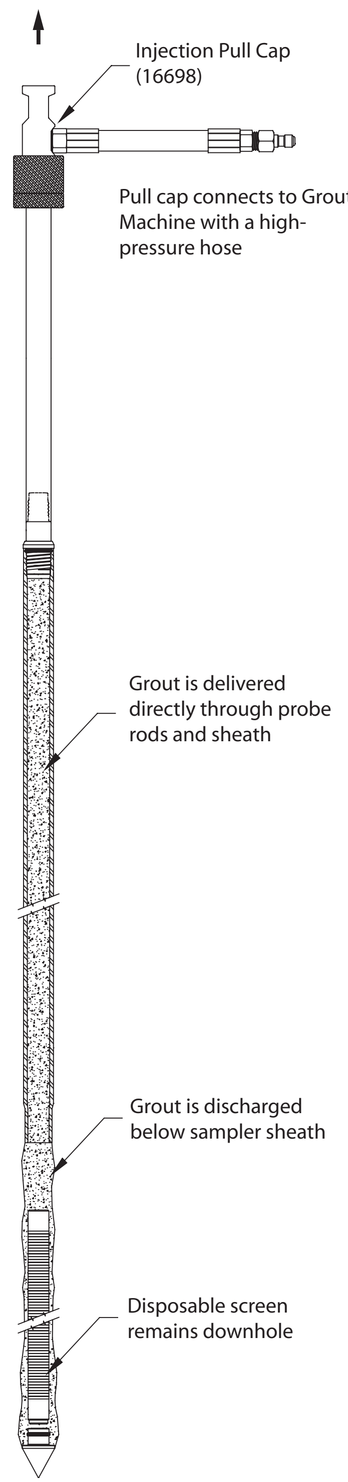



**FIGURE 4.5**

**Grouting the SP16 Sampler With a 16089 Disposable Screen**

3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

   **Note:** When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

   ***Note:*** *All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

### 4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.

2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.

3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.

4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

   The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.

6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.

7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

   The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

### 4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

## 5.0 REFERENCES

American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)

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Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.

## Appendix A
## ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

| **SP16 Sampler Parts and Accessories** | **Part Number** |
|---|---|
| SP16 Drive Head, 0.625-inch bore, 1.5-inch rods | 15188 |
| Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25) | GW1555ALK |
| Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25) | 17066K |
| Screen, PVC, 10-Slot | GW1530 |
| Screen, Disposable, PVC, 10-Slot | 16089 |

| **Groundwater Purging and Sampling Accessories** | **Part Number** |
|---|---|
| Polyethylene Tubing, 0.25-inch OD, 500 ft. | TB17L |
| Polyethylene Tubing, 0.5-inch OD, 500 ft. | TB37L |
| Polyethylene Tubing, 0.625-inch OD, 50 ft. | TB50L |
| Check Valve Assembly, 0.25-inch OD Tubing | GW4240 |
| Check Valve Assembly, 0.5-inch OD Tubing | GW4220 |
| Check Valve Assembly, 0.625-inch OD Tubing | GW4230 |
| Water Level Meter, 0.375-inch OD Probe, 100-ft. cable | GW2001 |
| Water Level Meter, 0.438-inch OD Probe, 200-ft. cable | GW2002 |
| Water Level Meter, 0.375-inch OD Probe, 200-ft. cable | GW2003 |
| Water Level Meter, 0.438-inch OD Probe, 30-m cable | GW2005 |
| Water Level Meter, 0.438-inch OD Probe, 60-m cable | GW2007 |
| Water Level Meter, 0.375-inch OD Probe, 60-m cable | GE2008 |

| **Grouting Accessories** | **Part Number** |
|---|---|
| Grout Machine, auxiliary-powered | GS500 |

| **Probe Rods, Extension Rods, and Accessories** | **Part Number** |
|---|---|
| Probe Rod, 1.5-inch x 1-meter | 17899 |
| Probe Rod, 1.5-inch x 48-inch | 13359 |
| Drive Cap, 1.5-inch rods (for GH40 Series Hammer) | 15590 |
| Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer) | GH1555 |
| Extension Rod, 48-inch | AT671 |
| Extension Rod, 1-meter | AT675 |

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.

Geoprobe Systems®

A DIVISION OF KEJR, INC.

**Corporate Headquarters**
601 N. Broadway • Salina, Kansas 67401
1-800-GEOPROBE (1-800-436-7762) • Fax (785) 825-2097
www.geoprobe.com

# APPENDIX C

## GHD MONITORING WELL INSTALLATION SAMPLING SOPS

# GHD Field Training Manual

Section 6.0
Monitoring Well Design and Construction Standard Operating Procedures

(T103)

July 2015

# Please adhere to the following Quality System training requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.

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# Quality System Forms Index

# 6. Monitoring Well Design and Construction Standard Operating Procedures

## 6.1 Introduction

Monitoring well design and construction is conducted to characterize the hydraulic and groundwater quality at a site. Standard Operating Procedures (SOPs) are presented herein for obtaining a variety of hydraulic and groundwater quality results, including:

- Groundwater elevation data
- Performance of aquifer testing
- Collection of groundwater samples for groundwater quality analysis

This guideline is not intended to provide the basis for designing a groundwater monitoring network, but instead assumes that a groundwater monitoring network has been designed, a site-specific Work Plan has been established, and that a GHD representative is preparing to mobilize to the site.

Monitoring well design and construction procedures vary from project to project due to different chemicals of concern, different guidance provided by the state/province where the site is located, and the specific objectives of the project (i.e., hydraulic monitoring, groundwater sampling, aquifer testing). It is essential that all monitoring well design and construction activities conform to local, provincial/state, and federal regulations. Therefore, it is essential that the GHD representative carefully review the Work Plan requirements. The primary goal of monitoring well design and construction is the appropriate placement of monitoring wells in various geologic and groundwater environments. It is imperative appropriate monitoring well installation and construction techniques are chosen.

The remainder of this section is organized as follows:

- Section 6.2 Background
- Section 6.3 Planning and Preparation
- Section 6.4 Safety and Health
- Section 6.5 Quality Assurance/Quality Control
- Section 6.6 Equipment Decontamination
- Section 6.7 Location and Marking of Well Sites/Final Visual Check
- Section 6.8 Drilling Methods
- Section 6.9 Well Design Considerations
- Section 6.10 Field Procedures for Well Installations
- Section 6.11 Well Construction Techniques
- Section 6.12 Well Installation Documentation

- Section 6.13 Well Installation Follow-up Activities
- Section 6.14 Well Development
- Section 6.15 Well Development Documentation
- Section 6.16 Well Development Follow-up Activities
- Section 6.17 References

## 6.2 Background

The design and installation of monitoring and extraction wells involves drilling boreholes into various types of geologic formations. Designing and installing monitoring wells may require several different drilling methods and installation procedures.

It is important that the drilling method used minimizes the disturbance of subsurface materials.

The drilling method should not contaminate the subsurface soils and groundwater. It is extremely important that drilling does not create a hydraulic link or conduit between different hydrostratigraphic units. Groundwater in monitoring and extraction wells must not be contaminated by drilling fluids or the borehole advancement process. Drilling equipment is decontaminated before use and between well locations to prevent cross-contamination between well locations and sites. Drilling equipment is decontaminated between all well locations regardless of whether or not contaminants are suspected. The Work Plan or Quality Assurance Project Plan (QAPP) will specify the required decontamination procedures for the site. At a minimum, decontamination procedures detailed in Section 6.6 should be used during monitoring well design and construction. The only time decontamination is not required is when boreholes are advanced on known clean sites for the purpose of collecting geologic information.

Finally, precleaned monitoring well construction materials are used in order to prevent the potential introduction of contaminants into a hydrostratigraphic unit.

> Caution: If using threaded low carbon steel (BIP) well materials, ensure that materials are thoroughly decontaminated. Threaded low carbon steel will have cutting oil on threads and on the inside and outside of the pipe. The outside of low carbon steel may also have a wax type coating which needs to be removed prior to installation.

## 6.3 Planning and Preparation

Prior to undertaking monitoring well design and construction:

1. Review the Work Plan and Site-Specific Health and Safety Plan (HASP), project documents, all available geologic and hydrogeologic mapping and reports, water well records, and historic site reports to become familiar with the geologic and hydrogeologic framework of the site and surrounding area. Review and become familiar with the health and safety requirements, and discuss the work activities with the Project Coordinator.

2. Complete a Field Equipment Requisition Form (QSF-014) and assemble all required equipment, materials, log books, and forms. Project Planning, Completion, and Follow-Up Checklist (Form SP-02) should be used for guidance throughout the project.
3. Obtain a site plan and previous stratigraphic logs. Determine the exact number, location, and depth of wells to be installed.
4. If not performed as part of borehole advancement, complete a Property Access/Utility Clearance Data Sheet (QSF-019). In most instances, the utility clearances and property access will have been completed as part of the well drilling and advancements.
5. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status on or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
6. Determine notification requirements with the Project Coordinator. Have all regulatory groups, the client, landowner, drilling contractor, and GHD personnel been informed of the well design and installation program?
7. Determine the methods for handling and disposal of well installation and decontamination fluids. Generally, this is dealt with as part of the well advancement activities.

In addition to the above, the following may be required when conducting monitoring well design and installation activities:

1. Establish a water source for well installation and decontamination. Pre-plan the methods of handling and disposal of well installation and decontamination fluids.
2. Arrange with the drilling contractor/client to provide a means of containment and disposal of fluids.

## 6.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

1. Assure the HASP is specific to the job and approved by a Regional Safety & Health Manager.
2. Confirm that all HASP elements have been implemented for the job.
3. A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.

4. Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
5. Review and implement applicable sections of the GHD Safety & Health Policy Manual.
6. Confirm that all site personnel have the required training and medical surveillance as defined in the HASP.
7. Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
8. Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
9. Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, vehicle incident, and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a job hazard analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's and the client's safety requirements.

## 6.5 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

## 6.6 Equipment Decontamination

### *Borehole Installation and Sampling*

Prior to use and between each borehole location, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the QAPP, or the methods presented in the following section.

The minimum wash procedures for decontamination of drilling or excavating equipment are:

1. High pressure hot water detergent wash (brushing as necessary to remove particulate matter)
2. Potable, hot water, high pressure rinse

Cover the clean augers with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where no contaminants are present, it is sufficient to clean the drilling or excavating equipment simply by removing the excess soils.

On environmental sites, soil sampling equipment (e.g., split spoons, trowel, spoons, shovels, bowls) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

In addition, the following steps may be added when sampling for volatile organic compounds (VOCs) and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (e.g., pesticide grade isopropanol, methanol, acetone, hexane).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap equipment in aluminum foil to prevent contamination.

Caution: Confirm the cleaning protocol from the QAPP. The use of an incorrect cleaning protocol can invalidate chemical data.

## 6.7 Location and Marking of Well Installation Sites/Final Visual Check

The proposed well locations marked on the site plan are located and staked in the field. On most sites, this should be completed several days prior to the drill rig arriving on site. Well locations are required for the completion of utility locates. Generally, well locations are strategically placed to assess site hydrogeologic conditions.

Once the final well location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

> Caution: Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.

Well locations are selected primarily to provide a good geographical distribution across the site. Most often, the well locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, nor to consider the site's specific characteristics (e.g., traffic patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

1. Select the exact location of each well consistent with the site and project requirements.
2. If a well must be relocated more than 20 feet (5.7 m) from the initially identified location, confirm the new location's suitability with the Project Coordinator.
3. Ensure all utilities have been cleared prior to initiating borehole advancement activities.

To the extent practical, wells should be located adjacent to permanent structures (e.g., fences, buildings) that offer some form of protection and a reference point for future identification. Wells located in high traffic areas or road allowances or low-lying wet areas are undesirable, but may be unavoidable.

> Note: Field tie-ins must be completed to accurately identify each well location. These will ensure that the wells are properly identified on plans and for future identification in the field.

## 6.8 Drilling Methods

The following drilling methods are listed in order of preference. However, final selection will be based on site geologic and hydrogeologic conditions. The drilling methods outlined below are discussed in detail in Section 4.0.

### *Hollow-Stem Augering*

Continuous flight hollow-stem augering (HSA) is the most frequently used method of borehole advancement. Its primary advantages are:

1. Generally, no additional drilling fluids are introduced into the formation.
2. Representative geologic samples can be obtained easily using split-spoon samplers in conjunction with the standard penetration test (SPT) and HSA.
3. A monitoring well can be installed through the auger, eliminating the need for a temporary borehole casing.

Information regarding split-spoon sampling is discussed in Section 5.0.

HSAs are available with an inside diameter of 2.5, 3.25, 4.25, 6.25, 8.25, and 10.25 inches (6.4, 8.3, 10.8, 15.9, and 26.0 cm). Some drilling contractors have inside diameter HSAs as large as 16.25 inches (41.3 cm). The most commonly used inside diameter is 4.25 inch for the installation of a 2-inch (5 cm) diameter monitoring well. Larger diameter HSAs, including 6.25, 8.25, and 10.25 inch (10.8, 15.9, 26.0 cm), are used for large diameter monitoring or extraction wells ranging in size from 4 to 8 inches (10 to 20 cm). Boreholes can usually be advanced to depths of about 100 feet (30 m) with an HSA in unconsolidated clays, silts, and sands.

Installation of a well through a HSA is a simple process, but precautions need to be taken to ensure that well construction, particular sealing, is properly completed.

Removing a HSA from flowing sand may be difficult since the auger has to be removed without rotation, if at all possible. A bottom plug or pilot bit assembly should be used to keep out soils and water that have a tendency to fill the bottom of the HSA during drilling. If flowing sands are encountered, potable water (analyzed for contaminants of concern) may be poured into the HSA to equalize the hydrostatic pressure, which will keep the formation materials and water from flowing into the HSA once the plug or pilot bit is removed.

### *Direct-Push Drilling*

Direct-push refers to the sampler being "pushed" into the soil material without the use of drilling to remove the soil. This method relies on the drill unit static weight, combined with rapid hammer percussion, to advance the tool string. Discrete soil samples are continuously obtained.

Groundwater and vapor samples can also be collected utilizing this method and appropriate tooling. Subsurface investigations typically sample to depths of 30 feet (9.1 m) or more; however, depth will vary based on the site-specific geology.

This method is used extensively for initial site screening to establish site geology and delineate vertical and horizontal plume presence. Small diameter wells (3/4 inch or 1 inch [2 cm or 2.5 cm]) can be installed using direct-push methods.

SPT values cannot be obtained when sampling with a direct-push discrete soil sampler.

The direct-push method is becoming more popular due to the limited cuttings produced and the speed of the sampling process, which can be much faster than the sample description and sample preparation process.

Discrete continuous soil samples are collected in tube samplers (various lengths) affixed with a cutting shoe and internal liner (polyvinyl chloride [PVC], Teflon, or acetate are available). The soil sampler may be operated in "open-mode" (when borehole collapse is not a concern), or in "closed-mode" (when minimization of sample "slough" is desired). Closed-mode operation involves placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. At the required depth, the temporary drill–point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner, with soil, is removed for examination. Extra care must be taken when cutting open the sample tube; not open blade cutting tools may be used in the process, you must have an appropriate stabilizer/holder for the tube, and cut resistant hand protection must be included as part of the overall PPE. Please review and modify the JSA for the site conditions.

### *Dual-Wall Reverse Circulation Air Drilling*

This method consists of two concentric strings of drill pipe (an outer casing and a slightly smaller inner casing). Compressed air is continually forced down the annulus between the inner casing carrying the drill cuttings and groundwater. At the surface, the inner casing is connected to a cyclone hopper where the drill cuttings and groundwater fall out from the bottom of the hopper, and air is disbursed from the top. The dual wall provides a fully cased borehole in which to install a well. The only soil or groundwater materials exposed at any time are those at the drill bit, so the potential for carrying contamination from one stratum to another is minimal. Depth-specific groundwater samples can be collected during drilling; however, since the groundwater is aerated, analysis for volatile organic compounds (VOCs) may not be valid.

### *Rotosonic Drilling*

This method consists of a combination of rotation and high frequency vibration to advance a core barrel to the desired depth. Once the vibration is stopped, the core barrel is retrieved and the sample is vibrated or hydraulically extracted into a plastic sleeve or sample tray. The well is installed through an outer casing. Rotosonic drilling generally requires less time than more traditional methods and continuous, relatively undisturbed samples can be obtained through virtually any formation. Conventional sampling tools can be employed as attachments (e.g., hydropunch, split spoon, Shelby tube). No mud, air, water, or other circulating medium is required. The main limitation of this method is the availability of equipment.

### *Rotary Method*

This method consists of a drill rod attached to a drill bit (for soils, a tricone or drag bit; for rock, a button studded or diamond studded bit) that rotates and cuts through the soils and rock. The cuttings produced are forced to the surface between the borehole wall and the drill rod by drilling fluids that generally consist of water or drilling mud, or air. The drilling fluid or air not only forces the cuttings to the surface but also keeps the drilling bit cool. Using the rotary method can be difficult as it requires several steps to complete the installation. First, the borehole is drilled, then temporarily cased, then the well is installed, and then the temporary casing is removed. In some cases, the borehole may remain open without installing a casing (e.g., cohesive soils).

### *Water Rotary*

When using the water rotary method, the potable water supply must be analyzed for contaminants of concern. Water rotary is the preferred rotary method since potable water is the only fluid introduced into the borehole during drilling. However, this method is generally only successful when drilling in cohesive soils. The use of potable water also reduces well development time.

### *Air Rotary (typically used in rock)*

When using the air rotary method, the air compressor must have an in-line oil filter system assembly to filter the oil mixed with the air coming from the compressor. This helps eliminate the introduction of contaminants into the formation. The oil filter system needs to be regularly inspected.

An air compressor with no in-line oil filter system is not acceptable for air rotary drilling. A cyclone velocity dissipater or similar air containment system must also be used to funnel the cuttings to one location rather than allowing them to blow uncontrolled out of the borehole. Air rotary may not be an acceptable method for well installation where certain contaminants are present in the formation. Alternatively, it may be necessary to provide treatment for the air being exhausted from the borehole during the installation process.

#### *Mud Rotary*

In some states (i.e., Ohio, Michigan), mud rotary is the least preferred rotary method because contamination can be introduced into the borehole from the constituents in the drilling mud. Drilling mud is generally non-toxic. However, it is possible for mud to commonly infiltrate and affect water quality by sorbing metals and polar organic compounds (Aller et al., 1991). Chemical composition and priority pollutants analysis can be obtained from the manufacturer. Mud rotary must utilize only potable water and pure (no additives) bentonite drilling mud. The viscosity of the drilling mud must be kept as low as possible. Proper well development is essential to ensure the removal of all the drilling mud and to return the formation to its previous undisturbed state.

#### *Well Point*

Occasionally, well points (sand points) are driven into place without using augers. This method provides no information on the geologic condition (other than the difficulty of driving which may be related to formation density). Well points are most often used simply to provide dewatering of a geologic unit prior to excavation in the area. Well points are also used in monitoring shallow hydrogeologic conditions such as in streambeds.

## 6.9 Well Design Considerations

Well design must be completed prior to initiating well installation activities.

The compatibility of the well construction materials with the groundwater environment should be verified. Certain materials are not compatible in a corrosive environment or where groundwater has high solvent concentrations. In deeper well applications, well material strength should be considered. Finally, the overall cost of the well materials should be considered.

### 6.9.1 Well Materials

The following well materials are commonly used:

- PVC well screen and riser pipe
- Stainless steel well screen and riser pipe
- Stainless steel screen and black iron (low carbon steel) riser pipe
- Stainless steel screen and PVC riser pipe

#### 6.9.1.1 PVC Well Materials

PVC is generally either Schedule 40 or Schedule 80. Schedule 80 PVC is thicker and provides more strength than Schedule 40. Schedule 80 PVC is more resistant to heat caused by the placement and setting of grout. Because of the higher strength and greater heat resistance, Schedule 80 is preferred for well applications greater than 100 feet (30 m).

PVC is available in a variety of diameters, from 0.5 inch (1.5 cm) to 8 inch (20 cm). PVC is relatively inexpensive and readily supplied by drilling contractors well material suppliers. PVC is light and generally comes pre-cleaned and bagged.

PVC is resistant to corrosion, most acids, oxidizing agents, salt, alkaline, and oils and fuels. However, it may break down in environments with high solvent concentrations. PVC can become brittle over time and is not as strong as metal.

PVC installations may be difficult in deep applications through a large water column because of its buoyancy.

PVC wells should not be constructed using solvent cement.

Threaded PVC well materials should be used where possible.

PVC well materials should meet the National Sanitation Foundation (NSF) Standard 14.

#### 6.9.1.2 Metallic Well Materials

Metallic materials include stainless steel, black iron (low carbon steel), and galvanized steel. Metallic well materials are less commonly used than PVC.

Metallic materials are suitable for deep well applications because of their high strength and resistance to the heat produced during grout and cement grout curing.

Black iron pipe (BIP) is susceptible to corrosive environments. Stainless steel well materials are generally pre-cleaned and bagged. Threaded BIP must be decontaminated prior to use to remove all waxes on the exterior of the pipe and to remove cutting oil from threads and the interior and exterior of the pipe.

Metallic well materials cost more than PVC.

### 6.9.2 Well Diameter

The diameter of a well is primarily dictated by the purpose of the well. Generally, wells installed for groundwater and hydraulic monitoring should be between 1 and 2 inches (2.5 and 5 cm) in diameter. The diameter is also dependent on the drilling method being used.

Small diameter wells allow for the installation of bladder pumps as well as small diameter tubing and bailers. Wells smaller than 1 inch (2.5 cm) should only be used for hydraulic monitoring. Due to the small diameter, sampling equipment cannot be used in wells smaller than 1 inch (2.5 cm) in diameter. The cost saving for wells smaller than 1 inch (2.5 cm) is negligible.

For groundwater extraction, 4- to 6-inch (10 to 15 cm) diameter wells are sufficient. Wells greater than 6 inches (15 cm) in diameter are generally installed for water supply and are project specific.

### 6.9.3 Screen Length and Placement

Screen lengths for wells can vary depending on a variety of factors including:

- Formation thickness
- Seasonal groundwater fluctuations
- Extraction/water supply

Screen length should be consistent with the hydrogeologic conditions and the desired monitored interval. A 10-foot (3.0 m) long screen is suitable for groundwater table wells when the screen is completely submerged and a specific monitoring interval is required.

If monitoring for light non-aqueous phase liquids (LNAPL), the screen length is generally 10 feet (3.0 m). A longer screen length can be installed to accommodate seasonal groundwater fluctuations. A 5- to 10-foot (1.5 to 3.0 m) screen length is adequate where the hydrostratigraphic formation is low and allows for the water level to be drawn down during sampling through the filter pack into the screened interval.

If monitoring for dense non-aqueous phase liquids (DNAPL), the screen needs to be placed at the bottom, or sumped slightly into the confining unit. In general, a 5-foot (1.5 m) long screen is suitable for wells designated for DNAPL monitoring. However, it is acceptable to use a 10-foot (3.0 m) long screen if the formation has sufficient saturated thickness.

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|---|---|
| Caution: | Do not penetrate the confining unit during advancement, especially if DNAPL is suspected. |

Monitoring wells installed in confined aquifer conditions can be installed using 5-foot (1.5 m) long screens.

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| Note: Well installations are not able to straddle a confined potentiometric surface. |

### 6.9.4 Well Slot Size

Well slot sizes are described in thousandths of an inch. For most monitoring wells, a No. 10 slot (0.01-inch [0.25 mm]) well screen is adequate in most hydrostratigraphic units. PVC wells screens are typically available in No. 10 (0.01-inch [0.25 mm]) or No. 20 (0.02-inch [0.51 mm]) slot sizes. Stainless steel screens are available in a wider range of slot sizes. Typically, stainless steel screens must be specially ordered and require additional delivery time. Wells screens can be slotted, continuous slot, or louvered. Well points come in very limited slot sizes.

Some state/provincial and federal regulators require design of monitoring well screen slot sizing. The design of the slot size is based upon grain size results from the desired monitored interval.

Pre-pack screens are an effective screening method for deep installations or where flowing sands exist. A pre-pack screen consists of two screens with filter pack placed between the screens. Pre-pack screens are most commonly constructed of PVC and are available in No. 10 (0.01-inch [0.25 mm]) or No. 20 (0.02-inch [0.51 mm]) slot sizes.

Filter socks or cloths are for use in fine-grained soils. Filter socks or cloths should not be used when monitoring for the presence of LNAPL or DNAPL. An alternative to using filter socks or cloths is to install well points.

### 6.9.5 Sand Pack Sizing

The silica sand pack placed around the well screen should be no finer than the slot size of the screen. Some companies supply different sieve size ranges for the same sand size number. Grain size curves should be obtained from the driller or well materials supplier to ensure proper sand size prior to placement.

In some instances, generally in situations with flowing sands, a natural sand pack may be required. A natural sand pack is not desired because of the increase in development time.

### 6.9.6 Well Sealing

All wells must be properly sealed. A seal is placed over the silica sand pack. Cuttings must never be used to seal a well.

Certain well applications require specific well seals including:

- bentonite gravel or chips
- bentonite grout
- cement/bentonite grout
- cement grout

Prior to initiating well installation activities, confirm sealing requirements with local, state/provincial, or federal regulations.

## 6.10 Field Procedures for Well Installations

The following presents the field procedure and techniques for installing a well in overburden and bedrock. Typical overburden well installation details are provided on Figure 6.1. Typical bedrock well installation details are provided on Figure 6.2.

### 6.10.1 Installation Requirements

Well installation requires the following components:

1. Annular space
2. Instrumentation details
3. Filter pack placement
4. Bentonite seal
5. Grouting
6. Protective casings and well caps

7. Surface seal
8. Protective posts (if required)

### 6.10.2 Annular Space

The annular space is the space between the outside of the riser pipe or casing and the inside of the HSA, casing, or borehole wall.

The borehole diameter must be sufficient to allow well construction to proceed without difficulty. Check with local, state/provincial, or federal regulations to insure that the borehole annular space meets regulations. To assure adequate size, a minimum 2-inch (5 cm) annular space is required to allow a minimum 1.5-inch (4 cm) tremie line for placing filter pack, seal, and grout at the specific intervals. An annular space of less than 2 inches (5 cm) is not acceptable.

### 6.10.3 Instrumentation Details

Prior to installation through the auger or into the borehole, the well assembly (i.e., well screen and riser components) and the length of each component must be measured and recorded. The borehole must be measured to ensure installation at the desired interval to be monitored.

| Note: Well screen and riser should only be handled using clean nitrile gloves. |
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Once the depth of the borehole has been confirmed and the length of the well assembly is known, well construction can proceed. Placement problems are easily identified by measuring the amount of riser stickup during installation and comparing to the measured depth of the borehole.

### 6.10.4 Filter Pack Placement

***Primary Filter Pack (see ASTM D5092)***

The primary filter pack is composed of graded washed silica sand. The silica sand size should be no finer than the screen size opening. The primary sand pack size may have to be designed based on the well screen slot size and the grain size of the hydrostratigraphic formation.

The primary filter pack is placed as follows:

1. The primary filter pack is placed using the tremie line method.
2. A minimum 6 inches (15 cm) of the primary filter pack material is placed under the bottom of the well screen. This interval of primary filter pack provides a firm footing for the well.
3. Where DNAPL is present, or is being monitored for, the well may be sumped into a confining unit. In this case, no primary filter pack is placed under the bottom of the well screen.
4. The top of the primary filter pack is determined in the field based on the geologic and hydrogeologic conditions encountered during borehole advancement.
5. The primary filter pack should extend a minimum of 2 feet (0.6 m) above the top of the well screen.

6. For shallow overburden wells it is common to extend the primary filter pack to about 2 feet (0.6 m) above the water table to account for anticipated seasonal groundwater fluctuations.
7. In shallow overburden wells the sand pack should not be extended across a native and fill unit. For deeper overburden wells, it is common to select a specific hydrogeologic unit to monitor.
8. The primary filter pack should never extend through a confining unit causing two or more permeable units to become connected.

Placing the primary filter pack by pouring may be acceptable if measurements are taken to ensure that the filter pack is reaching the assigned depth.

The primary filter pack must be carefully placed concurrent with the removal of the HSA or temporary casing when collapsing borehole conditions exists. The primary filter pack must be maintained in the HSA or temporary casing to ensure proper filter pack placement around the well screen.

Placement of the primary filter pack is typically a delicate and time-consuming operation. It requires a balance between placement of too much sand and "locking" the well components in the auger or temporary casing, or placing too little sand, which allows the formation materials to collapse around the well screen. A good well installation will involve constantly checking the primary filter pack level as the auger or temporary casing is extracted from the borehole. Constant measurement of the primary filter pack will allow for adjustment of the rate and amount of filter pack placement.

In certain situations it may be necessary to add potable water within the HSA or temporary casing to maintain a positive hydrostatic pressure on the formation materials. This will help stop the flow of formation materials into the HSA or temporary casing. This generally occurs in sandy/silty soils below the water table. If potable water is added, the volume of water added must be recorded and additional purging volumes will be required to remove the volume of potable water added.

#### *Secondary Filter Pack (see ASTM D5097 and D5092)*

The secondary filter pack is finer than the primary filter pack. The first secondary filter pack prevents the intrusion of grout from reaching the primary filter pack. The final secondary filter pack limits the migration of grout material into the bentonite seal. Generally, a bentonite seal over the primary filter pack is sufficient to stop grout from reaching the primary filter pack.

The secondary filter pack is a layer of fine-grained silica sand placed in the annular space between the primary filter pack and bentonite seal, and between the bentonite seal and grout seal. The secondary filter pack must be uniformly graded fine silica sand with 100 percent by weight passing the No. 30 U.S. Standard sieve, and less than 2 percent by weight passing the No. 200 U.S. Standard sieve. Blasting sand or "sugar" sand is typically used as a secondary filter pack.

### 6.10.5 Bentonite Seal

A bentonite seal is placed on top of the filter pack. This seal consists of high solids, pure bentonite material. Bentonite in either pellet or granular form is acceptable. Check with local, state/provincial, and federal regulations concerning bentonite seal material requirements.

Generally, 3/8-inch (1 cm) bentonite chips are used, but larger 3/4-inch (1.9 cm) bentonite chips may be used in larger annular spaces. Bentonite pellets have a machined surface and are good for deep well applications, or for adding bentonite seals through a long water column.

When placing a bentonite seal:

1. A tremie line is the preferred method. Pouring the bentonite seal is acceptable in shallow applications (less than 50 feet [15 m]) where the annular space is large enough to prevent bridging.
2. Take continuous measurements to ensure that the bentonite seal is being placed in the proper interval, and that bridging is not occurring.
3. Place the bentonite seal above the filter pack to a minimum of 2 feet (0.6 m) thick.
4. Allow the bentonite to hydrate before grouting.
5. If the water table is temporarily below the bentonite seal interval, use potable water to hydrate the bentonite.

### 6.10.6 Grouting

The annular space between the well casing and borehole wall must be filled with neat cement grout, cement/bentonite grout, or bentonite grout. Check required local, state/provincial, and federal regulations regarding well sealing requirements.

Bentonite grout does not crack or harden and is generally self-healing. Cement/bentonite grout may crack, but bentonite will typically seal any cracks. Cement/bentonite grout must contain at least 5 percent bentonite volume by weight. Neat cement will crack and may pull away from riser pipe or borehole wall.

When placing grout:

1. Prepare the grout in accordance with the manufacturer's specifications.
2. Using a tremie line, place the grout into the borehole, over the bentonite seal.
3. Place the grout from the top of the bentonite seal to within 2 feet (0.6 m) of the ground surface or, if possible, below the frost line.
4. Allow the grout to set for a minimum of 24 hours before installing a concrete surface seal. Grout will generally settle due to infiltration into medium- and coarse-grained soils. Check grout levels and, if required, add additional grout to the borehole to bring the grout level to the required depth.
5. When grouting on contaminated sites, collect and contain displaced fluids for future disposal.

When a concrete surface seal is not required, the grout is brought to within 0.5 to 1 foot (0.15 to 0.30 m) below ground surface. The remaining annular space is backfilled to match the surrounding ground surface conditions (e.g., asphalt, topsoil). This method will reduce surface water infiltration and well lifting due to frost.

### 6.10.7 Protective Casings

A protective casing is installed over the completed well and sealed in place. Once installed and grouted, the casing should extend about 2.5 feet (0.75 m) above ground surface. The outer protective casing is made of steel and has a locking cap that is hinged, waterproof, and resistant to vandalism. The protective casing should have sufficient clearance around the inner well casing so that no contact is made with the outer protective casing. A concrete surface seal is installed flush to promote drainage away from the outer protective casing at a depth below the frost line to deter frost heaving. Check local, state/provincial, and federal regulations pertaining to requirements for concrete surface seals.

Typically, a concrete form (sonatube) is used to provide a collar for the concrete around the protective casing. The concrete surface seal is placed as follows:

1. The concrete surface seal is sloped to promote surface drainage away from the well.
2. The protective casing is installed with two weep holes for drainage. The weep holes should be 1/4 inch (0.6 cm) in diameter and drilled into the protective casing slightly above the top of the concrete surface seal. The weep holes will prevent standing water from accumulating inside the protective casing and allow internal air pressure to be in equilibrium with atmospheric conditions.
3. Bentonite chips or pellets are placed in the annular space below ground level in the protective casing.
4. Silica sand is placed in the annular space above the bentonite chips or pellets and above the weep hole to prevent insect infestation.

Sometimes a well must be completed in a high traffic area. In this situation, the well is completed as a flush-mount installation. A waterproof protective casing is essential to ensure the integrity of the screened hydrostratigraphic unit. The protective casing is grouted in place and is fitted with bolts and a rubber gasket to deter surface water infiltration. For a flush-mount installation, the well top is generally fitted with a locking expandable cap with watertight screw-on connections (as referenced in ASTM F480). For a flush-mount installation, the well cap must have a lock to deter vandalism. The preferred cap is manufactured by OPW of Cincinnati, Ohio (OPW 634 TTM-7087). For above-grade installations, the well cap or well casing must be properly vented to allow air pressure to be in equilibrium with atmospheric conditions.

Flush-mount installations are typically more problematic and maintenance intensive. If possible, avoid the use of flush-mount installations.

A typical protective casing installation is shown on Figure 6.3.

Once all well installation activities are complete, wells are labeled with the appropriate well identification in at least two locations. Check for local, state/provincial, or federal regulations that may require that wells be assigned a specific well identification number. A well tag may be required on the well casing or embedded in the concrete surface seal.

| |
|---|
| Note: Lock all wells to prevent vandalism. |

#### 6.10.8 Protective Posts

When required, protective posts (bollards) can be constructed of 4-inch (10 cm) diameter Schedule 40 PVC; or low carbon steel pipe filled with concrete; or 4- by 4-inch (10 cm by 10 cm) wooden posts, and installed as follows:

1. Install the posts at least 3 to 4 feet (0.9 to 1.2 m) above ground surface. As many as four posts may be installed for each well location.
2. Set each post at least 2 feet (0.6 m) into the ground and install in a separate concrete seal.
3. Place the posts at the corners of the well concrete surface seal, 4 feet (1.2 m) radially from the center of the well at 90-degree increments.

If a well is installed in a heavily forested or vegetated area, identify the well location using a high visibility marker to allow for future identification.

### 6.11 Well Construction Techniques

#### 6.11.1 Well Installation

Boreholes for well installations should be drilled as close to vertical as possible. Slanted boreholes are not acceptable unless specified in the well design or Work Plan. Well casings and screens should be installed plumb in the boreholes. Where critical, especially on installations deeper than 50 feet (15 m), centralizers may be used to help keep the screen as close as possible to the center of the borehole. An alternative method to setting a well casing and well assembly is to suspend the casing or assembly from the wireline on the drill rig.

Petroleum-based lubricating oils or grease should not be used on casing threads. Teflon tape can be used to ensure a watertight seal. No glue of any kind should be used to secure casing joints. For some steel casings, welded joint construction is acceptable.

The well is installed as follows:

1. Before placing the well assembly at the bottom of the borehole, place at least 6 inches (0.15 m) of filter pack at the bottom of the borehole to serve as a footing.
2. If monitoring for DNAPL, the well assembly may be set directly on the bottom of the borehole. Place the well into the borehole plumb.
3. On a well installed to a depth greater than 50 feet (5 m), centralizers are required. Place the centralizers on the well casing or well assembly above the proposed bentonite seal interval. Place the centralizers so as not to interfere with the placement of the filter pack, bentonite seal, and annular grout. (Generally, wells less than 50 feet (15 m) deep will not require centralizers unless required by local, state/provincial, or federal regulations, or the Work Plan.)
4. During well installation through a HSA, slowly pull back the auger as the filter pack, bentonite seal, and annular grout are tremied or poured in place.
5. When the well has been lowered into the borehole, place the filter pack around and above the top of the screen, as required.

6. When the filter pack has been installed, place a minimum 2-foot (0.6 m) thick bentonite seal directly on top of the filter pack.
7. Allow the bentonite seal to hydrate for a reasonable amount of time (generally, 30 minutes is sufficient).
8. When the bentonite seal has hydrated sufficiently, seal the remaining borehole annular space grout placed with a tremie line using positive displacement methods. Generally, the grout will be brought to 2 feet (0.6 m) below ground surface or below the frost line, whichever is greater. In situations where no concrete seal is being placed, the grout can be brought to 0.5 to 1 foot (0.15 to 0.3 m) below ground surface.
9. During grout placement, ensure the end of the tremie line is always submerged in the grout to ensure positive displacement.
10. During grout placement on contaminated sites, containerize all fluids for future disposal.
11. Allow the grout to set for about 24 hours before installing the concrete surface seal. If the grout level has subsided, top off the borehole annular space with grout or bentonite pellets to the required depth.
12. Install protective casings in a minimum 2-foot (0.6 m) thick concrete surface seal graded to divert surface water away from the monitoring well. Check local, state/provincial, and federal regulations for concrete surface seal requirements. Some agencies require that concrete pads be constructed around the wells.
13. When installation is complete, label the well in at least two locations for future identification.

For well installation in a high traffic area (i.e., parking lot, residential yard, road allowances) it may be necessary to install a flush-mount protective casing. It is important that the flush-mount protective casing be watertight to protect the screened hydrostratigraphic unit. Flush-mount protective casings are designed to extend from ground surface down into the concrete surface seal. Elevate the areas in the immediate vicinity of a flush-mount well to the extent possible to promote surface water drainage away from the flush-mount protective casing. Be aware of possible trip hazards associated with a flush-mount protective casing in areas of pedestrian traffic need. It is also important to avoid installing a well in a low-lying area that is susceptible to surface water accumulation and ponding.

Typical overburden well installation details are shown on Figure 6.1. Typical protective casing installations are shown on Figure 6.3.

### 6.11.2 Double-Cased Wells

A double-cased well is constructed when there is a possibility that interconnection between two aquifers may occur during borehole advancement or well construction. This interconnection may cause cross-contamination of deeper aquifer units from shallower aquifer units due to the presence of a conduit between the two aquifer units. Pilot borings are advanced through the overburden or impacted zone into a confining layer or bedrock. An outer casing, generally referred to as a surface casing, is then installed in the borehole. The borehole and outer casing should extend at least 2 feet (0.6 m) into the confining layer if possible. However, the depth of penetration will depend on the overall thickness of the confining layer. Generally, in bedrock, the borehole will be advanced until competent bedrock is encountered. Check with the Work Plan to confirm the depth stipulated for the outer casing. The outer casing must be of sufficient inside diameter to contain the inner casing and a 2-inch (5 cm) minimum annular space. The casing is sealed in place with cement grout or cement/bentonite grout using a tremie line and positive displacement methods. On contaminated sites, fluids displaced during the placement of the grout need to be contained for future disposal. Check local, state/provincial, and federal regulations regarding the type of grout required. The outer casing is allowed to set or cure for a minimum of 24 hours before advancing the borehole through the outer casing. When advancing through the seal, take care to avoid cracking, shattering, or washing away the outer casing seal.

The pumping method and the immersion method are the two most commonly used casing installation techniques.

### *Pumping Method*

1. Drill a borehole.
2. Insert the casing into the borehole.
3. Insert the grout pumping tube and inflatable packer assembly into the casing.
4. Inflate the packer assembly (with the grout pumping tube extended through the center of the packer assembly).
5. Pump grout through the packer assembly until grout return is seen at ground surface. The grout will return to ground surface from around the outside of the casing (contain fluids if required for future disposal).
6. Tap the casing into the confining layer or bedrock.
7. Deflate and remove the packer assembly from the casing.

A typical casing installation using the pumping method is presented on Figure 6.4.

### *Immersion Method*

1. Drill a borehole.
2. Fill the borehole with grout.
3. Install casing that has the bottom end plugged with grout (previously placed and set) into the borehole.
4. To aid installation, water may be added to inside of casing to overcome buoyancy.
5. Tap the casing into the confining layer or bedrock.

A casing installation using the immersion method is presented on Figure 6.5.

### 6.11.3 Bedrock Wells

Bedrock well installations may be accomplished using two methods.

***Method 1***

1. Advance a pilot borehole through the overburden and into upper bedrock.
2. Install an outer casing into the borehole and grout in place using the grouting methods described in Section 6.10.6.

After the grout has properly set, further borehole advancement can occur through the grout seal into the underlying bedrock. Bedrock is typically advanced using rock coring techniques. Bedrock coring makes a smooth, round hole through the seal and into the underlying bedrock minimizing the possibilities of shattering or cracking the outer surface casing seal. Roller cone bits are also commonly used in soft bedrock formations. However, this method can produce excessive water and pressures that may cause the seal to crack, shatter, or wash away. Coring is preferred because it provides a continuous bedrock core. The bedrock cores can be logged for lithology, structure, and fracture presence and orientation. Bedrock cores can be kept at the site for geologic record. When drilling is completed to the required depth, the finished well consists of an open corehole from the bottom of the outer casing to the bottom of the well. There is no inner casing installed with this bedrock installation type. The open rock interval is the desired monitoring interval. The outer casing installed into the upper bedrock can be extended to above ground surface to serve as the protective casing, or typical above-grade or flush-mount protective casings can be installed. If the outer casing becomes cracked or is broken off, the well is open to contamination from the ground surface. If this occurs, the well must be immediately repaired or abandoned. It may be desirable to install a protective casing over the outer casing as an extra precaution.

For wells installed to monitor bedrock units below the uppermost layers or below a suspected confining unit in the bedrock, a second casing is installed to the top of the desired monitored interval. The borehole is then extended through the seal and second casing into the bedrock interval selected for monitoring.

***Method 2***

1. Install an outer casing and advance the borehole into the bedrock.
2. Install an inner casing and well screen to the selected monitoring interval in the bedrock.
3. Place a filter pack around and above the well screen.
4. Place a minimum 2-foot (0.6 m) thick bentonite seal over the filter pack.
5. Seal the remaining annular space with grout placed using a tremie line and positive displacement methods.

This installation method enables isolation of the bedrock monitoring interval. This method is also used in cases of poor bedrock quality, where the corehole continually collapses.

Typical bedrock well installation details are shown on Figure 6.2. Typical protective casing installations are shown on Figure 6.3.

## 6.12 Well Installation Documentation

Details of each overburden well installation are recorded on a Stratigraphy Log (Overburden) (Form SP-14) and also in the field book. Well installation details, comprised of the following, are recorded on a Well Instrumentation Log (Form SP-15):

1. Drilling method
2. Borehole diameter
3. Borehole depth
4. Well screen length
5. Well screen depth
6. Well screen and riser diameter
7. Outer casing diameter if present
8. Filter pack interval
9. Filter pack material
10. Seal/plug interval
11. Seal material
12. Grout interval
13. Grout material
14. Stickup/flush-mount detail
15. Surface seal detail
16. Protective type detail
17. Date installed

Overburden stratigraphic details are recorded in detail, in accordance with the soil classification methods detailed in Section 5.0, on a Stratigraphic Log (Overburden) (Form SP-14). Bedrock lithology and descriptions are recorded on a Bedrock Coring and Drilling Stratigraphic Log (Form SP-16).

Details of a bedrock well installation are typically recorded and sketched in a GHD standard field book. A Bedrock Coring and Drilling Stratigraphic Log (Form SP-16) are used to log lithology and structure for bedrock cores and bedrock boreholes.

The field book records and sketches of bedrock well installations must include:

1. Corehole diameter
2. Corehole depth
3. Overburden depth
4. Outer casing depth

5. Grout depths

6. Grout material

7. Surface cap details

8. Date of installation

Each well must be marked in at least two locations to identify the well designation for future reference.

> Note: Field tie-ins must be completed to accurately identify each well location upon completion of installation. These will ensure that the wells are properly identified on plans and for future identification in the field.

## 6.13 Well Installation Follow-up Activities

Upon completion of monitoring well installation activities:

1. Submit all stratigraphic and instrumentation logs to GHD's hydrogeology department for input of data and generation of final stratigraphic and instrumentation logs.
2. Plot well locations on site plan, since well locations may have changed in the field due to underground/overhead utilities or field conditions.
3. Arrange for a surveyor to obtain horizontal and vertical control for well locations.
4. Tabulate well construction details.
5. Measure groundwater levels in accordance with Section 8.0 to confirm hydraulic stabilization and groundwater flow direction.
6. Prepare a summary report describing the field activities including, but not necessarily limited to, drilling method(s), well design and construction details, site geology, and site hydrogeology.
7. File the field book at the appropriate GHD office.

## 6.14 Well Development

Monitoring well development is the process of obtaining hydraulic stabilization of a monitoring well. To ensure hydraulic stabilization of a well, it is recommended to remove five to ten well volumes. The removal of well volumes will aid in achieving a sand-free condition with the lowest possible turbidity.

The most suitable methods of well development are:

1. Waterra™ (surge block)
2. Surge block
3. Pumping/overpumping/backwashing
4. Bailing

5. Airlifting

6. A combination of the above five methods

> Note: Ensure the development method chosen conforms to local, state/provincial, and federal regulations.

### 6.14.1 Waterra™ (Surge Block)

Waterra™ is an inertial foot valve attached to flexible or rigid tubing. For well depths greater than 50 feet (15 m) rigid tubing is used. The inertia pump may be pumped by hand or with a power pump. As the inertia pump is moved up and down in the well, water is lifted to the surface. Surge blocks can be attached to the inertia pump so that surging and purging is performed simultaneously.

This development method is cost effective and works well for shallow and small diameter wells. However, this method can be labor intensive.

### 6.14.2 Surge Block

When used effectively, surge blocks can destroy the bridging of fine-grained particles from the formation. Surging creates the agitation necessary in the proper development of a well. A surge block is generally used alternately with either bailing or pumping so that purging removes all agitated and loosened particulate in the well. The surge block assembly must be of sufficient weight to freefall through the water column and create a vigorous outward surge. Surging begins at the top of the screen so that sand or silt loosened by the initial surging action will not cascade down on the surge block and "lock" or "bind" the surge block in the well. Surging is initially gentle, and the energy of the action is increased throughout the development process. Surging and pumping continue until the water is free of suspended particulate in the purge water.

### 6.14.3 Pumping/Overpumping/Backwashing

The least expensive and most commonly used well development technique is pumping.

Overpumping causes an increase in the flow velocity of water through the well screen. This creates a rapid and effective migration of particulate toward and through the well screen.

With no backflow prevention valve (check valve) installed on a pump, the pump can be alternately started and stopped. This backwashing creates a surging action in the well and generally loosens the bridging of fine particles in the formation. Backwashing must only be used with dedicated pumps and hoses or pumps that have been thoroughly decontaminated between well locations. Pumps commonly used for well development include BK pump, submersible pumps, and jet pumps.

> Note: Particulate wears out submersible pumps. A 2-inch (5.0 cm) Grundfos™ pump should not be used for well development.

All of the above techniques are designed to remove the drilling effects from the monitored interval and restore the formation to its previous condition. The above techniques avoid the introduction of fluids, including air, into the monitored interval during development. This minimizes adverse effects on the water quality and restricts available development options.

#### 6.14.4 Bailing

In a relatively clean permeable formation, bailing is an effective development technique. The bailer is allowed to freefall down the well until it strikes the water surface. That contact creates a strong outward surge of water through the screen into the formation. This action tends to break bridging that has occurred in the formation from the borehole advancement process. As the bailer fills and is rapidly removed from the water column, particulate matter outside the well intake flows through the well screen. Subsequent bailing will remove all accumulated particulate from inside the well. Bailing is continued until the water is free from suspended particulate matter.

#### 6.14.5 Airlifting

Airlifting is an effective development technique that is generally used in larger diameter wells. Airlifting is commonly performed using the drill rig that advanced the borehole. Air is injected through small diameter drill rods or pipe to the bottom of the well. The air loosens particulate from the formation and is carried with the water into the well. The particulate is then extracted along with water to the ground surface. Airlifting provides good development for the sand pack and formation. It is an excellent well rehabilitation tool. This development method can produce large volumes of water which can create some difficulties for containment.

### 6.15 Well Development Documentation

A well is developed after installation to ensure hydraulic stabilization.

Details of well development are recorded on a Well Development, Purging, and Sampling Form (SP-06) or in a standard GHD field book, and must include:

1. Well identification number
2. Date of development
3. Development method
4. Well type including diameter and construction
5. Measuring point location and elevation (if known)
6. Measured water level
7. Measured bottom depth
8. Water column length
9. Screened interval
10. Well volume
11. Volumes purged
12. All field measurements

## 6.16 Follow-up Activities

Once well construction and development is completed:

1. Submit and complete stratigraphic logs.
2. Tabulate well installation and development details.
3. Summarize the development activities including development method, development duration, volumes removed, and field parameters.
4. File the field stratigraphic log forms and field book at the appropriate GHD office.
5. Document the water level in the well.
6. Arrange for surveys of wells for horizontal and vertical control.

## 6.17 References

Numerous publications are available describing current monitoring well design and construction procedures. Four excellent references are:


1. Driscoll, F.G., 1986. Groundwater and Wells, 2nd Edition. Johnson Division.
2. Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice Hall, Inc.
3. ASTM D5092. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifer.
4. Nielsen, David M., 1991. Practical Handbook of Ground-Water Monitoring


In addition, the following ASTM publications apply:


| | |
|---|---|
| ASTM D5474 | Guide for Selection of Data Elements for Ground-Water Investigations |
| ASTM D5787 | Practice for Monitoring Well Protection |
| ASTM D5521 | Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers |
| ASTM D5978 | Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells |
| ASTM D5299 | Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes and Other Devices for Environmental Activities |

# GHD Field Training Manual

Section 7.0
Water Sampling Standard Operating Procedures

A. Groundwater
B. Residential
C. Surface Water

(T104)

July 2015

# Please Adhere to the Following Quality System Training Requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.
- Please note that three topics are discussed in this SOP. A separate QSF-021 is required for each topic:
  - Groundwater Sampling
  - Residential Water Sampling
  - Surface Water Sampling

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# Quality System Forms Index

# 7. Water Sampling (Groundwater, Residential, and Surface Water) Standard Operating Procedures

## 7.1 Introduction

Groundwater, residential, and surface water sampling are conducted in order to characterize the groundwater and surface water quality at a site. Standard Operating Procedures (SOPs) are presented herein for the collection of groundwater and surface water samples from:

- Monitoring wells
- Residential wells
- Surface water bodies

This guideline is not intended to provide the basis for designing a groundwater or surface water monitoring program, but instead assumes that a groundwater and/or surface water monitoring program has already been designed. It is also assumed that a site-specific Work Plan has been established and that a GHD representative is preparing to mobilize to the site.

Groundwater and surface water sampling procedures vary from project to project due to:

- Different chemicals of concern.
- Different guidance provided by local, provincial/state, and/or federal regulatory agencies with jurisdiction at the site.
- The specific objectives of the project.

It is essential that all groundwater, residential, and surface water sampling activities conform to local, state/provincial, and federal regulations. Therefore, it is essential that the GHD representative carefully reviews the Work Plan requirements. The primary goal of groundwater, residential, and surface water sampling is the collection of samples representative of the hydrostratigraphic unit and/or surface water body. It is necessary to use appropriate sampling techniques to collect representative samples that provide reliable and reproducible results in accordance with the Work Plan and all relevant regulations.

The remainder of this section is organized as follows:

- Section 7.2 Background
- Section 7.3 Planning and Preparation
- Section 7.4 Safety and Health
- Section 7.5 Quality Assurance/Quality Control
- Section 7.6 Equipment Decontamination
- Section 7.7 Field Procedures for Groundwater Sampling

- Section 7.8 Field Procedures for Residential Sampling
- Section 7.9 Field Procedures for Surface Water Sampling
- Section 7.10 Follow-Up Activities
- Section 7.11 References

## 7.2 Background

The objective of a groundwater and residential monitoring program is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of groundwater in the hydrostratigraphic unit. Surface water sampling is performed to collect samples that are representative of physical and chemical properties of surface water bodies. Improper sampling and transport practices will cause compounds of interest to be removed or added to a sample prior to analysis. The importance of proper and consistent field sampling methods cannot be over emphasized. It is equally important that proper documentation occurs throughout the sampling program.

The most important aspect of groundwater sampling is the collection of groundwater samples that are free of suspended silt, sediment, or other fine-grained material. Fine-grained material has a variety of chemical compounds sorbed to the particles or has the ability to sorb chemicals from the aqueous phase. This causes a bias in the subsequent analytical results. Reproducible and reliable analytical data are invaluable to a groundwater monitoring program. GHD frequently criticizes the sampling activities completed by others due to the collection and analyses of turbid samples. This SOP discusses sampling protocols that typically achieve sediment-free samples.

When sampling for monitored natural attenuation (MNA) parameters, more stringent protocols are followed to ensure sediment-free samples that are representative of the total mobile load (i.e., dissolved and naturally suspended particles). Low-flow purging (LFP) techniques are strongly recommended, if not mandated, when collecting groundwater samples for MNA parameters. The LFP techniques detailed in Section 7.7.5.3 are in accordance with United States Environmental Protection Agency (USEPA) LFP procedures (Puls and Barcelona, 1996).

Groundwater sampling is required for various reasons, including:

- Investigating potable or industrial water supplies
- Tracking contaminant plumes
- Investigating a site with suspected groundwater contamination

Groundwater is usually sampled from in-place wells, installed either temporarily or permanently. Municipal, industrial, or residential wells may also be sampled during an investigation. When completing residential well sampling it is important that representative samples are collected. Poor or incorrect sampling techniques will result in erroneous results. Incorrect results disclosed to the public will create a false impression, making it difficult to change the perception when correct results are reported.

Groundwater and residential sample collection are performed from non-impacted to most impacted locations. This eliminates the potential for cross-contamination. A review of all historical analytical data is performed to ensure the exact sampling sequence.

Surface water sampling locations are selected based on many factors including:

- The study objectives
- The location of point source discharges
- The location of no-point source discharges and tributaries
- The presence of structures (e.g., bridges, dams)
- Accessibility

Surface water sampling should be performed from downstream to upstream locations. This ensures that surface water sampling activities do not cause suspended sediments to bias samples collected downstream.

## 7.3 Planning and Preparation

Prior to groundwater, residential, and surface water sampling:

1. Review the Work Plan, project documents, and Site-Specific Health and Safety Plan (HASP) with the Project Manager/Coordinator.
2. Review the Quality Assurance Project Plan (QAPP) with the Project Coordinator and Project Chemist to determine Quality Assurance/Quality Control (QA/QC) and decontamination requirements.
3. Complete a Field Equipment Requisition Form (QSF-014). Assemble all sampling equipment and supplies required per the Groundwater Sampling Equipment and Supply Checklist (Form SP-05). The Project Planning, Completion, and Follow-Up Checklist (Form SP-02) should be used for guidance throughout the project.
4. Assemble the site plan, well logs, and previous sampling/purging data required for the sampling event. Determine the exact number and locations of wells to be sampled.
5. Obtain all forms to record purging and sampling activities (Forms SP-06, SP-08, and SP-09).
6. Confirm with the Project Manager/Coordinator that a Property Access/Utility Clearance Data Sheet (QSF-019) has been completed. For residential sampling, ensure that homeowners have been notified of the intended sampling event. Confirm the presence of any dogs on site, modify the site-specific Job Safety Analysis, if there is a dog.
7. Arrange access to the site. Obtain all well and site keys. Consider site access conditions (e.g., snow).
8. For surface water sampling consider if hazards exist due to deep/fast moving water, difficult access, and if additional GHD personnel are required for safety and health reasons.

9. For residential sampling contact homeowners to make arrangements for a site visit, arrange for site dog to be removed from all areas where a GHD employee will be working. The client of another party may be responsible for making arrangements.

10. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).

11. Contact the GHD Chemistry group to arrange:
    - SSOW (Simplified Scope of Work)
    - Laboratory
    - Sample containers delivery
    - Preservatives if required
    - Filtration information if required
    - Coolers
    - Shipping details
    - Sample starting date
    - Expected duration of sampling program

12. If several sampling events are planned, evaluate with the client the benefit of purchasing and installing dedicated sampling equipment. Dedicated purging and sampling equipment reduces potential cross-contamination and reduces decontamination requirements. At a minimum, sample tubing is dedicated to each well and is left secured in the well for future use. For LFP it is recommended that each well is dedicated with a bladder pump and tubing to eliminate well disturbance.

13. Evaluate sample notification needs with the Project Coordinator. Have the regulatory groups, client, landowner, GHD personnel, and laboratory been notified of the sampling activities?

14. Evaluate containment and disposal requirements for purge waters.

15. Plan sampling activities to ensure that wells that historically go dry or have poor recharge fit into the sampling program. This will reduce the time required for sample collection.

16. Plan the sequence of sampling activities to reduce the potential for cross-contamination. For groundwater sampling, start with clean wells and progress to impacted wells. For surface water sampling, start downstream and progress upstream.

## 7.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule implications.

Field personnel are required to implement the Safety Means Responsibility Awareness Teamwork (SMART) program as follows:

- Assure the HASP is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions, and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently, and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all involving injury/illness, property damage, vehicle incident, and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the Client's) safety requirements.

## 7.5 Quality Assurance/Quality Control

A well-designed QA/QC program will:

- Ensure that data of sufficient quality are obtained, for proper site management decisions or remediation design.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

It is important to note that a QA/QC program should be developed on a site-specific basis. QA/QC requirements are discussed in Section 3.9.

## 7.6 Equipment Decontamination

Equipment decontamination procedures for a groundwater, residential, or surface water monitoring program will be described in detail in the site-specific Work Plan or in the QAPP.

Equipment is decontaminated between sampling locations and prior to leaving the site. Upon completion of the sampling program, all equipment is decontaminated at the site and then returned clean to the appropriate field equipment manager.

For most groundwater, residential, and surface water sampling programs, sampling equipment (e.g., pumps, bailers, water level indicators) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

If required, the following steps may be added when sampling for Volatile Organic Compounds (VOCs) and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap samplers in aluminum foil to prevent contamination.

| | |
|---|---|
| Caution: | Check the QAPP to confirm the cleaning protocol. Use of incorrect cleaning protocol could invalidate chemical data. |

### 7.6.1 Purge Water and Decontamination Fluid Disposal

Project-specific disposal methods for purged groundwater and decontamination fluids are determined by the Project Manager during the sampling program's planning and preparation stage (see Section 7.3), but may include:

1. Off-site treatment at private treatment/disposal facility or publicly owned treatment facilities (sanitary sewer).
2. On-site treatment at a client-operated facility.
3. Direct discharge to the surrounding ground surface, allowing infiltration to the underlying subsurface.
4. Direct discharge to an impervious pavement surface allowing for evaporation.

Options 3 and 4 are permitted only after careful review of these practices and the anticipated site conditions. Under no circumstances shall GHD personnel aggravate an existing condition or spread contamination into clean areas.

Decontamination fluids (specifically cleaning solvents/acids) are segregated and collected separately from wash water and purge water. Often small volumes of solvents used during the course of a groundwater, residential, or surface water sampling program will evaporate if left in an open pail. If evaporation is not possible, off-site disposal need to be arranged.

## 7.7 Field Procedures for Groundwater Sampling

The typical series of events that takes place for a groundwater sampling program is:

1. Well identification and inspection
2. Air monitoring
3. Water level monitoring
4. Well depth sounding
5. Well volume calculation
6. Purging and sampling equipment installation
7. Well purging and stabilization monitoring
8. Sample collection, sample preparation, completion of chain-of-custody, (COC) sample packaging
9. Final water level monitoring (if required), purging, sampling equipment removal, secure the well
10. Equipment decontamination
11. Field note completion and review
12. Sample shipment and COC distribution
13. Purged groundwater and decontamination fluid disposal
14. Sample record documentation, equipment return
15. Completion and distribution of appropriate forms

It is recommended that new plastic sheeting be placed on the ground around the well to prevent contamination of purging and sampling equipment and accessories (e.g., pumps, hoses, rope.).

### 7.7.1 Well Identification and Inspection

At sites with numerous wells or wells nests, misidentification of wells has occurred. The GHD representative must be alert to the possibility of potential cap switching, mislabeled wells, or unlabeled well locations.

Determine proper well location and identification by comparing the well log details to the measured well depths (i.e., total well depth, casing diameter, casing stick-up, or stick-down distances), field tie-ins, and site plan.

Once well identification has been established, complete a thorough well inspection:

1. Determine if the well cap and lock are secure, and check for vandalism.
2. If no lock is present, dedicate a new lock to the well location.
3. Examine the integrity of the surface seal.
4. Check for cracks, evidence of frost heave, or subsidence in the vicinity of the well.
5. Examine the integrity of the protective casing. Ensure that the casing can be closed and locked.
6. If required, re-label the well to assist in future identification.
7. If the well is installed with dedicated sampling equipment, check for cracks or leaks in tubing, and worn or frayed rope.
8. Record all the well inspection details in the field book to document well conditions and suitability for groundwater sampling activities.
9. Forward the well inspection results to the Project Coordinator, especially if repairs are required.

### 7.7.2 Air Monitoring

Prior to removing a well cap, measure the breathing space above the well with a photoionization detector (PID) to establish background of undifferentiated organic vapor levels. Repeat this process once the well cap has been removed. If either of the PID levels exceed the air quality criteria established in the HASP, air-purifying respiratory (APR) protection or a supplied air system is required. Also take a PID reading inside the riser pipe. This PID reading is a good indication of elevated chemical or non-aqueous phase liquids (NAPL) presence. Report all elevated PID levels to the Project Coordinator immediately to determine if additional health and safety and personnel protective equipment is required. The HASP will provide the required action levels and PPE.

### 7.7.3 Water Level Monitoring/Well Depth Sounding

Prior to commencing well purging and groundwater sampling, the water level is measured for hydraulic monitoring and to determine the well volume. Typically, a complete round of water level measurements is taken at a site to establish groundwater conditions prior to initiating well purging or groundwater sampling activities.

A watertight cap provides an airtight seal on the casing and the water level positioned in the casing area. The cap creates a vacuum or pressurized condition in the casing section which can support or depress the water column in the well casing. This can produce an artificially high or low water level in the well casing. This effect can cause a few inches or feet of error in the static water level. Once the cap is removed, allow the pressure to stabilize for about a half hour. Measure the water level frequently to ensure that stabilization of the water level has occurred. Once the water level has stabilized (i.e., is static) the correct water level may be measured.

A number of instruments are available to measure groundwater levels. GHD typically uses:

- Battery-operated water level indicators (i.e., audible and/or visual identification of water level)
- Battery-operated oil/water interface probes (i.e., audible and/or visual identification of water levels and presence of NAPL)
- Electronic transducers (numerous manufacturers) and recording devices for long-term hydraulic monitoring
- Stevens™ recorders (both float and electronic instrumentation) for long-term hydraulic monitoring

Section 8.0 describes in detail the equipment and monitoring techniques for water level measurements.

Well depth sounding is often required to confirm well identification, evaluate the accumulation of sediment in the well bottom, or assist in determining the standing well volume. Sounding is performed using a water level indicator or a measuring tape with a weighted end. The water level indicator or weighted tape is lowered to the bottom of the well and a comparison is made of the installed well depth versus the measured well depth. The presence of excessive sediment or drill cuttings may warrant redevelopment of the well prior to well purging and groundwater sampling activities.

The total well depth is compared to the original installed total well depth. If the well screen is more than 50 percent blocked by accumulated sediment, the well is redeveloped prior to the next groundwater sampling event. Report all wells requiring redevelopment to the Project Coordinator. Well depth sounding is performed on an annual or biannual basis if the well is equipped with a dedicated pump.

For LFP, well depth measurement is performed to ensure proper pump intake placement. The used of a wide-based probe, such as a weighted tape, is necessary to minimize penetration and disturbance of accumulated sediment. The measuring device is lowered slowly through the water column to the well bottom to minimize mixing of the stagnant well casing water and disturbance of sediment.

Note: Don't forget that decontamination procedures apply to the water level monitoring equipment as well as the groundwater sampling equipment. If well sounding is performed, the entire measuring device must be thoroughly decontaminated prior to re-use. Measuring the well depth with certain water level indicators may damage the probe seal. Therefore, a tape with a weighted end should be used to measure well depth.

### 7.7.4 Well Volume Calculation

Prior to commencing well purging, the volume of water in the well must be known to determine the volume of groundwater to be removed. A well volume is defined as the volume of water contained in the well screen and casing (and in the case of an open bedrock hole, the volume of water in the open corehole and possibly in the well casing). To determine the standing water volume in a well:

1. Calculate the distance from the bottom of the well to the static water level.

2. Measure the inside diameter of the well or casing. Obtain the volume of standing water in the well using the following formula:

   V = $\pi r^2 h$ (7.48 U.S. gallons/cubic feet) (1 liter/1,000 cubic centimeters)

   Where:

   V = volume of water in gallons or liters

   $\pi$ = 3.142

   r = radius of well casing (feet or meters)

   h = depth of water column in the well (feet or meters)

| Typical 1 - Foot Casing Volumes | |
|---|---|
| Diameter (inches) | Gallons (U.S.) of Water Per Foot of Casing |
| 1.5 | 0.09 |
| 2 | 0.16 |
| 3 | 0.37 |
| 4 | 0.65 |
| 6 | 1.47 |

| Typical 1 Meter Casing Volumes | | |
|---|---|---|
| Diameter | | Litres per Meter of Casing |
| (inches) | 6 (cm) | |
| 1.5 | 3 | 1.14 |
| 2 | 5 | 2.02 |
| 3 | 8 | 4.56 |
| 4 | 10 | 8.11 |
| 6 | 15 | 18.24 |

### 7.7.5 Well Purging and Stabilization Monitoring

#### 7.7.5.1 Typical Method

Prior to initiating groundwater sample collection, the wells is purged of the standing stagnant groundwater volume. This volume is not representative of the groundwater in the hydrostratigraphic unit. Purging is performed until the water in the well is representative of the actual conditions in the hydrostratigraphic unit. Stabilization is usually achieved by the removal of three to five times the volume of standing water in the well (USEPA convention). Purging is considered complete once purged groundwater is free of sediment and field parameters including specific conductance, temperature, and turbidity are stable. Stabilization is achieved when field measurements for specific conductance and temperature are within a range of plus or minus 10 percent of the average for the last three readings. Field measurement for pH should be within a range of plus or minus 0.1 pH unit of the average for the last three readings, and groundwater turbidity values should be less than 5 nephelometric turbidity units (NTU) (guidance value only). Once the number of well volumes required to achieve stabilization is established, the volume required to reach stabilization for future sampling events is reduced or eliminated. Extended purging of a well will generally result in achieving sediment-free groundwater conditions.

During purging, if stabilization has not occurred after removal of five well volumes, purging is continued until ten well volumes have been removed. If stabilization still has not been achieved, stabilization may be dropped as a pre-condition to groundwater sampling. The Project Coordinator should be notified that stabilization has not occurred after the removal of ten well volumes.

At high yielding wells, removing three to five well volumes is usually sufficient prior to initiating groundwater sampling. For low yield wells (i.e., wells that pump dry after one well volume) it is necessary to purge the well dry on three successive days, unless the well recovers to full static conditions in a shorter time. If the recharge is relatively high, groundwater sampling will be initiated once the well has fully recovered to static groundwater conditions, or to a level that is sufficient to collect the necessary groundwater sample volume.

Note: Purging of dry wells should be scheduled to begin on Monday or Tuesday, to reduce weekend requirements.

Turbidity of purged groundwater is evaluated by a visual examination for sediment/silt presence or by using a nephelometer which physically measures groundwater turbidity in NTUs. Generally, a turbidity value of 50 NTU or less is acceptable, although some regulatory agencies have established lower criteria (i.e., less than 5 NTU). If 50 NTU is not achieved, filtration of samples may be required. LFP can generally result in turbidity values less than 5 NTU.

Note: Agitation of the water column within the well will increase turbidity. Therefore, bailers and inertia pumps (Waterra™) are of limited use for collecting sediment-free samples. The tubing of peristaltic pumps must be secured to prevent movement of the tubing within the water column which would disturb sediment. The best method to reduce sediment disturbance is low-volume non-agitation pumping (i.e., bladder pump).

Well purging is accomplished using dedicated equipment or by using either peristaltic, bladder, or other approved purging methods. Purging and sampling equipment are dependent on the total well depth. Bailing can be used for well purging but this method stirs up sediment and increases the purging effort required before stabilization is achieved. Equipment available for well purging is discussed in Section 7.7.7. Monitoring equipment used during well purging includes a water level indicator, pH meter, thermometer, conductivity meter, and turbidity meter.

#### 7.7.5.2 Purging Entire Water Column

The purging equipment is lowered into the top of the standing water column. Well purging is completed from as close to the top of the water column as possible, not from the well bottom, unless poor well recovery occurs. Purging from the top of the water column moves water from the formation through the well screen of the well and into the well casing. This allows for the entire static volume to be removed. Purging at depth in the water column does not remove water above the pump intake and results in the collection of unrepresentative samples.

If required, the pump intake can be adjusted. If the recovery rate is greater than the pumping rate, the pump should remain suspended until the required purged volume has been removed. If the recovery rate is less than the pumping rate, the pump should be lowered to ensure the removal of the required well volume.

#### 7.7.5.3 Low-Flow Purging (LFP) Technique

LFP purging results in minimal drawdown during well purging, so less purging is required before formation water is removed. The volume required for purging using LFP is significantly reduced. LFP results in less agitation and mobilization of sediments compared to traditional sampling techniques.

A pre-cleaned stainless steel bladder pump equipped with a Teflon™ bladder is strongly recommended for LFP. The discharge line should be polyethylene or Teflon™ lined tubing with an inside diameter of 1/4 or 3/8 inch (6 or 10 mm). Check the Work Plan or QAPP to ascertain the proper bladder and discharge tubing. Smaller discharge tubing ensures that the tubing remains filled with water and reduces air bubbles at low purging rates. The airline to the pump is generally 1/4-inch (6 mm) inside diameter polyethylene tubing. The pump is secured to nylon rope and positioned in the well so that the pump intake is set at the mid-point of the well screen, or a minimum of 2 feet (0.6 m) above the bottom of the well or accumulated sediment level. It is important that the rope, airline, and discharge tubing are measured prior to installation in the well. The bladder pump and tubing are lowered very slowly through the water column to minimize mixing of the stagnant well casing water and to minimize the agitation of sediment into suspension, which would increase the purging time. It is recommended, and in some instances regulated, that pump installation occurs at least 24 hours prior to initiating LFP. It is recommended that a bladder pump be dedicated to the well for regular monitoring events.

During LFP, the pumping rate should be between 100 and 500 milliliters per minute (mL/min). It is recommended that initial pumping be conducted at a lower rate to limit drawdown in the well. During purging, groundwater levels are measured to maintain a maximum 0.4 foot (0.1 m) of drawdown. The pumping rate can be gradually increased during LFP. Pumping rate increases will be dependent on the drawdown and the stabilization of field parameters discussed below. Pumping rate adjustments should occur in the first 15 minutes of purging. After this time the pumping rate should remain constant and flow rate adjustments should be avoided. During purging, the pumping rate and groundwater level should be measured at least every 10 minutes. It is recommended that water level measurements occur at 5-minute intervals.

During LFP, stabilization of the purged groundwater is required to ensure the collection of representative groundwater samples from the formation and not from the stagnant water in the well casing. Field parameters including pH, temperature, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity should monitored during LFP. The measurement of these field parameters is used to evaluate if stabilization of the purged groundwater has occurred prior to the collection of groundwater samples. The field measurements should be measured and recorded at 5-minute intervals. Groundwater stabilization is considered achieved when three consecutive readings for each of the field parameters, taken at 5-minute intervals, are within the following limits:

| | |
|---|---|
| pH | ±0.1 pH units of the average value of the three readings |
| Temperature | ±3 percent of the average value of the three readings |
| Conductivity | ±0.005 milliSiemen per centimeter (mS/cm) of the average value of the three readings for conductivity <1 mS/cm and ±0.01 mS/cm of the average value of the three readings for conductivity >1 mS/cm |
| ORP | ±10 millivolts (mV) of the average value of the three readings |
| DO | ±10 percent of the average value of the three readings |
| Turbidity | ±10 percent of the average value of the three readings, or a final value of less than 5 NTU |

During LFP, field parameters are measured using a flow-through cell apparatus. At the start of LFP the purge water is visually inspected for clarity prior to connecting to the flow-through cell. If the purge water is turbid, LFP continues until the purge water is visually less turbid prior to connecting to the flow-through cell. Field parameters may be obtained using individual meters or a multiple meter unit; however, the use of a flow-through cell is highly recommended. All meters must be calibrated daily in accordance with the manufacturer's and GHD's calibration instructions, and a calibration record maintained in a standard GHD field book.

During LFP the meter readings are monitored for evidence of meter malfunction. The following are common indicators of meter malfunctions:

- DO above solubility (e.g., oxygen solubility is approximately 11 milligrams per liter (mg/L) at 10°C) may indicate a DO meter malfunction.
- Negative ORP and DO less than 1 to 2 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have positive ORP and DO less than 1 to 2 mg/L under oxidizing conditions).
- Positive ORP and DO less than 1 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have a negative ORP and DO less than 1 mg/L under reducing conditions).

Meter calibration fluids should be available for meter recalibration in the field. Spare meters should also be available for meter replacement if necessary.

Note: DO levels exceeding the solubility of oxygen in water are erroneous and are indicative of meter malfunction or poor sampling techniques causing turbulence and aeration. DO concentrations cannot exceed:

9 mg/L at 20°C    10 mg/L at 15°C    11 mg/L at 10°C    14 mg/L at 1°C

Stabilization will be considered complete when the field parameters have stabilized as indicated in the above table. Purging will continue if stabilization does not occur, until a maximum of 20 screen volumes has been removed. LFP causes groundwater to be drawn from a significant distance above or below the pump intake. Therefore, the screen volume is based on a 5-foot (1.5 m) screen length. After the removal of 20 screen volumes, purging will continue if the purged water remains visually turbid and appears to be clearing. Also purging will continue if the field parameters vary only slightly outside of the stabilization criteria and appear to be approaching stabilization.

If the recharge to the well is insufficient to conduct LFP, the well should be pumped dry and allowed to recharge sufficiently for the collection of the groundwater sample volume. Wells purged dry are required to meet the stabilization criteria detailed above.

#### 7.7.5.4 Sampling Techniques

Upon completion of purging, with groundwater stabilization and clarity meeting the applicable protocol described above, groundwater sample collection can proceed. Generally the field parameters of pH, temperature, and specific conductance are monitored first, then any other required field measurements.

Samples are collected directly from the purging pump, when possible, or an alternate device (i.e., pump or bailer) may be installed or used. If new sampling equipment is installed, the first few bails or discharge volumes should be discarded to allow acclimation of the sampling equipment with the groundwater.

Samples are typically collected from the pump or bailer with the discharged groundwater collected directly in the appropriate sample containers. The interior of the bottle or cap must not be touched or handled in anyway. New gloves (i.e., disposable nitrile gloves or equivalent) should be worn for the collection of each sample. Caps from sample bottles must not be placed on the ground or in pockets to eliminate the possibility of cross-contamination.

Descriptions of the various equipment and sampling methods for the collection of groundwater samples are contained in Section 7.7.7.

The following describes the main activities involved in the collection of groundwater samples.

#### 7.7.5.5 Order of Sample Collection

Groundwater samples are collected and containerized in the order following volatilization sensitivity:

1. VOCs
2. Semi-volatile organic compounds (SVOCs)
3. Total organic carbon
4. Total organic halides
5. Extractable organics
6. Total metals
7. Dissolved metals
8. Phenols
9. Cyanide
10. Sulfate and chloride

11. Nitrate and ammonia
12. Microbiological parameters
13. Radionuclides

QA/QC requirements for groundwater sampling are described in detail in Section 3.9.

#### 7.7.6 Sample Acquisition and Transfer

If groundwater sample collection is performed using a pump, the flow rate must not exceed 100 mL/min during the collection of groundwater samples for VOCs. The low flow rate will reduce the possibility of degassing samples. During the collection of groundwater into the sample container or filtration device, minimize agitation and aeration of the sample. Groundwater samples are transferred directly into the sample container for submittal to the laboratory. Groundwater samples should not be collected in larger containers and subsequently transferred to smaller sample containers; however, on occasion this will be required for filtration or sample composting. During VOC sample collection, samples must not be collected, handled, or containerized near or in the vicinity of a running motor or exhaust which may contaminate the samples.

Groundwater samples for VOCs are collected in laboratory supplied 40 mL glass vials. The vials are filled to the top until a meniscus is formed, then topped with a Teflon™-lined cap. To prevent the loss of volatiles, it is important that no air bubbles or headspace are present in the sample container. Inverting and tapping the vial will check for the presence of air bubbles. If air bubbles are present, the sample should be topped off again and resealed. This process may only be performed a maximum of twice, at which time the sample must be discarded and the sample retaken. If preservatives were present in the bottle from the laboratory, a new sample vial must be used.

> Note: Gas bubbles that appear in VOC containers after sample collection may be a result of degassing or reaction with preservative. If this occurs, note this occurrence on the chain-of-custody. Re-sampling is not required in most cases.

During sample collection ensure groundwater samples are preserved according to laboratory requirements. If required and supplied by the laboratory, preserve the samples in accordance with the QAPP. Some laboratories pre-preserve bottles so that once the groundwater sample is added the preservation is completed. In either case, it is advisable to check sample preservation using litmus paper. Using litmus paper ensures that groundwater sample preservation has been completed to the proper pH as required by the QAPP. If preservation of a sample does not meet the requirements of the QAPP, it may be necessary to add additional preservative, or note on the chain-of-custody that incomplete sample preservation has occurred.

Once sample collection is complete, samples are placed in a cooler on ice to maintain a sample temperature no more than 4°C.

#### 7.7.6.1 Sample Labels/Sample Identification

Label all groundwater samples with the following, written in indelible ink:

1. A unique sample number (see Section 3.9 for guidance)
2. Date and time
3. Parameters to be analyzed
4. Job number
5. Sampler's initial

Secure the label to the bottle. It is recommended that bottle labels be covered with wide clear tape to protect the label during sample packing and shipment. Pack glassware in appropriate packing material to deter breakage during sample packing and shipment. Sample labels can be prepared in advance in GHD offices that have label-generating programs.

An example of a groundwater sample log entry is provided on Figure 3.8.

Section 3.9 details sample labeling requirements for environmental sampling programs. Section 3.9 also details COC requirements and sample shipment requirements.

### 7.7.7 Purging/Sampling Equipment

GHD maintains a wide variety of purging and sampling equipment for well purging and groundwater sample collection. The groundwater sampler should be familiar with purging and sampling equipment and understand equipment limitations and proper use. Some equipment is very useful for well purging (i.e., high flow rates) but is not permissible for LFP or for sampling sensitive parameters (e.g., VOCs cannot be collected with a submersible (turbine) or suction pump). If the groundwater sampler understands the various equipment operation and limitations, the proper selection of purging and sampling equipment is made, which will minimize the purging and sampling duration and maximize productivity.

| | |
|---|---|
| Caution: | Gas powered equipment requires special attention to ensure that staff hauling these units do not cause equipment or sample contamination. Frequent changes of disposable glove as well strict separation of sampling crew tasks (i.e., those handling pumps and hoses do not contact generator or are involved in any refueling activities) are required. |

The following subsections describe the equipment available for groundwater sampling, the equipment use, approximate flow rates, and advantages and disadvantages of the equipment.

#### 7.7.7.1 Peristaltic Pumps

A peristaltic pump is acceptable for purging wells and for most groundwater sample analytes. The groundwater sampler must ensure that a peristaltic pump is acceptable to regulatory agencies with local jurisdiction for VOC and SVOC sample collection. The QAPP will provide sampling requirements.

A peristaltic pump is capable of lifting water from a maximum depth of 25 feet (7.6 m) below ground surface or the pump, whichever is greater. A peristaltic pump is a self-priming, low volume, suction pump which consists of a rotor with ball bearing rollers. Flexible silicon tubing is inserted around or in the pump rotor and squeezed in place by the heads as they revolve in a circular pattern. The section of silicon tubing must not exceed 3 feet (0.9 m) in length. Additional rigid polyethylene or Teflon™ tubing is attached to the flexible tubing and placed in the well. Another piece of rigid tubing is attached to the discharge end of the flexible silicon tubing to facilitate sample collection. The entire length of rigid and flexible silicon tubing is dedicated to the well for future use. The tubing is typically tied and suspended in the well. The flexible or rigid tubing is not reused in other wells because cross-contamination will occur.

> Note: Often a length of tubing is accidentally dropped into a well and can be difficult to retrieve. Retrieval can be accomplished by sending another piece of tubing down the well overlapping the lost section of tubing. Once in place, rotate the tubing, essentially wrapping or corkscrewing the lost tubing and new tubing together. After a number of turns are completed pull the tubing, hopefully with the lost section wound around the new piece. Repeat the procedure until successful.

Liquid is pulled into the tubing by the peristaltic pump through the creation of a vacuum as the rotor head turns. An advantage of using a peristaltic pump is that no pump parts come in direct contact with the sample. A peristaltic pump is capable of providing low flow sampling rates (i.e., typically less than 500 mL/min) with less agitation than other suction pumps. However, it is important that the tubing is secured during pumping to prevent the tubing from moving and causing agitation. A peristaltic pump also allows for regulation of the flow rate by increasing or decreasing the rotor head speed.

Peristaltic pumps are small and easily mobilized to remote sample locations. They require minimal setup, and do not require decontamination between sample locations. The disadvantages of a peristaltic pump are its limited lift and flow capabilities and the limited ability to collect VOC and SVOC samples. If VOC or SVOC sampling, check the QAPP to see if sampling with a peristaltic pump is allowed. Also check with regulatory agencies with local jurisdiction to see if the use of a peristaltic pump for collection of VOC and SVOC samples is acceptable. If using a peristaltic pump for purging, and the collection of VOCs and SVOC samples with the peristaltic pump is not acceptable, it is common to collect the initial VOC and SVOC analytes with a stainless steel bottom loading bailer. The peristaltic pump can then be used to collect the remaining sample analytes.

Peristaltic pumps are becoming more popular for LFP. However, it should be noted that a peristaltic pump may cause degassing, pH modification, and possible VOC loss.

#### 7.7.7.2 Suction Pumps

A number of suction pumps (e.g., centrifugal) exist that can be used for purging applications only. A suction pump draws water through a suction line by creating a vacuum in the suction line or hose. Once drawn into the pump, the groundwater comes into direct contact with the pump rotor/pumping chamber area and it is therefore undesirable for groundwater sampling due to high groundwater agitation. Decontamination of suction pumps is extremely difficult. As with peristaltic pumps, most suction pumps have a limited lift capability of about 25 feet (7.6 m). Larger suction pumps, like

2-inch (5 cm) trash pumps, can achieve high flow rates under low hydraulic head. Flow rates of 15 to 20 U.S. gallons per minute (USgpm) (57 to 76 liters per minute [L/min]) can be achieved. This high flow rate minimizes purging time. New or dedicated suction line should be used at each well if a suction pump is used for purging.

Large suction pumps are also useful for well development, in conjunction with agitation and surging.

Large suction pumps are not suited for LFP due to degassing, pH modifications, VOC loss, and lack of flow adjustment.

> Caution: The groundwater sampler must prevent the siphoning of purged water from a bulk container back into the well. For example, the following scenario is possible: Joe Sampler has completed purging well 'xyz' and has turned off the 2-inch trash pump. The trash pump discharge line is inserted into a wastewater tank and is submerged below the tank water level. As Joe prepares his glassware and sample pump, the wastewater tank contents are siphoned back into the well. This can result in cross contamination with water from other sites/wells which have been purged either:
>
> - into the tank
> - through the pump
> - through the discharge line
>
> All discharge lines/groundwater purge pumps must be provided with a check valve to prevent this situation.

Drilling rig pumps including Moyno, progressive cavity, bean, and mud pumps can be used for well purging and well development.

Suction pumps are a useful tool for high rate purging and well development. They require no additional equipment other than a suction line and discharge line for each well. They are mobile and easily transported around and between sites. Suction pumps are limited to use in wells with less than 25 feet (7.6 m) of lift, are difficult to decontaminate, and are unsuitable for sample collection. Large suction pumps are not suitable for LFP.

#### 7.7.7.3 Submersible Pumps

A submersible pump generally provides high discharge rates for purging at depths beyond the capabilities of a suction pump. Based on its size, a submersible pump can pump water from substantial depths at very high pumping rates and can provide higher groundwater extraction rates than other methods. At high pumping rates, a submersible pump can cause agitation and aeration. This results in some submersible pumps not being suitable for the collection of groundwater samples for VOC and SVOC analysis.

Adjustable rate submersible pumps, constructed of stainless steel or Teflon™, are suitable and approved for LFP provided low flow rates are maintained.

The submersible pump, including the electrical cable and lowering cable, must be decontaminated between wells in accordance with the Work Plan or QAPP.

A submersible pump installed in bedrock or in a deep well should be attached to rigid piping (i.e., 3/4-inch (1.9 cm) steel) to allow for pulling or pushing of the pump. The pump may need to be pushed or pulled to the appropriate installation depth, past tight spots in the well, and when affixing the electrical cable and lowering the cable/safety line. Even when rigid piping is used, a safety line must be attached to the pump in case the piping becomes unthreaded or the pump connection is lost.

Submersible pumps can provide high flow rates that are useful for deep well or large diameter well purging activities. They tend to be labor intensive because of decontamination problems, power supply, and discharge piping size. Some submersible pumps are not suitable for some sample analytes. Small submersible pumps (i.e., 2-inch (5 cm) Grundfos™) have the proper construction and have adjustable flow rates, making them suitable for LFP.

#### 7.7.7.4 Air Lift Pumps

An air lift pump operates using compressed air or nitrogen. The compressed air or nitrogen comes into direct contact with the groundwater and forces groundwater from the pump chamber through a series of check balls into the discharge line. An air lift pump operates on alternate pump discharge and pump recharge cycles. The pump and recharge cycles are controlled using a control box at ground surface. Air lifting is possible from deep depths with moderate to low flow rates (2 to 3 USgpm [7.6 to 11.5 L/min]) depending on the pump installation depth, static head, discharge tubing diameter, and air supply pressure.

Since the air or nitrogen comes in direct contact with the groundwater, an air lift pump should not be used for the collection of groundwater samples for VOC and SVOC analysis.

An air lift pump is a good tool for deep well purging and development. If an air lift pump is used for purging, an alternate sampling method will be required (e.g., bailers or bladder pump) for the collection of VOC and SVOC groundwater samples.

#### 7.7.7.5 Bladder Pumps

Bladder pumps, as with air lift pumps, are driven by compressed air or nitrogen but the air or nitrogen does not come in contact with the groundwater. The contact between the air or nitrogen and the groundwater is eliminated by the presence of a Teflon™, polyethylene, or natural rubber bladder. The pump operation, as with the air lift pump, is cyclic and is controlled using a control box at ground surface. The control box controls the pump filling and discharge time. Because the air or nitrogen does not come in direct contact with the groundwater, and there is limited groundwater agitation and degassing, a bladder pump is the best sampling equipment for the collection of groundwater samples for VOC and SVOC analysis.

Bladder pump operation is very quiescent, causing little formation and well disturbance. By using a bladder pump, collecting a sediment-free groundwater sample is easily achieved. An adjustable rate bladder pump should be used for LFP. Bladder pumps generally are only able to achieve a maximum pumping rate of 1.5 USgpm (5.7 L/min). It is important to note that flow rates should be reduced in deep well applications.

Well purging and sampling can be performed using a bladder pump. Once sampling is completed, the pump should be disassembled and decontaminated in accordance with the Work Plan or QAPP prior to use in other wells. The sample tubing is generally 1/4- or 3/8-inch (6 or 10 mm) diameter polyethylene or Teflon™ lined polyethylene tubing. The air line is generally 1/4-inch (6 mm) polyethylene tubing. The sample and air line tubing are typically suspended in the well for future use (dedicated). At some sites a complete sampling system (bladder pump, discharge tubing, and air line) is dedicated to each well.

Bladder pumps provide excellent sample quality and are useful in deeper sampling applications. There are no analyte restrictions. Bladder pumps are strongly recommended for LFP applications.

Bladder pumps require additional equipment including control box, compressed air or nitrogen, and tubing. The setup of a bladder pump is quite labor intensive unless a dedicated system is in place. Decontamination of a bladder pump requires pump disassembly and re-assembly. Finally, bladder pumps are not capable of high flow rates, thus purging times tend to be increased slightly.

#### 7.7.7.6 Inertia Pumps

An Inertia pump or Waterra™ pump is a manually operated or mechanically driven pump which uses only a foot valve on the sample/purge tubing. "Jerking" the sample/purge tubing with the attached foot valve removes groundwater from the well. The rapid lifting and lowering action of the tubing imparts an inertia to the water column within the sample/purge tubing. This causes the water column to rise to ground surface and discharge from the end of the sample/purge tubing. The foot valve holds the water column in the tubing during the lifting process and allows groundwater to enter the sample/purge tubing during the lowering, or down stroke.

GHD owns both manual and mechanical gas-powered inertia systems. Flow rates with inertia pumps are variable and are dependent on cycle speed, tubing size, foot valve size, well depth, and depth to groundwater. The inertia pump is a useful method for purging and for collection of most groundwater sample analytes. Acceptability of VOC and SVOC sampling with inertia pumps is gaining approval in selected areas. Prior to using an inertia pump as a sampling device, check the sampling requirements in the QAPP, or obtain approval from the Project Coordinator.

Inertia pumps are useful for the extraction of dense non-aqueous phase liquids (DNAPL). The only equipment that is exposed to the gross contamination is the foot valve and a small section of the sample/purge tubing. On most projects, the foot valve and sample/purge tubing are dedicated to the well.

Inertia pumps tend to cause extensive disturbance to the water column. The vigorous lifting and lowering of the inertia pump tends to make it difficult to collect sediment-free groundwater samples. Therefore, inertia pumps are not suitable for LFP.

#### 7.7.7.7 Bailers

A bailer is a manual sampling device consisting generally of a hollow tube (e.g., Teflon™, PVC, or stainless steel) with a lower check ball that permits water entry and prevents water loss. The bailer is lowered slowly into the well. This allows water to enter the bailer through the bottom, and the weight of the water inside the bailer closes the check ball when the bailer is retrieved from the well.

A rope or cable is affixed to the bailer to allow the lowering and retrieval of the bailer from the well. Bailing tends to be disruptive to the water column and formation. Obtaining sediment-free groundwater samples using a bailer tends to be difficult, if not impossible. VOCs and SVOCs, as well as other analytes can be collected using a bailer, but it is important that these analytes be as sediment-free as possible. The compatibility of the bailer material and groundwater analytes should be reviewed and approved prior to using a bailer for the collection of groundwater samples. Generally, Teflon™ bailers are acceptable for the collection of most analytes.

Power winches with overhead tripods are available to assist in purging and sampling deep or large volume wells.

Flow rates attained using a bailer is a function of the bailer size and retrieval frequency. Retrieval frequency is dependent on well depth, water depth, and well recharge rate. Bailing is not practical for deep wells or for the removal of large well volumes.

A bailer is a useful tool for well development as the surging action from the bailer insertion and removal from the well promotes sediment suspension and subsequent removal. However, obtaining completely sediment-free samples, or samples below 50 NTU, is difficult if not impossible using a bailer.

A bailer provides representative samples once the well has been adequately developed and purged. A bailer is not suitable for LFP. Rope used for bailing must be kept off the ground and free of other contaminating material that could be introduced to the well. Rope can either be dedicated to the well for future use or discarded.

#### 7.7.7.8 Passive Diffusion Bags

When sampling with diffusion bags the well must be fully developed using an alternate method.

A diffusion bag is a polyethylene bag that contains deionized water. The bag is attached to an appropriate length of rope or cable in order to be submerged to the appropriate depth (indicated in the Work Plan, QAPP, or as instructed by the Project Coordinator). Cable or rope used to suspend diffusion bags can be dedicated to the well for future use or discarded.

Once submerged to the appropriate depth, the diffusion bag is left in the well for an extended period of time, usually 14 days, to allow the bag to equilibrate with the water in the well. The use of diffusion bags eliminates well purging prior to sampling. Placement of multiple diffusion bags in a well allows for vertical groundwater profiling.

Diffusion bags are a low cost method for the collection of groundwater samples. Advantages include:

- No purge water to dispose of.
- No equipment decontamination between wells.
- Simple logistics and operation.
- Reduction in personnel and exposure times.
- Samples collected are representative of formation water adjacent to well.

- Allow for vertical profiling of water column.
- Appropriate for long-term monitoring programs.

The disadvantage of diffusion bags is the length of equilibrium time, generally 14 days. Currently, there are membranes available for diffusion bags suitable for the collection of groundwater samples for select SVOC, and metals analyses. However, there are no membranes currently available for polychlorinated biphenyls (PCBs).

| Note: Handle diffusion bags only when wearing clean nitrile or surgical gloves. |
|---|

#### 7.7.8 Filtering of Groundwater Samples

Filtering is an important process to remove suspended particulate that affect sample results. Filtration of groundwater samples is generally limited to metals analysis.

Filtering can be completed in the field using in-line filters or a vacuum filter kit. Filtering of samples can also be completed by the laboratory, in which case the samples must not be preserved and must be at the laboratory in at least 24 hours of sample collection.

### 7.8 Field Procedures for Residential Sampling

#### 7.8.1 General

When sampling potable water supply wells it is important to ensure that the samples collected are representative of the aquifer being sampled. Poor or incorrect sampling techniques will result in erroneous sample results that can be disclosed to the public. Incorrect sample results may make any changes in the public perception hard to accomplish when correct results are reported.

#### 7.8.2 Field Procedures

The requirements of a residential well sampling program should be reviewed with the Project Coordinator prior to initiating sampling activities. While similar field procedures used in groundwater sampling (including documentation, sample identification, date, time, etc.) are required in residential well sampling, additional procedures are also required.

Prior to collection of groundwater samples from a residential well, the well must be purged to ensure that samples collected are representative of the formation. Purging removes standing water from the well casing, pipes, and pressure or holding tank. Purging of a residential well requires the removal of one well volume. If access to the well is not available to determine the well volume, purging for a period of 15 to 30 minutes is generally sufficient. Field measurements for pH, conductivity, and temperature are recorded during purging activities until the readings indicate that stabilization has occurred.

Sampling of residential wells is generally performed using the existing pumping system. However, GHD purging and sampling equipment can be used. It is important that only designated **clean** purging and sampling equipment be used for residential well sampling. The use of the existing pumping system is preferred, as this is more representative of the water quality provided to the residence. Using the existing pumping system also minimizes the possibility of damaging the well and existing pumping system when installing additional purging and sampling equipment.

If GHD equipment is used for residential well sampling, it must be cleaned prior to and between use with a bleach and deionized water solution wash followed by a thorough deionized water rinse.

> Note: In addition to the special technical procedures noted, GHD personnel must be aware of this unique situation of conducting sampling at private residences. Special care must be taken to be polite and courteous at all times. Offer only necessary information and maintain a clean work area that is returned to pre-sampling conditions. Personnel should have proper identification available, and only remain in areas long enough to complete the required tasks.

Taps selected for residential well sampling should be located as close to the well as possible. Locate the taps before any treatment systems and, if possible, the pressure tank. It is important to note, if possible, all water treatment devices in operation at the residence including:

- Water softeners
- Filtration units
- Ultraviolet light
- Reverse osmosis
- Distillers
- Chlorinators

Leaking taps that allow water to flow from the stem of the valve handle and around the tap should not be used as sampling locations. Aerators, strainers, and hose attachments should be removed prior to sampling. Maintain a steady flow of water during sampling activities to avoid pressure fluctuations that may cause sheets of microbial growth lodged in the pipes to break loose. Open the cold water tap for a period of 15 to 30 minutes to allow for the complete purging of the pumping system. Maintain a smooth-flaring water stream at a low to moderate pressure without splashing. Do not change the flow rate. Changes in the flow could dislodge particles in the pipes or faucet.

When sampling for microbiological parameters, the end of the faucet must be flame sterilized. During residential well sample, never place caps from sample containers on the ground or in a pocket. Instead, hold the sample container in one hand and the sample container cap in the other. Be very careful not to touch the inside of the sample container cap. Wear new disposable gloves at each sampling location and following contact with a potential contaminant source. The inside of the sample bottle must not be touched with bare hands or allowed to contact the surface of the faucet.

### 7.8.3 Field Notes for Residential Sampling

Full documentation of each residential well is required and includes:

1. Well depth
2. Casing construction and diameter

3. Well installation date if known

4. Pumping system configuration

5. Piping system construction (e.g., copper, lead-joint, ABS)

6. Presence of treatment devices

Obtain the name and exact mailing address for all residence or well owners, as well as home and work telephone numbers. This information is required to inform the residence or well owner of the results of the sampling activities.

Document residential well sampling activities in a standard GHD field book. Figure 3.8 provides typical residential well sampling field note requirements. Note that additional documentation of well details, treatment devices, piping system, and special circumstances are required in the field book in addition to the sample log entry.

## 7.9 Field Procedures for Surface Water Sampling

### 7.9.1 General

Surface water sampling is performed to obtain samples for surface water bodies that are representative of existing surface water conditions.

Surface water sampling locations for surface water quality and groundwater interaction studies are selected based on the following:

1. Study objectives

2. Location of point surface discharges

3. Non-point source discharges and tributaries

4. Presence of structures (e.g., bridge, dam)

5. Accessibility

During surface water sampling it is important to obtain samples that are not impacted by the re-suspension of sediment produced because of improper or poor surface water sampling techniques.

### 7.9.2 Surface Water Sample Location Selection

Prior to conducting surface water sampling activities, the first requirement is the consideration and development of surface water sampling locations. It is important that all surface water sampling locations be selected in accordance with the Work Plan and described to and discussed with the Project Coordinator.

Bridges and piers are good locations for surface water sampling locations since they provide easy access and permit water sampling across the entire width of the surface water body. The JSA for sampling from bridges must include a traffic management plan to assure the employee has considered using a spotter, signage, cones, and flags to warn car traffic of the work adjacent to the roadway. Wading for surface water samples increases the chances of disturbance of sediments from the floor of the surface water body.

When wading for surface water samples in lakes, ponds, streams, and slow moving rivers be aware of potential safety and health risks. A life vest and safety line must be worn at all times where footing is unstable or when sampling in fast moving or more than 3 feet (0.9 m) deep. A two-person team is required for most surface water sampling activities, a Project Manager must approve a one person sampling team. If the site conditions require the use of the life vest and safety line, the two people involved in the sampling must be competent swimmers.

Surface water samples must be collected with no suspended sediments. Surface water samples are collected commencing with the furthest downstream location to avoid sediment interference with upstream locations.

#### 7.9.2.1 Rivers, Streams, and Creeks

Surface water samples are generally collected in areas of surface water bodies that are representative of the surface water body conditions. Representative surface water samples will usually be collected in sections of surface water bodies that have a uniform cross section and flow rate. Mixing is influenced by turbulence and water velocity, therefore the selection of surface water sampling locations immediately downstream of a riffle area (i.e., fast flow zone) will ensure good vertical mixing. These locations are also likely areas for deposition of sediment since this occurs in areas of decreased flow velocity.

Surface water sampling locations should not be established in areas near point source discharges including tributaries, industrial effluents, and municipal effluents. Surface water sampling of these source discharge points can be performed to assess the impact of these source areas on overall surface water quality.

Sample tributaries as close to the mouth as possible. It is important to select surface water sample locations considering the impact downstream, including tributary flow and sediment.

In all instances, properly document all surface water sampling locations in a standard GHD field book. Documentation may include photographs and tie-ins to known structures.

#### 7.9.2.2 Lakes, Ponds, and Impoundments

The surface water in lakes, ponds, and impoundments has a greater tendency to be stratified than water in rivers and streams. Lack of mixing in these surface water bodies may require additional surface water sample collection. Extreme turbidity variances may occur where highly turbid surface water courses enter a lake or pond. Therefore, each layer of the stratified surface water column may need to be considered separately. Stratification is generally a result of water temperature differences, with cooler heavier water being trapped below warmer water.

Surface water sample locations for lakes, ponds, and impoundments should adequately represent the conditions of the surface water body. All intakes and outflows that may provide biased surface water representation should be identified and documented. Surface water sample locations with adjacent structures (e.g., banks, piers) may also provide biased samples, as the potential for boundary flow and eddies exists.

The number of surface water sample locations on lakes, ponds, or impoundments will vary depending on the purpose of the investigation, as well as the size and shape of the surface water body. In ponds and small impoundments a single surface water sample should be collected at the deepest point. In naturally formed ponds, the deepest point is usually near the center of the surface water body. In impoundments the point is usually near the dam.

In lakes and larger impoundments, several sub-samples should be taken to form a single composite sample. These vertical surface water sampling locations are collected along a pre-determined grid.

In irregular shaped lakes with several bays and covers that are protected from the wind, additional surface water samples are required to properly represent surface water quality at various locations in the lake. Additional surface water samples should be taken at discharges, tributaries, and other factors or sources that are suspected of affecting the surface water quality.

In all instances, properly document all surface water sampling locations in a standard GHD field book. Documentation may include photographs and tie-ins to known structures.

### 7.9.3 Sampling Equipment and Techniques

When collecting surface water samples, direct dipping of the sample container into the stream or water is acceptable unless the sample container contains preservatives. If preserved, a pre-cleaned unpreserved sample container should be used to collect the surface water sample. The surface water sample is then transferred to the appropriate preserved sample container. When collecting surface water samples, submerse the inverted bottle to the desired sample depth and tilt the opening of the sample container upstream to fill. During surface water sample collection, wading or movement may cause sediment deposits to be re-suspended and can result in biased samples. Wading is acceptable if the stream has a noticeable current and the samples are collected directly in the sample container when faced upstream. If the stream is too deep to wade in or if addition samples must be collected at various depths, additional sampling equipment will be required. Surface water samples should be collected about 6 inches (15 cm) below the surface, with the sample bottles being completely submerged. Taking the surface water sample at this depth eliminates the collection of floating debris in the sample container.

Surface water sample collection where the flow depth is less than 1 inch (<2.5 cm) requires the use of special equipment to eliminate sediment disturbance. Surface water sampling may be conducted with a container then transferred to the appropriate sample container, or collection may be performed using a peristaltic pump. A small excavation in the stream bed to create a sump for sample collection can also be considered but should be prepared in advance to allow all the sediment to settle prior to surface water sampling activities.

Teflon™ bailers can be used for surface water sampling if it is not necessary to collect surface water samples at specific depths. A bottom loading bailer with a check ball is sufficient. When the bailer is lowered through the water, the water is continually displaced through the bailer until the desired depth is reached. The bailer is retrieved and the check ball prohibits the release of the collected surface water sample. Bailers are not suitable in surface water bodies with strong currents, or where depth-specific sampling is required.

For discrete and specified depth surface water sampling, and the parameters to be monitored do not require a Teflon™ coated sampling device, a standard Kemmerer or Van Dorn sampler can be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the sampler ends open while the sampler is being lowered. The sampler is lowered in a vertical position to allow water to pass through. The Van Dorn sampler is plastic and is lowered in a horizontal position. For both samplers, a messenger is sent down a rope when the sampler has reached the required depth. The messenger causes the stopper on the sampler to close. The sampler is then retrieved and the surface water sample can be collected through a valve. DO sample bottles can be filled by allowing overflow using a rubber tube attached to the valve. During depth-specific surface water sampling, take care not to disturb bottom sediments.

Glass beakers or stainless steel cups may also be used to collect surface water samples if parameter interference does not occur. The beaker or cup must be rinsed at least three times with the surface water sample prior to sample collection.

All equipment must be thoroughly decontaminated as outlined in Section 7.6.

### 7.9.4 Field Notes for Surface Water Sampling

Use a standard GHD field book to record daily surface sampling activities, describe surface water sampling locations, sampling techniques, and, if applicable, provide a description of photographs taken. Visual observations are important and provide valuable information when interpreting surface water quality results. Observations include:

1. Weather conditions
2. Stream flow directions
3. Stream physical conditions (width, depth, etc.)
4. Tributaries
5. Effluent discharges
6. Impoundments
7. Bridges
8. Railway trestles
9. Oil sheens
10. Odors
11. Buried debris
12. Vegetation
13. Algae
14. Fish and other aquatic life
15. Surrounding industrial areas

The following factors should be considered for surface water sampling:

1. Predominant Surrounding Land Use: Observe the prevalent land use type in the vicinity and note any other land uses in the area which, although not dominant, may potentially affect surface water quality.
2. Local Watershed Erosion: Note the existing or potential erosion of soil in the local watershed and its movement into the stream. Erosion can be rated through visual observation of watershed stream characteristics including increases or decreases in turbidity.
3. Local Watershed Non-Point Source Pollution: This refers to problems or potential problems other than erosion and sedimentation. Nonpoint source pollution can be diffuse agricultural and urban runoff. Other factors may include feed lots, wetlands, septic systems, dams, impoundments, and mine seepage.
4. Estimated Stream Width: The estimated distance from shore at a transect representative of the stream width in the area.
5. Estimated Stream Depth: Riffle (rocky area), run (steady flow area), and pool (still area). Estimate the vertical distance from the water surface to the bottom of the surface water body at a representative depth at three locations.
6. High Water Mark: Estimate the vertical distance from the bank of the surface water body to the peak overflow level, as indicated by debris hanging in bank or flood plain vegetation, and deposition of silt. In instances where bank flow is rare, high water marks may not be evident.
7. Velocity: Record or measure the stream velocity in a representative run area.
8. Dam Present: Indicate the presence or absence of a dam upstream or downstream of the surface water sampling location. If a dam is present, include specific information detailing the alteration of the surface water flow.
9. Channelized: Indicate if the area surrounding the surface water sampling location is channelized.
10. Canopy Cover: Note the general proportion of open to shaded areas which best describes the amount of cover at the surface water sampling location.

## 7.10 Follow-Up Activities

The following should be performed once groundwater, residential, and surface water sampling is completed:

1. Double check the Work Plan and QAPP to ensure all samples and QA/QC samples have been collected and confirm with the Project Coordinator.
2. Decontaminate all equipment at the site then return clean to the appropriate office equipment manager.
3. Dispose of purge water and cleaning fluid as specified in the Work Plan.
4. Notify the contract laboratory when the samples should arrive. Enclose a completed chain-of-custody in each cooler.

5. Complete and file the appropriate forms and data sheets. Also file the field notes. For groundwater, residential, and surface water sampling these forms include:
   - Project Planning, Completion, and Follow-Up Checklist (Form SP-02)
   - Well Development, Purging, and Sampling Form (Form SP-06)
   - Sample Collection Data Sheet - Groundwater Sampling Program (Form SP-08)
   - Monitoring Well Record for Low-Flow Purging (if performed) (Form SP-09)
6. Return site and well keys.

## 7.11 References

For additional information pertaining to groundwater sampling activities the user of this manual may reference the following:

| | |
|---|---|
| ASTM D5474 | Guide for Selection of Data Elements for Groundwater Investigations |
| ASTM D4696 | Guide for Pore-Liquid Sampling from the Vadose Zone |
| ASTM D5979 | Guide for Conceptualization and Characterization of Groundwater Systems |
| ASTM D5903 | Guide for Planning and Preparing for a Groundwater Sampling Event |
| ASTM D4448 | Standard Guide for Sampling Groundwater Wells |
| ASTM D6001 | Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations. |

For additional information pertaining to surface water sampling, the user of this manual may reference the following:

| | |
|---|---|
| ASTM D5358 | Practice for Sampling with a Dipper or Pond Sampler |
| ASTM D4489 | Practices for Sampling of Waterborne Oils |
| ASTM D3325 | Practice for the Preservation of Waterborne Oil Samples |
| ASTM D4841 | Practice for Estimation of Holding Time for Water Samples Containing Organic and Inorganic Constituents |
| ASTM D4411 | Guide for Sampling Fluvial Sediment in Motion |
| ASTM D4823 | Guide for Core-Sampling Submerged, Unconsolidated Sediments |
| ASTM D3213 | Practice for Handling, Storing, and Preparing Soft Undisturbed Marine Soil |
| ASTM D3976 | Practice for Preparation of Sediment Samples for Chemical Analysis |
| ASTM E1391 | Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing |
| ASTM D4581 | Guide for Measurement of Morphologic Characteristics of Surface Water Bodies |
| ASTM D5906 | Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths |
| ASTM D5073 | Practice for Depth Measurement of Surface Water |

# GHD Field Training Manual

Section 5.0
Soil Sampling Standard Operating Procedures

Part 1 - Surficial Soil Sampling, Borehole Installation and Sample Collection, and Test Pit Excavation and Sampling

(T102A)

Part 2 - GHD Approach for Soil Materials Description and Classification

(T100)

July 2015

# Please adhere to the following Quality System training requirements:

- Employees who are required to conduct a specific field activity must be properly certified to do the work.
- This involves reviewing the SOP and completing the online training course and exam.
- Employees must also conduct this field work under supervised conditions on at least three occasions, and must be certified by a qualified mentor. Only then can an employee conduct a specific field activity on their own. This is documented on a Field Method Training Record (QSF-021).
- Complete the QSF-021 and forward it to trainingrecords-northamerica@ghd.com.
- Please note that four topics are discussed in this SOP. A separate QSF-021 is required for each topic:
  - Surficial Soil Sampling
  - Borehole Installation and Sample Collection
  - Test Pit Excavation and Sampling
  - GHD Approach for Soil Materials Description and Classification

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# 5. Soil Sampling Standard Operating Procedures

## 5.1 Introduction

Soil sampling is conducted to characterize the physical and/or chemical conditions at a site. Standard Operating Procedures (SOPs) are presented herein for obtaining a variety of soil samples for physical and chemical analyses, including:

- Surficial soil samples (soil between ground surface and 6 to 12 inches (15 to 30 cm) below ground surface)
- Subsurface samples that require borehole installation
- Test pit excavations

This guideline is not intended to provide the basis for designing a soil sampling program, but instead assumes that a soil sampling program has been designed, a Work Plan has been established, and the sampling team is preparing to mobilize to the field.

Soil sampling procedures vary from project to project due to different parameters of concern, different guidance provided by the state/province where the site is located, or the specific objectives for the project. Therefore, it is essential that the sampling team members carefully review the Work Plan. The primary goal of surface soil sampling is to collect representative samples for examination and chemical analysis (if required).

The remainder of this section is organized as follows:

- Section 5.2 Sampling Methods
- Section 5.3 Planning and Preparation
- Section 5.4 Safety and Health
- Section 5.5 Quality Assurance/Quality Control
- Section 5.6 Equipment Decontamination
- Section 5.7 Procedures for Soil Classification
- Section 5.8 Procedures for Surficial Soil Sampling
- Section 5.9 Procedures for Borehole Installation and Sampling
- Section 5.10 Procedures for Test Pit Excavation and Sampling
- Section 5.11 Follow-up Activities
- Section 5.12 References

## 5.2 Sampling Methods

### 5.2.1 Surficial Soil Sampling

Surficial soil sampling is less frequently used than subsurface soil sampling (which involves borehole installation). Typically, surficial soil sampling is used when a large site is being assessed and the extent of contamination is unknown. In this case, surficial sampling is helpful in identifying the location of surface releases (e.g., historical spills of hydrocarbons) that may have contributed to subsurface contamination. A surficial soil sampling program is also recommended for sites with suspected atmospheric deposition of contaminants (e.g., stacks), areas of surface spills, or recent spills.

Surficial soil sampling is used when contamination is known to be restricted to the surficial region of the soil stratum. Thus, surficial sampling can be useful at brownfield sites, where it is necessary to determine if soils are contaminated with specific contaminants of concern (e.g., metals) as part of a purchaser's due diligence. Surficial soil sampling can also be required when obtaining data in order to perform a site-specific risk assessment.

For the purposes of this section, the surficial soil is considered to be the 0- to 6-inch (0 to 15 cm) soil horizon.

Samples are collected from areas where surficial soil contamination is known or suspected. Samples from a particular depth increment must not be mixed with soil from other depths. Soil horizons displaying different properties should be sampled separately, since they may behave very differently with respect to contaminant accumulation and movement.

### 5.2.2 Borehole Installation and Sampling

A significant portion of GHD's field activities involve borehole installation.

Several manual methods are available for the collection of shallow subsurface soil samples (e.g., hand augers, post-hole augers). However, the most common methods used by GHD to advance boreholes are a drill rig equipped with continuous flight hollow-stem augers (HSAs) and split-spoon samplers, or a direct-push drilling unit equipped with solid tube soil samplers.

### 5.2.3 Test Pit Excavation and Sampling

Test pits are typically excavated to explore and define geologic conditions (or buried waste/debris) and to allow the collection of subsurface soil samples for geotechnical or chemical analysis. Test pits give a more complete view of the subsurface soil conditions than soil borings. Test pits are excavated using either a rubber-tired backhoe or track-mounted excavator, and can extend 10 to 15 feet (3.0 to 4.6 m) below ground surface.

The use of test pits for investigation is determined on a site-specific basis. Experience from past projects has identified the following issues:

1. The nature and extent of contamination which may be encountered may be unknown. The Site-specific Health and Safety Plan (HASP) and Job Safety Analysis (JSA) must be specific to the level of Personal Protective Equipment (PPE); this may be Level A or B.

2. Waste materials, including drums, may be encountered. A plan must be in place specifying how this material will be handled.
3. Air emissions of some compounds may occur. A plan must be in place to ensure that employees and the public are adequately protected.
4. Community relations concerns may exist (e.g., workers in chemically protective "moon suits"). A notification plan may be required.
5. All underground utilities must be located utilizing documentation using the GHD Subsurface Clearance Protocol.

#### 5.2.4 Grab Versus Composite Samples

A grab sample is collected to identify and quantify compounds at a specific location or interval. The sample is comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample analyses. Composite samples are a mixture of a given number of sub-samples and are collected to characterize the average composition in a given surface area.

Samples to be analyzed for volatile organic compounds (VOCs) are always collected as grab samples. Mixing of soil samples to create a composite is not performed. Mixing of soil samples results in partial volatilization of VOCs from the soil, and thus compromises the integrity of the composite soil sample.

### 5.3 Planning and Preparation

The following activities are required prior to undertaking a soil sampling program:

1. Review the Work Plan, project documents, and health and safety requirements with the Project Coordinator.
2. Complete a Field Equipment Requisition Form (QSF-014) and assemble all equipment, materials, log books, and forms. Form SP-02 (Project Planning, Completion, and Follow-Up Checklist) should be used for guidance throughout the project. Borehole Installation/Soil Sampling Equipment and Supply Checklist (Form SP-12) provides a summary of the typical equipment/materials required for soil sampling. Drilling/Well Construction Checklist (Form SP-13) provides a listing of pre-planning and site activities that is designed as an aid to preparing and completing the project.
3. Obtain a site plan and any previous stratigraphic logs. Determine the exact number, location, and depths of samples to be collected.
4. Complete a Vendor Evaluation Form (QSF-012) and file in the project file for any vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work; QSF-031 for U.S. work) is necessary for all vendors who complete field services. Prior to mobilization on site, the vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).

5. Contact GHD's Chemistry Group to arrange/determine:
    - SSOW (simplified Scope of Work)
    - Glassware/sample jars
    - Cooler
    - Shipping details
    - Start date
    - Laboratory
    - Expected sampling duration
6. Initiate a Property Access/Utility Clearance Data Sheet (QSF-019), if necessary. In most instances, surface sampling activities do not require utility clearances.
7. Determine notification needs with the Project Coordinator. Have the regulatory groups, client, landowner, GHD personnel, and laboratory been informed of the sampling event?
8. Determine the methods for handling and disposal of wash waters and spent decontamination fluids.

In addition to the above, the following may be required when conducting a borehole or test pit program:

1. Establish a water source for drilling and decontamination activities. Pre-plan the methods for handling and disposal of drill cuttings, wash waters, and spent decontamination fluids.
2. Arrange with driller to provide paraffin wax, melting pot, and heat source (if required).

## 5.4 Safety and Health

GHD is committed to conducting field activities in accordance with sound safety and health practices. GHD adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule implications.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the HASP is specific to the job and approved by a Regional Safety and Health Manager.
- Confirm that all HASP elements have been implemented for the job.
- A JSA for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the GHD Safety and Health Policy Manual.

- Confirm that all site personnel have the required training and medical surveillance, as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure the equipment is in good working order.
- Maintain all required PPE, safety equipment, and instrumentation necessary to perform the work effectively, efficiently, and safely.
- Be prepared to call the GHD Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all GHD field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet GHD's (and the client's) safety requirements.

## 5.5 Quality Assurance/Quality Control

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management.
- Allow for monitoring of staff and contractor performance.
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 3.9.

## 5.6 Equipment Decontamination

### *Borehole Installation and Sampling*

Prior to use and between each borehole location at an environmental site, the drilling and sampling equipment must be decontaminated in accordance with the Work Plan or the methods presented in this section.

The minimum wash procedures for decontamination of drilling or excavating equipment are:

1. High pressure hot water detergent wash (brushing as necessary to remove particulate matter).
2. Potable, hot water, high pressure rinse.

Cover the clean augers with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where contaminants are not present, it is sufficient to clean the drilling or excavating equipment simply by removing the excess soils.

On environmental sites, the soil sampler equipment (split spoons, trowel, spoons, shovels, bowls) are typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

In addition, the following steps may be added when sampling for VOCs and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap split-spoon samplers in aluminum foil to prevent contamination.

| | |
|---|---|
| Caution: | Check the Quality Assurance Project Plan (QAPP) to confirm the cleaning protocol. Use of incorrect cleaning protocol could invalidate chemical data. |

## 5.7 Procedures for Soil Classification

This SOP for Soil Classification is not intended to provide complete training in soil classification. Soil Classification will require additional training and experience.

Criteria and procedures for soil classification and description include:

1. A standard method of describing the soil by name and group symbol.
2. Standard field identification methods based on visual examination and manual tests on representative soil samples by a qualified GHD representative for interpretation of subsurface conditions at the site.
3. Verifying field description descriptions through the inspection.
4. Confirming descriptive information by laboratory determination of selected soil characteristics if required in the Work Plan.
5. Factual overburden stratigraphic logs completed by GHD personnel responsible for interpreting the subsurface conditions at the site and review/confirmation of soil descriptions by the Project Coordinator.

The overburden stratigraphic log is the factual description of the soil at each borehole location and will be relied on to interpret soil characteristics at the site. The overburden stratigraphic log will also be used to interpret the soil characteristics' influence and significance on the subsurface environment. GHD personnel responsible for interpreting the subsurface conditions at the site will also verify overburden stratigraphic log accuracy. If practical, the Project Coordinator, Geologist, or Geotechnical Engineer should confirm the soil descriptions and examine representative soil samples.

Describing and classifying soils is a skill that is learned through experience and by systematic training using laboratory results of soil composition in comparison to field descriptions.

| Note: Attendance at a soil identification course provided by GHD is mandatory. |
|---|

Descriptions for natural undisturbed soils are recorded on a Stratigraphy Log (Overburden) (Form SP-14). An example of a completed Stratigraphy Log (Overburden) is presented on Figure 5.1.

Soil descriptions are completed in the following order:

1. Unified Soil Classification System (USCS) group symbol(s) (e.g., SM) of primary soil components or dual or borderline symbols.
2. Name and adjective description of primary, secondary, and minor grain size components.
3. Relative density for non-cohesive soils or consistency for cohesive soils.
4. Gradation and soil structure for non-cohesive soils or structure and plasticity for cohesive soils.
5. Color.
6. Moisture content.
7. Other physical observations including presence of staining and or odors.

| Note: When describing observed odors, be as specific as possible to classify general odor category and strength of odor. Odors are generally chemical, petroleum, or septic related, varying from slight to moderate to strong. Identification of specific chemical compounds (i.e., benzene, gasoline) is not necessary and is often inaccurate as detailed chemistry commonly shows an array of chemicals present. |
|---|

When describing vegetative matter presence in soils, do not use the term organic. The use of the term organic often leads to confusion regarding the presence of organic chemicals (i.e., VOCs, semi-volatile organic compounds [SVOCs]). Similarly, as noted above, use more specific terms for odors than organic.

The description of fill soils is similar to those used to describe native undisturbed soils. Fill soils will be identified as fill (i.e., SP/GP-Sand and Gravel [Fill]). To determine if soils are fill, look for evidence that the soil has been artificially placed (e.g., brick fragments, slag, glass, wood fragments). Relative or inconsistent soil density can also assist in determining if soils are fill, along with irregular soil structure.

Soils are identified and grouped consistently to determine subsurface pattern or changes and non-conformities in the soil stratigraphy. The stratigraphy of each soil boring or test pit is compared to ensure that patterns or changes in soil stratigraphy are noted and that consistent terminology is used.

Visual examination, physical observation, and manual tests (based on ASTM D2488, Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]) are used to aid in classifying and grouping soil samples in the field. These procedures are described in the following subsection. ASTM D2488 should be reviewed for detailed explanations of the procedures. (Note that the related ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System] uses slightly different percentages of soil components.) Visual-manual procedures used to aid in soil identification and classification include:

1. Visual determination of grain size, soil gradation, and percentage of various soil components to the nearest 5 percent (i.e., gravel, sand, silt, and clay).
2. Dry strength, dilatancy, toughness, and plasticity tests (i.e., thread or ribbon test) for identification of inorganic fine-grained soils (e.g., CL or CH [clays], and ML or MH [silts]).
3. Soil compressive strength and consistency estimates based on thumb indent and or pocket penetrometer (preferred) methods.

The three main soil divisions are:

1. Coarse-grained soils (e.g., sand and gravel)
2. Fine-grained soils (e.g., silts and clays)
3. Soils with high natural organic and vegetative matter content (e.g., peat, marl)

These soil divisions are presented in the table of USCS classifications below.

| Major Division | | | Group Symbol | Typical Description |
|---|---|---|---|---|
| Coarse grained soils more than 50% retained on No. 200 sieve | Gravel more than 50% of coarse fraction retained on No. 4 sieve | clean gravel <5% fines | GW | well graded gravel, gravel-sand mixtures |
| | | | GP | poorly graded gravel, gravel-sand mixtures |
| | | gravel with >15% fines | GM | silty gravel, gravel-sand-silt mixtures |
| | | | GC | clayey gravel, gravel-sand-clay mixtures |
| | Sand more than 50% of coarse fraction passes No. 4 sieve | clean sand <5% fines | SW | well graded sand, fine to coarse sand, gravelly sand |
| | | | SP | poorly graded sand |
| | | sand with >15% fines | SM | silty sand, sand-silt mixtures |
| | | | SC | clayey sand, sand-clay mixtures |
| Fine grained soils more than 50% | | inorganic | ML | Inorganic silt |
| | | | CL | Inorganic clay |

| Major Division | | | Group Symbol | Typical Description |
|---|---|---|---|---|
| passes No. 200 sieve | Silt and Clay liquid limit <50, low plasticity | organic | OL | organic silt, organic clay |
| | | | | silt of high plasticity, elastic silt |
| | Silt and Clay liquid limit ≥50, high plasticity | inorganic | MH | clay of high plasticity, fat clay |
| | | | CH | organic clay, organic silt, low plasticity |
| | | organic | OL | organic clay, organic silt, high plasticity |
| | | | OH | |
| Highly organic soils | | | Pt | peat |

### 5.7.1 Coarse Grained Soils

The USCS symbols for coarse-grained soil are primarily based on grain size, grain size distribution (gradation), and percent of fines (silt and clay content).

Grain size classification used for describing soils is in terms of particle size and sieve size (e.g., gravelly sand, trace silt). Coarse-grained soil is composed of more than 50 percent by weight, sand size, or larger (75 µm diameter, No. 200 sieve size). Note that there are other definitions for coarse-grained or coarse textured soil and for sand and for sand size as soil having greater than 70 percent particles equal to or greater than 50 µm diameter (after "Guidelines for Contaminated Sites in Ontario") or 60 µm diameter ("Canadian Foundation Manual").

The percentage descriptors for soil components are different for coarse-grained versus fine-grained soils. The following are the percentage component descriptors for coarse-grained soils:

| | |
|---|---|
| Noun (e.g., sand, gravel) | Major Component |
| Adjective (e.g., silty, clayey, sandy, gravelly) | Greater than 15% |
| With (e.g., with silt, with clay, with sand, with gravel) | 5% to 15% |
| Trace (e.g., trace silt, trace clay, trace sand, trace gravel) | <5% |

Grain size distribution of coarse-grained soils includes:

- Poorly graded (i.e., soil having a uniform or predominantly one grain size, SP and GP)
- Well graded (i.e., poorly sorted soils with a wide range of particle sizes with substantial percentage of intermediate sizes, SW and GW)
- Dirty (i.e., soil having greater than 15 percent fines, SM, SC, GM, and GC)

Coarse-grained soils are further classified based on the percentage of fine-grained soils (e.g., silts and clays) they contain. Coarse-grained soils containing greater than 15 percent fine-grained soils are described with an adjective (e.g., silty [SM, GM], clayey [SC, GC]). This description is attributed to soil particles that adhere when the soil sample is rubbed between the hands or adhere to the sides of sample jars after shaking, or rolling in the jar. The jar shake test will also result in the segregation of sand and gravel particles and can be used as a visual aid in determining sand and gravel content percentages.

Examples of the group symbol, name, and adjectives used to describe the primary, secondary, and minor components of soil are:

- GW - Sandy Gravel (e.g., 70 percent gravel and 30 percent sand, well graded)
- GW - Sandy Gravel-trace silt (less than 5 percent silt, well graded)
- SP - Sand (a uniform sand, predominantly one sand grain size)
- SM - Silty Sand, with clay (sand with greater than 15 percent silt, and 5 to 15 percent clay)

Relative density is important in establishing the engineering properties and behavior of coarse-grained soils. Relative density of non-cohesive (coarse-grained) soils is determined using the standard penetration test (SPT) blow counts (N-values) in accordance with ASTM D1586. A detailed discussion of the SPT and N values can be found in Section 5.9.2.1.

The SPT provides reliable indications of the relative density of sand and fine gravel. N-values in coarse-grained soil are influenced by a number of factors that result in overestimated relative densities. For example, in coarse-grained gravel, dilatent silty fine sands, sand below the water table and uniform coarse sand, N-values tend to be conservative and under estimate the relative density. The Project Geotechnical Engineer will assess these effects, if required.

Other methods, such as modified SPT and cone penetration tests, are used on occasion to supplement or replace the SPT method for certain site-specific conditions. All modifications to the SPT or substitute methods must be recorded as required to interpret test results and correlate relative density.

### 5.7.2 Fine-Grained Soil

A fine-grained soil is made up of more than 50 percent silt and clay (i.e., fines greater than 50 percent by weight passing the 75 μm (No. 200) sieve size). Description of visual-manual field methods and criteria to further characterize and group fine-grained soil (e.g., CL, CH, ML, and MH) are discussed in ASTM D2488.

The percentage descriptors for components is different for fine-grained versus coarse-grained soils. The following are the percentage component descriptors for fine-grained soils:

| | |
|---|---|
| Noun (e.g., silt, clay) | Major Component |
| Adjective (e.g., sandy, gravelly, silty, clayey) | Greater than 30% |
| With (e.g., with sand, with gravel, with silt, with clay) | 15% to 30% |
| Few (e.g., few sand, few gravel, few silt, few clay) | 5% to 15% |
| Trace (e.g., trace silt, trace clay, trace sand, trace gravel) | <5% |

Further soil characterization tests include dry strength, dilatency, toughness, and plasticity (thread or ribbon test).

#### *Criteria for Describing Dry Strength*

| Description | Criteria |
|---|---|
| None | The dry specimen crumbles into powder with mere pressure of handling. |
| Low | The dry specimen crumbles into powder with some finger pressure. |

| Description | Criteria |
|---|---|
| Medium | The dry specimen breaks into pieces or crumbles with considerable finger pressure. |
| High | The dry specimen crumbles into powder with finger pressure; specimen will break into pieces between thumb and a hard surface. |
| Very High | The dry specimen cannot be broken between the thumb and a hard surface. |

### *Criteria for Describing Dilatancy*

| Description | Criteria |
|---|---|
| None | No visible change in small wetted specimen when rapidly shaken in palm of hand. |
| Slow | Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing. |
| Rapid | Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing or stretching. |

### *Criteria for Describing Toughness*

| Description | Criteria |
|---|---|
| Low | Only slight pressure is required to roll the thread near the plastic limit; the thread and the lump are weak and soft. |
| Medium | Medium pressure is required to roll the thread to near the plastic limit; the thread and the lump have medium stiffness. |
| High | Considerable pressure is required to roll the thread to near the plastic limit; the thread and the lump have very high stiffness. |

### *Criteria for Describing Plasticity*

| Description | Criteria |
|---|---|
| Nonplastic | 1/8-inch (3 mm) thread cannot be rolled at any water content. |
| Low | The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit. |
| Medium | The thread is easy to roll and not much time is required to reach the plastic limit; the thread cannot be re-rolled after reaching the plastic limit; the lump crumbles when drier than the plastic limit. |
| High | It takes considerable time rolling and kneading to reach the plastic limit; the thread can be re-rolled several times after reaching the plastic limit; the lump can be formed without crumbling when drier than the plastic limit. |

Examples of group symbol identification based on visual-manual procedures and criteria for describing fine grained soil are:

| Group Symbol | Dry Strength | Dilatancy | Toughness | Plasticity |
|---|---|---|---|---|
| ML | None to low | Slow to rapid | Low or thread cannot be formed | Slight |
| CL | Medium to high | None to slow | Medium | Low |
| MH | Low to medium | None to slow | Low to medium | Low |
| CH | High to very high | None | High | High |

Positive classification by USCS group symbols as described in ASTM D2487, is through laboratory determination of particle size characteristics, liquid limit, and plasticity index. The need for laboratory testing will be determined by the Project Hydrogeologist, Geologist, or Geotechnical Engineer and will be detailed in the Work Plan. If no laboratory testing is performed to confirm soil classification, a statement of qualification (method used) is required for group symbols.

Examples of terminology that accompany the group symbols are:

- ML - Sandy Silt (e.g., 30 percent sand)
- CL - Clay (lean) with sand (e.g., 15 to 29 percent sand)

The USCS group symbols require the use of lean clay (CL) and fat clay (CH). The use of these symbols is dependent on the plasticity of the soil. Classification such as silty clay can only be used for a very narrow set of conditions, and will only be used if Atterberg Limit results are available. The lean and fat clay designations are not universally used, but adherence to the USCS requires that these symbols be used.

Correlation of N-values and consistency for clays is unreliable. Consistency determinations will be performed using more appropriate static test methods, especially for very soft to stiff clays. N-values are more reliable in hard clays.

Estimates of unconfined compressive strength (Su) can be obtained by a pocket penetrometer test. To estimate consistency and compressive strength with a pocket penetrometer, cut a minimum 4-inch (10 cm) soil core perpendicular to the soil core length. Hold the core with moderate confining pressure so as not to deform the soil core. Slowly insert the pocket penetrometer tip into the perpendicular face of the soil core until the pocket penetrometer indents the soil core to the mark indicated on the piston of the penetrometer. The pocket penetrometer estimate of the soil compressive strength (Su) is the direct reading of the value mark on the graduated shaft indicated by the shaft ring marker, or by the graduated piston reading at the shaft body. For average estimates, complete this procedure several times on the ends and middle of the soil core. For Shelby tube samples (or thin wall samplers), perform the pocket penetrometer test at several locations on the exposed ends of the sample.

In situ shear vane tests or other test methods provide better compressive strength estimates for very soft to stiff consistency clay soil.

Describing soil consistency is an important component in evaluating the engineering properties and strength characteristics of fine-grained cohesive soil. Consistency terms like soft and hard are based on the unconfined compressive strength (Su) and shear strength or cohesion (cu) of the soil.

Patterns of soil gas and groundwater movement in fine-grained soil are influenced by natural soil structure. Soil structure is dependent on the depositional method and to a lesser extent climate. The identification of fill soil is equally important in determining soil characteristics in fine-grained soils.

## 5.8 Procedures for Surficial Soil Sampling

This section provides a limited discussion on considerations for the design of a soil sampling program in order to provide the sampling team members with a basic understanding of those considerations.

### 5.8.1 Background

Soil sampling locations are selected in order to obtain representative soils with the minimum number of samples. Prior to conducting an investigation, a site inspection may eliminate many uncertainties with respect to site characteristics and result in a more complete soil sampling study. The site inspection should identify pertinent features (e.g., rock outcrops, drainage patterns, surface runoff, surface cover characteristics (e.g., grass, gravel, concrete), wet areas, and fill areas) and evaluate the relationship between those features and potential sources of contaminants. An understanding of these relationships and conditions is important in developing a sampling plan.

### 5.8.2 Random, Biased, and Grid-Based Sampling

Unless there is a strong indication of contaminant presence, such as staining, soil sample locations may be randomly selected from several areas within the site, such as near obvious potential sources of current or historic contamination. Potential sources include large transformers, aboveground storage tanks (ASTs), mandoors, outdoor storage racks, and drainage swales.

If an area shows evidence of contamination, such as staining or vegetative stress, biased samples are collected from the area to characterize the contamination. Background and control samples are also biased, since they are collected in locations typical of non-site-impacted conditions.

When a soil sampling investigation involves a large area, grid-based soil sampling is performed. There is no single grid size that is appropriate for all sites. Common grid sizes are developed on 50- and 100-foot (15 to 30 m) centers. It is acceptable to integrate several different grid sizes in a single investigation.

For a surficial soil sampling program, it is also important to consider the presence of structures and drainage pathways that might affect contaminant migration. It is sometimes desirable to select sampling locations in low-lying areas which are capable of retaining some surface water flow since these areas could provide samples which are representative of historic site conditions (worst-case scenario if surface water flow is a concern).

### 5.8.3 Sample Interval

Surficial soil is generally considered to be soil between ground surface and 6 to 12 inches (15 to 30 cm) below ground surface. However, for risk assessment purposes, regulatory authorities often consider soil from ground surface to 2 feet (0.6 m) below ground surface to be surficial soil.

| |
|---|
| Note: Ontario regulations state that surficial soils are 0 to 6 inches (0 to 15 cm) below ground surface. |

The exact interval to be considered as surficial soil is often a matter of discussion with the regulatory authorities that review the Work Plan. The sample interval is important to the sample collection method and to the manner in which the data are ultimately interpreted. Another important factor is the type of soil. If there are different types of soil present at the site, this may have a bearing on the sample interval. For example, it may be important to separately sample a layer of material with high organic carbon content which overlies a layer of fine-grained soil.

#### 5.8.4 Procedures for Surficial Sampling

Soil sampling methods are dependent upon the sample interval of interest, the type of soil material to be sampled, and the requirements for handling the sample after retrieval. The most common method for collection of surficial soil samples is the use of a stainless steel trowel. Soil samples may also be collected with spoons and push tubes. Often a shovel is required to open a trench such that sampling can be conducted. Soil that has come in contact with the shovel cannot be used as sample material.

In all cases, the sampling device must be constructed of an inert material with smooth surfaces which can be easily decontaminated. The decontamination protocol employs a sequence of cleaning agents and water designed to remove surface contaminants (refer to Section 5.6). All sampling equipment is cleaned between sample locations. A typical surficial soil sampling protocol is outlined below:

1. Collect surficial soil samples using a precleaned stainless steel trowel or other appropriate tool. Each sample consists of soil from the surface (or other starting depth) to the depth specified in the Work Plan. Sample in ditches only when there is no water present.
2. Use a new pair of disposable gloves at each sample location.
3. Prior to use, at each sample location, decontaminate all sampling tools as specified in the Work Plan or as described in Section 5.5.
4. Use a precleaned sampling tool to remove the sample from the layer of exposed soil. Place the collected soil directly into a clean, prelabeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a precleaned stainless steel bowl.
5. After collection, place the samples on ice or cooler packs in a laboratory-supplied cooler.

Surficial debris (e.g., grass cover) should be removed from the area where the sample is to be collected using a separate precleaned device.

In the event that soil conditions are not as described in the Work Plan, or if there are unexpected distinct layers of soil present (e.g., a layer of high organic carbon content overlying a layer of fine-grained soil), sampling personnel should immediately report the conditions to the Project Coordinator for direction. Similarly, if a sampling location is in a gravel or paved area, sampling personnel should confirm with the Project Coordinator whether the surface samples are to be collected from the gravel/pavement subbase material or from the first layer of soil beneath these layers.

Also, sampling team members should immediately report any conditions to the Project Coordinator that they believe may have a negative effect on the quality of the results.

It is generally inadvisable to collect samples containing excessive amounts of large particles such as gravel. Gravel presents difficulties for the laboratory in terms of sample preparation and the results may not be truly representative of contaminant concentrations in nearby soil.

All conditions at the time of sample collection are properly documented in a field log book. This includes a thorough description of the sample characteristics including grain size, color, and general appearance; date/time of sampling; and labeling information. The location of the sampling point is described in words, and three measurements are taken from adjacent permanent structures so that, if necessary, the sample location can be readily identified in the field at a future date. It is often advisable to have a licensed land surveyor accurately survey the locations.

Soil samples are homogenized in a stainless steel bowl prior to filling sample containers. This step can be bypassed if only one sample container is required to be filled, as long as the laboratory will homogenize the sample upon receipt. It is important that soil samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample interval. When using a round bowl, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Fill the sample container completely, leaving no headspace.

Do not mix soil for samples for VOC analyses as this promotes the partial volatilization of compounds from the soil.

In 1997, EPA adopted new methods for sampling soils for VOC analysis. Method 5035 calls for collecting soil using a coring device (EnCore). For analysis of low level VOCs (typically 1 to 200 μg/kg), soil is sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil is placed in a vial with a volume of methanol. This method increases the complexity of collecting soils and makes it imperative that the sampler and laboratory work closely together. For some soil sampling programs, multiple EnCores are required for each sample interval. The number of EnCores required per sample interval should be ascertained during the prior planning and preparation stage.

### *Discrete Grab Sampling Methodology for Surficial Soils*

Discrete grab sampling is employed when the sampling location is considered to be a small area (approximately 1 square foot [0.1 square meter]) that has both a consistent soil type and a consistent level of contaminant impact.

When collecting a discrete grab surficial soil sample, use the following procedure:

1. Using the sampling device (e.g., trowel, spoon, Oakfield sampler) scoop soil from the top 2 inches (5 cm) into the sample container. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil.
2. Collect a field screening sample from the same sampling location as the discrete grab sample and at the same time. Scoop soil into a zip-loc bag until it is no more than one quarter full.

3. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

### *Composite Sampling Methodology for Surficial Soils*

A composite sample can be obtained directly from the soil surface by combining a number of discrete grab samples from a number of sampling locations on the soil surface. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should have (by visual observation) similar contaminant concentrations.

When collecting a composite surface soil sample, use the following procedure:

1. Choose a number of discrete sampling locations that will give a representative sample of the defined composite area at each sampling location.
2. Using the sampling device (e.g., trowel, spoon), scoop the soil from the top 2 inches (5 cm) into the sample container. As much as practical, try to put approximately the same volume of soil from each sampling location into the container.
3. Move to the next sampling location and repeat steps 1 and 2.
4. Collect a maximum of five surface samples (to avoid the complete dilution of any hot spots).
5. When the last location has been sampled, ensure the sample container is filled with soil, leaving no headspace.
6. Since composite samples are used for semi-volatile organic compounds (SVOCs) and inorganic parameters, minimizing the sample collection time is not as important as when discrete samples for VOC analyses are being collected. However, the preferred practice is that the sampler take no longer than necessary to obtain the sample.
7. Collect a field screening sample from the same sampling location as the composite sample and at the same time. As much as practical, try to put approximately the same volume of soil from each discrete grab sampling location into a zip-loc bag. The zip-loc bag should be no more than one quarter full after all the sub-samples have been added.

Since composite samples are not analyzed for VOCs, there is no reason to avoid mixing the sub-samples from the various sampling locations in the sample container (homogenization). However, since the laboratory will use coring techniques to ensure that a sample is representative of the entire container, there is no need to perform field homogenization of the soil within the sample container.

During the sampling program, the sampling team leader will stay in contact with the GHD chemist assigned to the project such that the GHD chemist can properly inform the contract laboratory of the progress of the work. This includes submitting sample summaries and/or copies of completed chain-of-custody forms to the GHD chemist.

Finally, some GHD QAPPs require a designation of a QA/QC officer for field activities. The sampling team leader may be required to conduct certain field audit activities and, at minimum, should be familiar with and responsible for completion of all QA/QC sample activities.

## 5.9 Procedures for Borehole Installation and Sampling

Once the prior planning and preparation activities are completed, the drilling program can proceed. The typical series of events that takes place is:

1. Locating and marking boring locations.
2. Initiation of a Property Access/Utility Clearance Data Sheet (QSF-019), including obtaining appropriate signoffs by the client representative and drilling subcontractor representative.
3. Contractor mobilization; equipment and material check.
4. Site selection of decontamination pad and drum staging area (if applicable); final visual examination of proposed drilling area for utility conflicts.
5. Decontamination of sampling and drilling equipment prior to use in accordance with the Work Plan or as described in Section 5.6.
6. Borehole advancement utilizing the approved method as outlined in the Work Plan.
7. Soil sample collection; descriptions of the soil samples in accordance with GHD protocol.
8. Monitoring well installation (if applicable).
9. Sample preparation and packaging.
10. Abandonment of boreholes or installation of monitoring wells.
11. Collection of groundwater samples (if monitoring wells are installed).
12. Surveying of borehole location and elevations.
13. Field note completion and review.

### 5.9.1 Location and Marking of Drill Sites/Final Visual Check

The proposed borehole locations marked on the site plan are located in the field and staked. On most sites, this will likely be done several days in advance of the drill rig arriving on site. Unless boreholes are to be installed on a fixed grid, the proposed locations are usually strategically placed to assess site conditions.

> Note: Any borehole (and all the records thereof) which is completed with casing as a temporary or permanent monitoring well, will be designated by the monitoring well number only (i.e., MW1-yy). Boreholes drilled strictly as soil test borings in which no casing is set (even if an open-hole groundwater sample is collected) will be designated by the boring number only (i.e., BH1-yy).

Once the final location for the proposed boring has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds. This should confirm the locations of any adjacent utilities (subsurface or overhead) and verification of adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

If possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

| | |
|---|---|
| Caution: | Do not assume site plan details regarding pipe alignments/position are correct. Visually check pipe position when drilling near sewers. Personnel should also be alert to additional piping presence if the plans are outdated. |

If it is necessary to relocate a proposed borehole due to terrain, utilities, access, etc., the Project Coordinator must be notified and an alternate location will be selected.

#### 5.9.2 Sample Collection

A boring is advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the Project Coordinator or Work Plan. Typically, the depth interval for sampling is 2.5 to 5 feet (0.75 to 1.5 m), or less in homogeneous strata, with at least one test and sampling location at every change of stratum. In some cases samples are taken continuously (i.e., 2-foot (0.6 m) long samples at 2-foot (0.6 m) intervals).

Collected soil samples are described in the field using the USCS (visual-manual procedure). The soil description is recorded on a Stratigraphic Log (Overburden) (Form SP-14) or field book in the following order:

1. USCS Soil Symbol of major component
2. Native or fill
3. Secondary and minor soil components
4. Relative densities/consistency
5. Grain-size/plasticity
6. Gradation/structure
7. Color
8. Moisture content
9. Observations of odor or visual chemical presence (i.e., non-aqueous phase liquid [NAPL])
10. Additional descriptions

For environmental sampling, always change gloves between collecting subsequent soil samples to prevent cross-contamination. Decontaminate all tools (e.g., samplers, spatulas) prior to use on each sample to prevent cross-contamination in accordance with the Work Plan or as described in Section 5.6.

Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler, and assures that the standard penetration test (SPT) or other sampling technique is performed on essentially undisturbed soil, is acceptable. The drilling method is selected based on the subsurface conditions. Each of the following methods has proven to be acceptable for specific subsurface conditions:

- HSA with inside diameter between 2.5 and 6.25 inches (5.7 to 15.9 cm)
- Solid stem auger (SSA) with auger diameter between 2.5 and 6.25 inches (5.7 to 15.9 cm)
- Direct-push (dual tube systems, discrete soil sample systems)
- Open-hole rotary drilling
- Wash boring

Several drilling methods are not acceptable. These include:

- Jetting through an open tube sampler and then sampling when the desired depth is reached.
- SSA use below the groundwater table in non-cohesive soils.
- Casing driven below the sampling depth prior to sampling.
- Advancing a borehole with bottom discharge bits.
- Advancing a boring for subsequent insertion of the sampler solely by means of previous sampling when performing SPT (the open hole must be larger in diameter than the split-spoon sampler).

### *Discrete Grab Sampling Methodology for Boreholes*

When borehole drilling, the split-spoon sample retrieved from the borehole is considered a discrete grab sample that has been taken from one sampling location, as long as both the stratigraphy of the entire sample and the level of contamination are consistent over the length of the split-spoon sample. If a single split-spoon sample contains soils from two different stratigraphic units, the soils from each of these stratigraphic units are considered separate discrete grab samples.

If a single split-spoon sample contains soils from a single stratigraphic unit, but visual observation indicated that some of the soil was heavily impacted with contaminants, while the rest of the soil was only lightly impacted, then the soils representing each of the two levels of contamination are considered two separate discrete grab samples.

### *Composite Sampling Methodology for Boreholes*

A composite sample is obtained by combining a number of discrete grab samples from the same borehole. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different split-spoon samples should be from a single stratigraphic unit and have (by visual observation) similar contaminant concentrations (or be physically similar for geotechnical testing purposes).

Use the following methodology for preparing a composite sample from these discrete grab split-spoon samples:

1. Prior to collecting a sample of the soil for field vapor screening or chemical analysis, if smearing of soil is apparent on the outside of the soil core, scrape away the outer layer of the soil using a decontaminated putty knife, stainless steel spoon, or similar implement. This should only be performed if the soil core sample is consolidated. Do not use this procedure for unconsolidated soil samples.
2. Split the sample longitudinally along the length of the split-spoon sampler. Use one half of the core sample to prepare a composite sample to be used in soil headspace vapor screening measurements, and the other half to prepare a composite sample to be submitted to the laboratory for chemical analysis or geotechnical testing.
3. Place sub-samples from various sampling locations (i.e., split-spoon samples) into a zip-loc bag for field screening. As much as practical, attempt to place approximately the same volume of soil from each sampling location into the zip-loc bag.
4. For samples where labo , ratory analysis is also desired, place sub-samples from various sampling locations into the appropriate soil sample containers. As much as practical, attempt to place approximately the same volume of soil from each sampling location into the sample container.

The following subsections describe specific protocols for split-spoon sampling, Shelby tube sampling, and methods for collecting soil samples using a direct-push rig.

#### 5.9.2.1 Split-Spoon Samplers

This method is used to obtain representative samples of subsurface soil materials and to determine a measure of the in situ relative density of the subsurface soils. The test methods described below must be followed to obtain representative samples.

SPT involves the use of split-barrel samplers (also known as split spoons). Split-spoon sampling is performed in accordance with ASTM D1586. The split-spoon sampler consists of an 18- or 24-inch (45 or 60 cm) long, 2-inch (5 cm) outside diameter tube, which comes apart lengthwise into two halves. An example of a split-spoon sampler is presented on Figure 5.2.

> Note: A typical 2-inch (5 cm) outside diameter split-spoon is 1 3/8-inch (3.5 cm) diameter at the drive shoe and 1 1/2-inch (3.8 cm)diameter within the barrel of the split spoon. The volume of the soil in a completely filled 24-inch (61 cm) long split-spoon is approximately 19.8 oz (586 mL), thus the sample volume requirements are important if multiple types of parameters requiring differing analytical techniques are required (i.e., VOCs, SVOCs, metals, petroleum hydrocarbon compounds [PHC]). Soil recovery in a split spoon is often less than 24 inches (61 cm), resulting in less available volume.

Once the borehole is advanced to the target depth and cleared of cuttings, representative soil samples are collected in the following manner:

1. The split-spoon sampler is inspected to ensure it is properly cleaned and decontaminated. The driving shoe (tip) should be relatively sharp and free of severe dents and distortions.
2. The cleaned split-spoon sampler is attached to the drill rods and lowered into the borehole. Do not allow the sampler to drop onto the soil in the bottom of the borehole.
3. After the sampler has been lowered to the bottom of the hole, it is given a single blow to seat it and make sure that it is in undisturbed soil. If there still appears to be excessive cuttings in the bottom of the borehole, remove the sampler from the borehole and remove the cuttings.
4. Mark the drill rods in three or four successive 6-inch (15 cm) increments, depending on sampler length, so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-inch (15 cm) increment.

The sampler is then driven continuously for either 18 or 24 inches (45 or 60 cm) by use of a 140-pound (63.5 kg) hammer. The hammer may be lifted and dropped by either the cathead and rope method, or by using a trip, automatic, or semi-automatic drop system. The hammer should free-fall a distance of 30 inches (±1 inch) (75 cm, ±25 mm) per blow. Measure the drop at least daily to ensure that the drop is correct. To ensure a free-falling hammer, no more than 2 1/4 turns of the rope may be wound around the cathead (see ASTM D1586). The number of blows applied in each 6-inch (15 cm) increment is counted until one of the following occurs:

1. A total of 50 blows have been applied during any one of the 6-inch (15 cm) increments described above.
2. A total of 100 blows have been applied.
3. There is no advancement of the sampler during the application of ten successive blows of the hammer (i.e., the spoon is 'bouncing' on a stone or bedrock).
4. The sampler has advanced the complete 18 or 24 inches (45 or 60 cm) without the limiting blow counts occurring as described above.

In some cases where the limiting number of blow counts has been exceeded, GHD may direct the driller to attempt to drive the sampler more if collection of a greater sample length is essential, as long as the sampler is still being advanced.

On the field form, record the number of blows required to drive each 6-inch (15 cm) increment of penetration. The first 6 inches (15 cm) is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches (15 cm) of penetration is termed the "standard penetration resistance" or the "N-value".

Note: If the borehole has sloughed and there is caved material in the bottom, the split spoon may push through this under its own weight, but now the spoon is partially 'pre-filled'. When the spoon is driven the 18 or 24 inches (45 or 60 cm) representing its supposedly empty length, the spoon fills completely before the end of the drive interval. Three problems arise:

1. The top part of the sample is not representative of the in-place soil at that depth.
2. The SPT value will be artificially higher toward the bottom of the drive interval since the spoon was packed full. These conditions should be noted on the field log.
3. The available sample volume is significantly reduced.

The sampler is then removed from the borehole and unthreaded from the drill rods. The open shoe (cutting end) and head of the sampler are partially unthreaded by the drill crew and the sampler is transferred to the geologist/engineer work surface.

Note: A table made out of two sawhorses and a piece of plywood is appropriate, or a drum, both covered with plastic sheeting.

The open shoe and head are removed by hand by the drill crew or GHD representative, and the sampler is tapped so that the tube separates.

Note: Handle each split spoon with clean disposable gloves if environmental samples are being collected from that split-spoon sample.

Measure and record the length of sample recovered making sure to discount any sloughed material that is present on top of the sample core.

Caution must be used when conducting split-spoon sampling below the groundwater table, particularly in sand or silt. These soils tend to heave or "blow back" into the HSA due to the difference in hydraulic pressures between the inside of the HSA and the undisturbed soil. To equalize the hydraulic pressure, it may be necessary to fill the inside of the HSA with potable water from a reliable and pre-tested source. Drilling mud is uncommonly used and presents problems for sample collection and well development. The water level within the boring or HSA needs to be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling. Since heave or blow back is not always obvious to the driller, it is essential that the water level in the borehole always be maintained at or above the groundwater level. Split-spoon sampling below the water table in sands and silt occasionally results in non-representative samples being collected due to the heaving effect disturbing the soil. This is particularly important if the water level in the hole has not been maintained at the in situ water level.

Heaving conditions and the volume of potable water used should be noted on a Stratigraphic Log (Overburden) (Form SP-14). The volume of water added must be removed during well development prior to groundwater sampling. This practice may not be acceptable if environmental samples are to be collected.

Suspected low N-values should be noted on the field logs. If it is critical to have accurate N-values below the water table, other methods can be employed, such as conducting a dynamic cone penetration test. This quick and easy test involves attaching a cone shaped tip to the end of the drill rods, and driving the tip into the ground similar to the split-spoon method, except that the borehole is not pre-augered. Cones may be driven 20 to 40 feet (6.1 to 12.2 m) through a formation without augering. Blow counts are recorded for each 1 foot (0.3 m) of advancement. Consult the Project Manager if such conditions are unexpectedly encountered.

> Note: A 3-inch (7.5 cm) outside diameter split spoon is available in order to obtain larger sample volumes. However, the SPT values from driving this sampler are typically much higher than those for the 2-inch (5 cm) split spoon.

#### *Larger-Diameter Barrels*

A variation of split-barrel sampling involves the use of a longer, larger diameter barrel in conjunction with a HSA. The sampling barrel is installed inside the auger with a swivel attachment to limit rotation of the barrel. After completion of a 5-foot (1.5 m) auger penetration, the auger is left in place and the barrel retrieved from the borehole. This method provides a larger diameter core, which may be desirable for bench-scale testing or where a large volume of soil is required for sample analyses. The sampler should be handled and the sample retrieved in the same way as described above for split-spoon sampling.

#### 5.9.2.2 Shelby Tube Samplers

Thin-walled samplers such as Shelby tubes are used to collect relatively undisturbed samples (as compared to split-spoon samples) of soft to stiff clayey soils. The Shelby tube has an outside diameter of 2 or 3 inches (5 to 7.5 cm) and is 3 feet (0.9 m) long. These undisturbed samples are used for certain laboratory tests of structural properties (consolidation, hydraulic conductivity, shear strength) or other tests that might be influenced by sample disturbance. Procedures for conducting thin-walled tube sampling are provided in ASTM D1587, and are briefly described below:

1. The soil deposit being sampled must be cohesive in nature, and relatively free of gravel and cobble materials, as contact with these materials will damage or collapse the sampler.
2. Clean out the borehole to the sampling elevation using whatever method that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above groundwater level during the sampling operation.
3. Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.
4. Remove loose material from the center of the casing or HSA as carefully as possible to avoid disturbance of the material to be sampled.
5. Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler into the formation without rotation by a continuous and relatively rapid motion. Usually hydraulic pressure is applied to the top of the drill rods.
6. Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

7. In no case should the length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 inches (7.5 cm) for cuttings.
8. The tube may be rotated to shear the bottom of the sample 2 to 3 minutes after pressing in, and prior to retrieval to ensure the sample does not slide out of the tube. Lift the weight of the rods off of the tube prior to rotating.
9. Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.
10. Package and transport the sample in accordance with project-specific requirements.

Occasionally, the Project Manager/Coordinator may require extraction of the sample from the tube in the field. Use the following procedure:

1. A sample extruder, which consists of a clamp arrangement to hold the tube and a hydraulic ram to push the sample through the tube, is usually provided by the driller. To prevent cross-contamination, ensure the extruder is field cleaned between each sample.
2. The sample is then extruded into a carrying tray; these are often made from a piece of 4-inch (10 cm) or 6-inch (12.5 cm) diameter polyvinyl chloride (PVC) pipe cut lengthwise. Ensure the carrying tray is field cleaned between each sample. The sample is carried to the work station for geologic description. Trim the potentially cross-contaminated exterior and place it in the appropriate container.
3. The Shelby tube sampler is then thoroughly field cleaned and decontaminated for reuse. Since they are thin-walled, the tubes are easily damaged, crimped, or otherwise distorted during handling or pushing. The Shelby tube should be inspected before use and, if significantly damaged, rejected.

#### 5.9.2.3 Direct-Push Sampling Systems

Direct-push refers to the sampler being 'pushed' into the soil material without the use of rotation to remove the soil. This method relies on the drill unit static weight combined with rapid hammer percussion for advancement of the tool string. Soil samples are continuously obtained. Groundwater and vapor samples can also be collected utilizing this method and appropriate tooling. Subsurface investigations typically sample to depths of 30 feet (9.1 m) or more; however, depth will vary based on the site-specific geology.

Direct-push methods are widely used for underground storage tank (UST) investigations and property investigations. This method is used extensively for initial site screening activities to establish site geology and to delineate vertical and horizontal plume presence. Small diameter wells (3/4 or 1 inch [2 or 2.5 cm]) diameter can be installed using direct-push methods, often using a pre-packed screen. SPT values cannot be obtained when sampling with a direct–push discrete soil sampler.

This method is also popular due to the limited cuttings produced during the drilling and sampling process and the increased sampling process speed, which can be much quicker than the sample description and sample preparation process. (It is often helpful to have two people, depending on the nature of the work program.)

Continuous soil samples are collected in tube samplers (various lengths), affixed with a cutting shoe and internal liner (PVC, Teflon, or acetate are available). The soil sampler may be operated in open-mode (when borehole collapse is not a concern), or closed-mode (when minimization of sample slough is desired). Closed-mode operation involves the placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. Once at the required depth, the temporary drill–point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner with soil, is removed for examination.

Caution: Be careful when opening interval liners with knives, as severe cuts may result from the knife slipping. A special two-blade hooked knife is available for opening the liners. Generally the driller/helper will open the liner for you.

### 5.9.3 Field Sample Screening

When soil sampling at sites with known or suspected VOC impact, it is often required to measure the soil for the presence of undifferentiated organic vapors. This field screening can be performed using a photoionization detector (PID). Immediately upon the opening of the split-spoon or discrete soil sampler, the soil is screened with a PID (HNu, Microtip, or equivalent) for the presence of undifferentiated organic vapors. This is accomplished by running the PID along the length of the soil sample. Record the highest reading.

Note: The PID measurement must be taken upwind of the drill rig or any running motors so that exhaust fumes will not affect the measurements.

Another method of field screening is head space measurement. This consists of placing a portion of the soil sample in a sealable glass jar, placing aluminum foil over the jar top, and tightening the lid. The jar is only partially filled. The jar is shaken and set aside for at least 30 minutes. After the sample has equilibrated, the lid of the jar is opened, the foil is punctured with the PID probe, and the air (headspace) above the soil sample is monitored. Record this headspace reading on the field form or in the field book. As an alternative, the soil can be placed in a sealable zip-loc bag.

Note: Perform headspace readings in an area that is not subject to wind. Also, in the winter, it is necessary to allow the samples to equilibrate in a warm area to ±70°F (20°C) (e.g., site trailer or van, but not direct heat or sunshine). The portion of the sample used for headspace analysis cannot be used for VOCs analysis.

Representative portions of the soil sample must be retained for geologic record following description. Place the soil portions into labeled, sealable sample containers (usually mason jars or zip-loc bags) without destroying any apparent stratification. If a stratigraphic change is observed within the split-spoon sampler, a separate geologic record sample is kept.

All geologic record samples are to be retained by the client. Geologic record samples must not return to or be placed in storage at a GHD office. An example of a properly completed Stratigraphy Log (Overburden) is presented on Figure 5.2.

#### 5.9.4 Chemical Description

During soil examination and logging, carefully check for the presence of light or dense NAPL. NAPL may be present in gross amounts or present in small/minute quantities. The adjectives and corresponding quantities used when describing NAPL within a soil matrix are as follows:

| Visual Description | Fraction of Soil Pore Volume Containing NAPL |
|---|---|
| Saturated | >0.5 |
| Some | 0.5 - 0.25 |
| Trace | <0.25 |

A complete description of NAPL must describe the following:

- Color
- Quantity
- Density (compared to water) (i.e., light/floats or heavy/sinks)
- Odor (if observed)
- Viscosity (i.e., mobile/flowable, non-mobile/highly viscous-tar like)

The presence of an "iridescent sheen" by itself does not constitute "NAPL presence", but may be an indicator that NAPL is close to the area.

NAPL presence within a soil matrix may be confirmed by placing a small soil sample within water, shaking, and observing for NAPL separation (i.e., light or dense) from the soil matrix.

Trace amounts of NAPL are identified/confirmed by a close visual examination of the soil matrix, (i.e., separate soil by hand, wearing disposable gloves) and performing a careful inspection of the soil separation planes/soil grains for NAPL presence.

Often during sample examination with a knife, an iridescent sheen will be noted on the soil surface (i.e., clay/silts) if the knife has passed through an area of NAPL.

There are a number of more complicated tests available to confirm/identify NAPL presence, these are:

- Ultraviolet (UV) fluorescent analysis
- Hydrophobic dyes (use with care, consult the health and safety SOPs as some hydrophobic dyes are potential human carcinogens)
- Centrifugation
- Chemical analysis

GHD typically utilizes organic vapor detection results, visual examination, soil/water shake testing, and chemical analysis, to confirm NAPL presence. The more complex techniques described may be incorporated on sites where clear colorless NAPL is present and its field identification is critical to the program.

### 5.9.5 Chemical Sample Preparation and Packaging

Subsurface soil samples are usually grab samples, used to characterize the soil at a specific depth or depth interval (e.g., 2 to 4 feet [0.6 to 1.2 m]). On occasion, composite samples are collected from a borehole over a greater depth interval (e.g., 5 to 15 feet [1.5 to 4.1 m]).

The following describes the collection of grab samples for chemical analysis (all soil from one split spoon). Figure 5.2 shows the split-spoon sample selection details.

#### *Clayey Soils*

1. Discard upper and lower ends of sample core (3 inches [7.5 cm]).
2. Use a precleaned stainless steel knife.
3. Cut the remaining core longitudinally.
4. With a sample spoon, remove soil from the center portion of the core and place in a precleaned stainless steel bowl.
5. Remove large stones and natural vegetative debris.
6. Homogenize the soil and place directly into sample jars.

> Note: Samples for VOC analysis must not be homogenized. Collect soil from the length of the center portion of the core and place in the sample container. Completely fill the container. No air space (headspace) should remain in the sample container.

#### *Sandy Soils*

As sandy soils have less cohesion than clayey soils, it is not easy to cut the core longitudinally to remove the center of the sample. Therefore, with a stainless steel spoon, scrape away surface soils which have likely contacted the sampler and then sample the center portion of the soil core.

> Note: Place all soil samples collected for chemical analysis immediately into a cooler with ice.

Record all soil samples in the sample log book. Label samples as specified in Section 3.9.1.2.

In 1997, EPA adopted new methods for sampling soils for VOC analysis. Method 5035 calls for collecting soil using a coring device (EnCore). For analysis of low-level VOCs (typically 1 to 200 $\mu$g/kg) soil is commonly sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil is placed in a vial with a volume of methanol. This method increases the complexity of collecting soils and makes it imperative that the sampler and laboratory work closely together. For some soil sampling programs, multiple EnCores are required for each sample interval. Holding times for samples in EnCores may be 24 to 48 hours if not field preserved; therefore, the GHD sampler, laboratory, and GHD chemist should discuss sampling and shipping procedures prior to beginning the work program.

### 5.9.6 Physical Sample Preparation and Packaging

When a sample is collected for geotechnical or hydrogeologic properties, the sample needs to be prepared and packaged in a manner to maintain its physical properties. Soil samples are usually grab samples, collected from a specific depth or depth interval (e.g., 2 to 4 feet [0.6 to 1.2 m]). On occasion, composite samples are collected from the borehole over a greater depth interval (e.g., 5 to 15 feet [1.5 to 4.6 m]).

The following describes the collection of grab samples for geotechnical or hydrogeologic purposes for common samplers, the split-spoon, thin-wall, and direct-push discrete soil sampler. For soil samples collected for geotechnical purposes, the samples must not be allowed to freeze.

#### 5.9.6.1 Split-Spoon Samples

1. Following completion of PID screening of the split spoon, remove and dispose of soil at the top of the sample that is obviously sloughed material not representative of the soil at the sampled depth.
2. Measure the length of the sample and record as the recovered length.
3. If cohesive, perform a pocket penetrometer reading and describe the soil.
4. Carefully transfer the sample onto a sheet of aluminum or tin foil, taking care to maintain structure and bedding of the soil sample as much as possible. This may not be possible with non-cohesive soils with low silt or clay contents. The sample may need to be packaged in three 6- to 8-inch (15 to 20 cm) segments.
5. Roll the sample in the tin foil and fold over the ends to seal. Wrap in a second layer of tin foil.
6. Identify the top, middle, and bottom segments with a T, M, and B using an indelible marker.
7. For each segment record the "up" direction with an arrow.
8. Place the foil wrapped sample in a plastic bag and write the sample identification on the bag using an indelible marker. Storing the sample in foil, as opposed to a jar, has the advantage of retaining the soil's in-place structure and preventing loss of moisture.
9. If the soils are sandy and it is not possible to retain the soils structure by rolling it in tin foil, packaging the sample in a jar or zip-loc bag is also acceptable, provided the jar or zip-loc bag is filled to eliminate air space which could result in the soil sample drying out.

A split-barrel sample is approximately 4 inches (10 cm) in diameter and requires different handling than a split-spoon or Shelby tube sample. For a cohesive core sample, the section of drill core is wrapped in several layers of cheesecloth, coated with paraffin wax, and the process repeated until the entire sample is sealed adequately. These samples are usually utilized for specific bench-scale tests.

#### 5.9.6.2 Shelby Tube Samples

1. Remove any sloughed material from the top of the sample using a knife or similar long bladed instrument. If it is not possible to distinguish sloughed soil from intact soil, do not remove.
2. Following removal of sloughed material, measure the tube length and the air space in the tube above the sample and record the difference as the sample recovery. In the unusual circumstance that there is also air space at the bottom of the sample, subtract this as well and record this latter measurement as a separate entry.

3. Seal the top and bottom of the sample with wax (wax is normally provided and prepared by the driller) and first pour the liquefied wax into the top of the sample to a thickness of about 1 inch (2.5 cm). Once this is cooled, remove approximately 1/2 inch (1.3 cm) of soil from bottom of sample (unless there is already a cavity at bottom of sample) and seal similarly.
4. Fill the remaining air space above the sample with loose soil to prevent the sample from shifting in the tube, and then cap both ends of the sample with plastic caps. Tape the caps on using duct tape.
5. Write the sample identification number on the cap using an indelible marker.

Shelby tubes containing soft clays and wet silts need to be handled with care to avoid damage to the sample. Keep samples in an upright position at all times and transport either in a specifically designed cushioned box or position in your vehicle with cushioning under and around the individual tubes. Do not allow geotechnical soil samples to freeze.

#### 5.9.6.3 Direct–Push Soil Samples

1. Once removed to the ground surface, open the discrete soil sampler by removing the cutting shoe, and extract the soil liner (with recovered soil) from the sampler body.
2. Place the soil liner into a holder and cut lengthwise (using a liner knife) to expose the collected soil core.
3. Perform PID screening for organic vapors and record readings.
4. Measure length of sample and record as the recovered length.
5. If cohesive, perform pocket penetrometer reading and describe soil.
6. Carefully transfer the sample onto a sheet of aluminum or tin foil taking care to maintain structure and bedding of the soil sample as much as possible. This may not be possible with non-cohesive soils with low silt or clay contents. The sample may need to be packaged in multiple 6- to 8-inch (15 to 20 cm) segments.
7. Roll the sample in the tin foil and fold over the ends to seal. Wrap in a second layer of tin foil.
8. Identify the depth interval of each segment using an indelible marker.
9. For each segment record the "up" direction with an arrow.
10. Place the foil-wrapped sample in a plastic bag and write the sample identification on the bag using an indelible marker. Storing the sample in foil, as opposed to a jar, has the advantage of retaining the soil's in-place structure and preventing loss of moisture. If the soils are sandy and it is not possible to retain the soils structure by rolling it in tin foil, packaging the sample in one or more jars or zip-loc bags is also acceptable, provided each jar or bag is filled to eliminate air space which could result in the soil sample drying out.

The soil core is split lengthwise to allow inspection. Chemical samples can be removed from the soil core (if required), or soil record samples can be retained (if a component of the project scope). Soil record samples are often retained to allow sample collection for analysis later (depending upon analyte sensitivity/holding times), or for later inspection/geotechnical testing if required.

### 5.9.7 Communication of Field Findings

Field findings should be communicated frequently with the office technical staff responsible for the program. This communication allows the office staff to: confirm that the investigation meets the intent of the Work Plan; alter procedures and sampling protocol if soil conditions are markedly different from those assumed; and assist in determining screening intervals for piezometers or monitoring wells.

Call office staff no later than the completion of the first borehole, and sooner if possible. Be prepared to discuss the results by faxing the field logs beforehand (wherever possible) and by having a copy of the field log in hand when on the telephone. Call after each borehole and call before leaving the site.

### 5.9.8 Borehole Abandonment

Following completion of the borehole it must be properly abandoned in accordance with the project documents. Some jurisdictions have requirements or standards of practice that require filling the borehole with bentonite or cement grout.

> Note: The integrity of any underlying confining layer must be restored to prevent chemical cross-contamination or hydraulic cross-connection. This is true for all sites, regardless of the known presence or absence of contaminants. This normally requires grouting of the borehole within the zone of the confining layer.

Whenever possible, the cuttings are returned to the borehole to within 1 foot (0.3 m) of the ground surface. The remainder of the borehole is topped off with material consistent with the surrounding ground surface. Excess cuttings are usually collected in drums or a lugger box or spread on the surrounding ground surface consistent with the protocols specified in the Work Plan and as required by federal, state, provincial, and local regulations.

Check with the Project Coordinator to determine the method for handling drill cuttings.

> Note: Always include the method of abandonment in the field log book or on a Stratigraphic Log (Overburden) (Form SP-14)

### 5.9.9 Borehole Tie-In/Surveying

Recording the locations of boreholes on the site plan is extremely important, and may be accomplished by manual measurement (i.e., swing ties) and surveying. Manual measurements for each borehole must be tied into three permanent features (e.g., buildings, utility poles, hydrants). Include diagrams with measurements in the field book.

In addition to manual measurements, surveying with respect to a geodetic benchmark and a site coordinate system is often completed at larger sites for horizontal and vertical control.

> Note: Manual field measurements are always necessary regardless of whether a survey is completed.
> Manual measurements in field notes allow future identification of the sample/drill site without the need for a survey crew to locate positions using a grid system. This becomes important when trying to locate flushmount wells buried by snow or soils.

#### 5.9.10 Field Notes

Field notes must document all the events, equipment used, calibration activities, and measurements collected during the sampling activities. The field notes must be legible and concise such that the entire borehole installation and soil sampling event can be reconstructed for future reference.

Field notes documenting events, equipment used, and related items are typically recorded in a standard GHD field book, while soil descriptions and PID readings are recorded on a Stratigraphic Log (Overburden) (Form SP-14). Standard GHD field books are available from all GHD equipment administrators. Form SP-14 is available as a printable linked document in this file or as a bound pad from each office.

> Note: Use a Stratigraphic Log (Overburden) for recording all soil descriptions and related notes unless otherwise approved by the Project Coordinator/Manager.

Field book/form entries are made in black ink and any changes/corrections are stroked out with a single line, initialed, and dated to indicate when and by whom the correction was made.

The field notes should document the following for each borehole completed:

1. Identification of borehole
2. Depth
3. Static water level depth and measurement technique
4. Time started and completed
5. Measured field parameters
6. Sample appearance
7. Sample odors (if respiratory protection is not required)
8. Types of sample containers and sample identification numbers
9. Parameters requested for analysis
10. Field analysis data and method(s)
11. Sample distribution and transporter
12. Laboratory shipped to
13. Chain-of-custody number for shipment to laboratory
14. Field observations on sampling event
15. Name of collector(s)

16. Climatic conditions including air temperature

17. Problems encountered and any deviations made from the established sampling protocol

## 5.10 Procedures for Test Pit Excavation and Sampling

Once the prior planning and preparation activities are completed, the test pit excavation and subsurface soil sampling program can proceed. The typical series of events which takes place is:

1. Location and marking of test pit locations
2. Final visual examination of proposed excavation area for utility conflicts
3. Excavation of test pits and collection of the soil samples
4. Field screening of soil sample with specific air monitoring equipment (e.g., PID, LEL meter)
5. Description of soil sample and test pit
6. Completion of Test Pit Stratigraphy Log (Form SP-03)
7. Documentation, including photographs and/or videotape, as required
8. Chemical sample preparation and packaging
9. Backfilling of test pit excavation
10. Surveying of test pit locations
11. Field note completion and review.

### 5.10.1 Location and Marking of Test Pits/Final Visual Check

Proposed test pit locations marked on the site plan are located in the field and staked. The proposed test pit locations are usually strategically placed to assess site conditions, former facilities, waste areas, etc.

Once the final location for the proposed test pit has been selected and utility clearances are complete, one last check of the immediate area is performed before excavation proceeds to confirm the locations of any adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers are opened and the conduit/sewer alignments confirmed.

| | |
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| Caution: | Do not assume site plan details regarding pipe alignments/position are correct. Visually check pipe position when excavating near sewers. Personnel should also be alert to the presence of additional piping, especially if the plans are outdated. |

If it is necessary to relocate a proposed test pit due to terrain, utilities, access etc., the Project Coordinator must be notified and an alternate location will be selected.

### 5.10.2 Test Pit Location Setup

The test pit location is set up as follows:

1. The excavator is positioned such that the excavation spoils are deposited by the excavator downwind of all staff.
2. A sheet of polyethylene is placed downwind of the test pit location to accept spoils, if required by the Work Plan.
3. To the extent practicable, the investigation area is set up such that water or liquids that may be excavated, freely drain back into the excavation.
4. The excavation begins at one location with the excavator backing up (as required) to extend the pit.

### 5.10.3 Sample Collection

Soil samples can be collected from the backhoe/excavator bucket or from the test pit excavation face. Samples which require a discrete depth interval are collected from the excavator bucket following excavation of all or a portion of the test pit. Samples are collected using a cleaned steel trowel, shovel, or stainless steel spoon. Samples are placed in a stainless steel bowl and mixed (except VOCs). **Do not enter the test pit**. (Confined Space Entry requirements apply and proper shoring of the excavation walls may be necessary.)

| | |
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| Caution: | Personnel observing or sampling test pit operations must never stand within the "turning radius" or "reach-zone" of the excavation equipment. Operator error or equipment failure could result in severe injury or death if struck by the backhoe bucket or the backhoe itself. Stand opposite the backhoe well beyond the far end of the trench for communication.<br>Personnel should also be alert to test pit side wall conditions which typically undermine the ground surface and create unstable soils surrounding the test pit area. |

#### *Discrete Grab Sampling From Test Pits*

When taking discrete grab samples from a test pit using an excavator bucket, the sampling location is considered a volume of soil in the bucket that has both a consistent soil type and a consistent level of contaminant impact. When sampling using an excavator bucket, the operator will dig to the desired depth and then provide a small volume of soil from a discrete position and depth in the test pit.

When collecting a discrete grab sample from the excavator bucket, use the following procedure:

1. Scrape off the top 2 inches (5 cm) of soil at the sampling location in the excavator bucket.
2. Using the sampling device (e.g., trowel, spoon) scoop the freshly exposed soil into the sample container. Ensure that the samples taken were not in contact with the excavator bucket to avoid the potential for cross-contamination.

3. Pushing the sample container into the soil in order to fill the container is not recommended. This could result in breaking the sample container and potential injury to field personnel (e.g., cutting hands on broken glass).
4. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil.
5. Collect a field screening sample from the same sampling location as the discrete grab sample and at the same time. Scoop soil into a zip-loc bag until it is no more than one quarter full.
6. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

### *Composite Sampling*

A composite sample can be obtained by combining a number of discrete grab samples from a test pit sampling location (i.e., excavator bucket). For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should be from a single stratigraphic unit and have (by visual observation) similar contaminant concentrations.

When taking composite samples from multiple excavator buckets, consider each excavator bucket of soil to be a sampling location. When taking a composite sample using the excavator, use the following procedure:

1. Pick a number of discrete sampling locations that will give a representative sample of the horizon of interest in the test pit.
2. From each of these sampling locations, obtain a soil sample from the excavator bucket using the same methodology described in the previous subsection for a discrete grab sample.
3. The sample container should be partially filled with soil from each discrete grab sampling location. As much as practical, try to put approximately the same volume of soil from each sampling location into the container.
4. Move to the next sampling location and obtain another discrete grab soil sample.
5. Collect a maximum of five surface samples (to avoid the complete dilution of any hot spots).
6. When the last location has been sampled, ensure the sample container is filled with soil, leaving no headspace.
7. Since composite samples are used for SVOCs and inorganic parameters, minimizing the sample collection time is not as important as when discrete samples for VOC analyses are being collected. However, the preferred practice is that the sampler take no longer than necessary to obtain the sample.
8. Collect a field screening sample from the same sampling location as the composite sample and at the same time. As much as practical, try to put approximately the same volume of soil from each discrete grab sampling location into a zip-loc bag. The zip-loc bag should be no more than one quarter full after all the sub-samples have been added.

### 5.10.4 Field Sample Screening

Upon collection of a soil sample, the soil is screened with a PID (HNu, Microtip, or equivalent) for the presence of undifferentiated organic vapors. This is accomplished by running the PID across the soil sample. Record the highest reading and sustained readings.

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| Note: The PID measurement must be taken upwind of the excavating equipment or running motors so that exhaust fumes will not affect the measurements. |

Another method of field screening is head space measurement. This consists of placing a portion of the soil sample in a sealable glass jar, placing aluminum foil over the jar top, and tightening the lid. The jar should only be partially filled. Shake the jar and set aside for at least 30 minutes. After the sample has equilibrated, open the lid of the jar, puncture the foil with the PID probe, and monitor the air (headspace) above the soil sample. Record this headspace reading on a Test Pit Stratigraphy Log (Form SP-03) or in the field book.

| |
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| Note: Perform all headspace readings in an area that is not subject to wind.<br>Also, in winter it is necessary to allow the samples to equilibrate in a warm area (e.g., site trailer or van). This requirement is usually dictated by the Work Plan. |

### 5.10.5 Sample Description and Logging of Test Pits

During the excavation of a test pit, samples may be collected to provide a geologic record, to assist the geologist/engineer in completing or characterizing the stratigraphic units, and to allow for physical or chemical testing.

Soil samples collected are described in the field using the USCS. The soil descriptions are recorded on the field form or field book in the following order:

1. USCS Soil Symbol of major component
2. Native or fill
3. Secondary and minor soil components
4. Relative densities/consistency
5. Grain size/plasticity
6. Gradation/structure
7. Color
8. Moisture content
9. Observations of odor or visual chemical presence (i.e., NAPL)

In addition to describing the soil properties, enter the following information into a Test Pit Stratigraphy Log (Form SP-03):

1. Presence of groundwater and the rate of seepage (if groundwater is encountered).
2. Thickness of each stratigraphic unit.

3. Description of bedding plane features (e.g., continuous, discontinuous, graded, wavy bedding).

4. Description of joints, fractures and faults, if bedrock is encountered (number and orientation).

5. Any appearance of weathering.

6. Description of fill and waste materials.

> Note: When describing observed odors, be specific in terms of general odor category and strength of odor noted. Odors may typically be chemical, petroleum, or septic related, varying from slight, to moderate, to strong. Identification of specific chemical compounds (i.e., TCE or C-56 odor) is usually unnecessary and often inaccurate as a detailed analysis commonly shows an array of chemistry present.
> When describing the presence of vegetative matter in the soil sample, do not use the term "organic" as this often leads to confusion with regards to the presence of organic chemicals (i.e., NAPL).

When describing the soil samples and the stratigraphy observed in the test pit, it is imperative that the sampler use consistent terms from one test pit to the next. As test pits are installed, compare the stratigraphy of completed test pits to the stratigraphy of the test pit you are currently excavating. Be aware of patterns and confirm all inconsistencies at the time the test pit is being excavated. Since soil stratigraphy is so important to understanding site conditions, soil samples are collected from each stratigraphic unit, and described in full.

#### 5.10.6 Chemical Description

Representative portions of the soil sample should be retained as a geologic record along with a description. Place the soil portions into labeled, sealable, sample containers (usually mason jars) without destroying any apparent stratification.

All geologic record samples are to be retained by the client. Geologic record samples must not return to or be placed in storage at a GHD office.

An example of a properly completed Test Pit Stratigraphy Log is presented on Figure 3.12 and described in Section 3.4.1.5.

During soil examination and logging, carefully check for the presence of light or dense NAPL. NAPL may be present in gross amounts or present in small/minute quantities. The adjectives and corresponding quantities used when describing NAPL within a soil matrix are as follows:

| Visual Description | Fraction of Soil Pore Volume Containing NAPL |
|---|---|
| Saturated | >0.5 |
| Some | 0.5 - 0.25 |
| Trace | <0.25 |

A complete description of NAPL includes the following:

- Color
- Quantity

- Density (compared to water) (i.e., light/floats or heavy/sinks)
- Odor (if observed)
- Viscosity (i.e., mobile/flowable, non-mobile/highly viscous-tar like)

The presence of an iridescent sheen by itself does not constitute NAPL presence, but may be an indicator that NAPL is close to the area.

NAPL presence within a soil matrix may be confirmed by placing a small soil sample within water, shaking, and observing for NAPL separation (i.e., light or dense) from the soil matrix.

Trace amounts of NAPL are identified/confirmed by a close visual examination of the soil matrix, (i.e., separate soil by hand [wearing disposable gloves]) and perform a careful inspection of the soil separation planes/soil grains for NAPL presence.

Often during the sample examination with a knife, an iridescent sheen will be noted on the soil surface (i.e., clay/silts) if the knife has passed through an area of NAPL.

There are a number of more complicated tests available to confirm/identify NAPL presence, these are:

- UV fluorescent analysis
- Hydrophobic dyes
- Centrifugation
- Chemical analysis

GHD typically utilizes organic vapor detection results, visual examination, soil/water shake testing, and chemical analysis, to confirm NAPL presence. The more complex techniques described may be incorporated on sites where clear colorless NAPL is present and its field identification is critical to the program.

### 5.10.7 Chemical Sample Preparation and Packaging

Subsurface soil samples are usually grab samples, used to characterize the soil at a specific depth or depth interval (e.g., 2 to 4 feet [0.6 to 1.2 m]). On occasion, composite samples are collected from a test pit over a greater depth interval (e.g., 5 to 15 feet [1.5 to 4.6 m]).

The following describes the collection of grab samples for chemical analysis.

#### *Clayey Soils*

Scrape away the surface soils and collect the sample. Remove large stones and natural vegetative debris and homogenize the soil and place it directly into the sample jars.

> Note: Samples for VOC analysis must not be homogenized. Remove the outer layer of soil from the excavation face then collect the sample and place it in the sample container. Completely fill the container. No air space (headspace) should remain.

*Sandy Soils*

As sandy soils have less cohesion than clayey soils, with a stainless steel spoon or other device scrape away surface soils which have likely contacted the backhoe/excavator bucket, then collect the sample.

| |
|---|
| Note: All soil samples collected for chemical analysis must be placed immediately into a cooler with ice. |

Record all soil samples recorded in the sample log book as described in Section 3.4.1. Labeling of samples shall be consistent with Section 3.9.1.2.

#### 5.10.8 Documentation

In addition to completing all field logs and books, it will generally be necessary for test pits to be documented with photographs and/or video tape. This requirement should be fully ascertained and coordinated in advance of field activities.

#### 5.10.9 Test Pit Abandonment

Following completion of the test pit, backfill the excavation using the soil excavated from the pit. To the extent practicable, replace materials in the test pit in the same intervals from which they were extracted.

It should be noted that the material will tend to "bulk" after excavation. As a result, the excavator operator must be informed to compact the materials as they are replaced within the excavation.

#### 5.10.10 Restoration

The test pit location must be fully restored. Ensure that restoration activities are properly designed and incorporated within the scope of services for the test pit contractor.

Restoration could include:

- Landscaping
- Paving
- Concrete

### 5.11 Follow-up Activities

Complete the following activities at the conclusion of the field work:

1. Double check the Work Plan to ensure all samples have been collected and confirm this with the Project Coordinator.
2. Ensure that all sample locations are surveyed such that the sample location could be readily re-established.

3. Clean equipment and return to the equipment administrator with the appropriate form dated and signed. Complete water disposal (if required), and cleaning fluid disposal requirements as specified in the Work Plan.
4. Notify the contract laboratory as to when to expect the samples. Enclose the chain-of-custody and covering letter, indicating the parameters and number of samples, in the sample cooler. Ensure that the GHD chemist has all relevant information required to track the progress of the sample analysis.
5. Submit a memo to the Project Coordinator indicating sampling procedures and observations (such as surface staining), grid layout, and all QA/QC documentation.
6. Prepare and distribute a Project Planning, Completion, and Follow-Up Checklist (Form SP-02).

## 5.12 References

For additional information pertaining to this topic, the user of this manual may reference the following:

### *Surficial Soil Sampling*

| | |
|---|---|
| ASTM D4547 | Practice for Sampling Waste and Soils for Volatile Organics |
| ASTM D6044 | Guide for Representative Sampling for Management of Waste and Contaminated Media |
| ASTM D6051 | Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities |

### *Subsurface Soil Sampling*

| | |
|---|---|
| ASTM D420 | Guide for Site Characterization for Engineering, Design, and Construction Purposes |
| ASTM PS 89 | Guide for Expedited Site Characterization of Hazardous Waste Contaminated Sites |
| ASTM D5434 | Guide for Field Logging of Subsurface Explorations of Soil and Rock |
| ASTM D2487 | Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D2488 | Practice for Description and Identification of Soils (Visual-Manual Procedure) |
| ASTM D5781 | Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D5782 | Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D5783 | Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices |

| | |
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| ASTM D5784 | Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D5872 | Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D5875 | Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D5876 | Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices |
| ASTM D4700 | Guide for Soil Sampling from the Vadose Zone |
| ASTM D1586 | Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils |
| ASTM D1587 | Practice for Thin-Walled Tube Geotechnical Sampling of Soils |
| ASTM D4220 | Practices for Preserving and Transporting Soil Samples |
| ASTM D6001 | Guide for Direct-Push Water Sampling for Geoenvironmental Investigations |

# APPENDIX D

## SOIL VAPOR INSTALLATION AND SAMPLING SOPS

# SOIL GAS MONITORING POINT INSTALLATION AND SAMPLING

# STANDARD OPERATING PROCEDURE

Prepared by and for

HAMP, MATHEWS & ASSOCIATES, INC.

Updated
May 5, 2020

## Introduction

The installation of soil gas sample points will generally be performed in accordance with the MEGLE (2013) *Guidance Document for the Vapor Intrusion Pathway* which includes standard operating procedures (SOPs) in Appendix F.1 for the installation of soil gas monitoring points, and collection of soil gas samples utilizing the United States Environmental Protection Agency (USEPA) Method TO-15 as described in Appendix F.3. The MEGLE (2013) guidance provides flexibility regarding the installation of soil gas monitoring points to adapt techniques and materials to reflect site-specific conditions.

## Personnel and Health and Safety Considerations

Field personnel shall review the project health and safety plan and this SOP prior to mobilization to the site. Field personnel are expected to receive a briefing from the project manager or supervisor to discuss the scope of the work and project objectives. The briefing shall also encompass known or suspected chemicals of concern, physical hazards, and site conditions.

Field personnel shall be up to date with HAZWOPER refresher courses and first aid training.

## Utilities

During any subsurface work, all members of the project team are to consider the likelihood of utilities both overhead and below ground level. Overhead utilities are usually wires associated with telephone, television, and electrical services. These wires may also be located in the subsurface. Other subsurface utilities may include water supply; natural gas, propane, or other fuels; sewer; drain tiles or piping; irrigation system lines; and electric supply to outbuildings, signs, or lighting.

The use of tools for drilling or boring shall maintain a minimum of 10 feet of clearance from any overhead wires. Keep in mind that this 10-foot distance is required through the advancement and retraction of tools from a borehole. For instance, when removing a hand auger from the borehole to empty the bucket, do not raise the handle near overhead wires.

For each property, call MISS DIG System Inc. (800-482-7171) to request utility marking a minimum of three days prior to planned field work. Information requested by MISS DIG is the property address and nearest cross road. Describe the location on the property where subsurface work will be performed or if the entire property is to be marked.

Utility locating services will mark individual lines or leads up to the structure, but secondary lines leading out from the main building to other locations will not likely be marked by these services. The field supervisor shall inquire with the property owner or representative to gain knowledge of any subsurface utilities which may be in the proximity of the field activities.

## Equipment

The equipment necessary to install soil gas monitoring points may vary depending on the site conditions and project requirements. Field personnel shall review and prepare necessary equipment and additional equipment and supplies specific to the work scope for the site.

Often, subsurface obstructions such as rocks or very tight soils preclude boring with a hand auger. Consequently, a Geoprobe® is used to create a borehole to a desired depth for soil gas point installation.

Typical equipment will include the following items:

- Field notebook;
- Site map;
- Blank boring log pages;
- Personal protective equipment (PPE) appropriate to the site;
- Geoprobe®;
- Spud bar;
- Hand shovel;
- Plastic sheeting;
- Photo-ionization detector (PID);
- 1½-inch PVC pipe, 6 feet long;
- Tape measure;
- 3-inch long by 0.5-inch outside diameter stainless-steel mesh soil gas implant (http://www.envservprod.com/3-Stainless-Steel-Implant-with-Speed-Fit-Fitting-P1927C5.aspx or similar);
- ¼-inch Teflon® tubing;
- ¼-inch valve (brass or stainless steel with compression fittings);
- Coarse well-pack sand;
- Fine granular bentonite clay;
- Potable water;
- Powdered bentonite and water to mix a thick slurry;
- Latex or nitrile gloves;
- Work gloves;
- Flush mount protective cover;
- Redi-mix concrete, and
- 50-ml to 100-ml plastic syringe.

## Soil Gas Monitoring Point Installation

The depth of the soil gas monitoring point is to be set at approximately 5.0 to 5.5 feet below ground level, possibly deeper depending on the depth to groundwater; however, the monitoring point must be at least 1 foot above the groundwater. Additionally, if a basement is present in nearby buildings, the soil gas monitoring point may need to be set deeper to represent the soil gas in relation to the subsurface structure. The HMA project manager will assess project objectives and determine the depth requirements of monitoring points.

Field personnel are to examine marked utilities and consider other unmarked subsurface utilities that may be near the location of the soil gas point. Examine clearance from overhead wires.

If surface pavement is present at the sampling location, set up a coring machine and bore through the pavement. Generally, a 6-inch diameter hole is needed to install a 4-inch flush-mount cover. Water is necessary to lubricate and cool the core bit. Stop the coring machine once the pavement has been fully penetrated.

If no surface pavement is present, remove landscaping or other vegetative ground surface cover. Lay plastic sheeting on the surface to cover an area of about 4 feet by 4 feet. Cut an opening in the center of the plastic at the soil gas point location. Initiate Geoprobe® process, and describe the soil cuttings on a boring log form. Take readings with the PID every foot and record on the boring log form. Continue geoprobing to the desired depth while describing soil cutting and taking PID readings. Note soil moisture conditions. If very moist or wet soils are encountered, the depth of soil gas point installation will be adjusted; wet soils less than 3 feet below ground surface will be evaluated for soil gas installation based on professional judgment and/or consult with MEGLE. If groundwater is encountered, allow water to rise in the borehole to static conditions. Do not install the 3-inch stainless-steel mesh implant closer than one foot above water saturation.

Measure the depth of the hole with the tape measure. Insert the PVC pipe to the bottom of the borehole. Pour filter sand through the pipe to place approximately 1 inch across the bottom of the hole. Raise the pipe, and lightly tamp the sand. Measure the depth to the filter sand. Assemble the stainless-steel implant onto the Teflon® tubing and lower to the bottom of the hole through the PVC pipe. Add filter sand inside the pipe until 2 to 3 inches above the implant. Continually raise the pipe and lightly tamp the sand to compact around the implant. Take measurements as needed to assure the sand pack is correct and to record the final depth to the top of the sand. The PVC pipe can be removed at this point.

Pour 6 to 8 inches of dry granular bentonite into the borehole and hydrate with a small amount of potable water every 3 to 4 inches. The remainder of the borehole can be backfilled with soil cuttings tamped every 6 inches to firmly pack.

Cut the Teflon® tubing approximately 3 inches above ground level and affix a tubing cap over the end. Record the depth intervals of the sand pack, implant, and bentonite on the boring log and/or field notebook.

The soil gas point installation process introduces atmospheric air into the sand pack around the implant. Affix the plastic syringe to the valve on the soil gas point. Purge air from the sand pack by slowly drawing 400 to 600 ml from the soil gas point.

For the surface completion, install a flush-mount protective cover. The flush mount is to be cemented in place. Restore the surface to original conditions as closely as possible. Clean the surface as needed. Disposal of excess soil will be determined by the project manager and landowner.

Take measurements of the soil gas point location in relationship to physical features (e.g., corner of the building, distance from building, sidewalks, and driveways). Record these measurements in the field notebook and site map.

It is recommended to allow a minimum of 24 hours for the soil gas point to equilibrate with the surrounding soil before collecting soil gas samples.

## Soil Gas Sampling Equipment

Soil gas sampling from the soil gas implants will typically follow the procedures of indoor sub-slab soil gas points, including the use of a helium tracer gas test for possible leakage in the sample train and/or annulus of the borehole. Field equipment includes:

- Teflon® tubing and air-tight connections;
- 1-liter Bottle-Vac™;
- Flow regulator and gauges;
- Helium detector;
- Clear plastic shroud;
- Landtec GEM™ 5000 landfill gas meter;
- PID;
- ¼-inch Master Flex® tubing;
- Zip ties;
- Soil gas sampling field data sheet;
- Field notebook;
- Chain of custody;
- Latex or nitrile gloves; and
- Hand tools – open-end wrench, Channel Lock® pliers, etc.

## Soil Gas Sample Collection

Sampling personnel should avoid activities immediately before and during the sampling process that may contaminate the sample, such as using personal care products, using marking pens, and fueling vehicles, etc. Record the weather conditions, and the time, in the field notebook. Note the temperature, precipitation, if precipitation had occurred in the past 24 hours, likelihood of frozen ground, and damage or suspected changes to the surface completion. If water is apparent in the soil gas point during sampling, note this in the field notebook and postpone sampling.

Field measurements oxygen, carbon dioxide, and methane are taken with a Landtec GEM™5000 portable gas analyzer and extraction monitor or similar instrument. The electronic meter is connected to the tubing via supplied tubing and fittings. The GEM™5000 draws in air at a typical flow rate of 300 milliliters/minute (ml/min). Tubing with a ¼-inch inside diameter has approximately 10 ml of volume per foot. Five feet of tubing can be purged in about 10 seconds.

The GEM™5000 has a response time of less than 20 seconds. It analyzes and displays concentrations of oxygen, carbon dioxide, and methane. The instrument also offers data logging capabilities to internally store readings manually or automatically. Attach the GEM™5000 to the sample tubing. The cap at the top of the soil gas point tubing is opened, and the portable gas analyzer tubing is connected to begin operation and collection of at least three readings. The first reading is usually a mix of air within the analyzer and tubing along with some soil gas. The last two readings represent the soil gas after the instrument and tubing is purged. These last two readings are compared to determine if stabilization has occurred. All three instrument readings will be recorded on a field sampling data sheet. No more than three readings with the GEM™5000 are recommended to avoid over purging.

Following measurements with the GEM™5000, the soil gas point tubing is purged, and a helium leak test procedure is performed, prior to volatile organic carbon (VOC) sampling.

A helium leak test is conducted to verify that there is no more than a minimal amount of leakage within the sample train (including the flow regulator) or through the soil gas point installation. Introduce helium into the shroud. If helium is detected in tubing extending from the shroud, check all connections for tightness. All connections in the sample train may need to be disconnected and then reassembled to eliminate the leak. Also, verify that the soil gas point tubing is sealed within the boring or flush mount. If the tubing is within a cemented flush mount, a small amount of water poured around the tubing should determine the adequacy of the seal. If the water drains readily, the tubing may not be sealed from the atmospheric air. If the water doesn't drain, the seal is verified.

Rerun the helium test. The helium detector may need to be zeroed if background helium is detected (helium will be slowly released from the shroud). If helium is again detected, the soil gas point may have to be abandoned and replaced. First, verify all points of entry of helium are sealed and that the helium detector is operating correctly by testing in unaffected air.

Following the successful completion of the tracer gas test, the shroud is removed.

Attach the Bottle-Vac™ sampler to the quick connect fitting on the flow regulator supplied by the laboratory. Record the initial vacuum reading of the Bottle-Vac™ sampler. Flow is regulated with a critical orifice within the flow controller, which is set by the laboratory at 200 ml/min. Check the initial pressure of the vacuum gauge on the flow regulator. Pre-sampling vacuum should be in the range of -30 and -25 inches of mercury. Monitor the vacuum gauge. Bottle-Vac™ samplers with vacuums outside the range will be replaced with a new Bottle-Vac™ sampler, and the new Bottle-Vac™ will be checked as described. Record the start time.

Stop sample collection with a vacuum reading of 2 to 4 inches of mercury remaining. Disconnect the Bottle-Vac™ sampler from the quick connect fitting on the flow regulator. Record the ending time and pressure reading on the vacuum gauge.

Remove the flow regulator apparatus from the sample point tubing and affix the end tube cap on the tubing. Fill out the sample label on the Bottle-Vac™ sampler, and record the sample on the chain of custody. Complete other forms provided by the laboratory. Insert the Bottle-Vac™ sampler in the package provided by the laboratory.

Assure that the soil gas point end cap is affixed and replace the flush-mount cover.

Submit the soil gas samples to the laboratory for analysis of the project constituents of concern.

# HMA STANDARD OPERATING PROCEDURE

## TO-15 Soil Vapor Bottlevac® Sampling Utilizing Leak Test Kit


### Summary

This Standard Operating Procedure (SOP) outlines the process taken when sampling for soil vapor for volatile organic compounds (VOCs) via United States Environmental Protection Agency (EPA) Method Toxic Organics-15 (TO-15). This SOP covers the purge process, leak detection process, and sampling process.



Dylan Harter


September 21, 2023

## 1.0 PURPOSE

1.1 The purpose of this SOP is to outline the procedures involved when Bottlevac® sampling for soil vapor following US EPA Method TO-15. This procedure applies to both sub-slab soil vapor sampling and exterior soil vapor implant sampling. Purging and leak testing is also covered in this SOP, as it is a critical component of proper soil vapor sampling.

## 2.0 SCOPE

2.1 The scope of this SOP is to outline the proper procedures to be taken when collecting a Bottlevac® soil vapor sample for EPA Method TO-15. The proper sampling procedure is broken down into three steps: Puring, Leak Testing, and Sample Collection. Ensuring each step is completed correctly is critical to collect a representative sample of soil vapor conditions. Analytical results gathered from the sample will then be used in comparison to applicable criteria to determine if the potential for an unacceptable exposure risk exists in the area.

## 3.0 HEALTH AND SAFETY

3.1 Review of the site-specific health and safety plan (SS HASP) should always occur prior to mobilization to the site/work area. All HMA field personnel should be up to date with training such as but not limited to HAZWOPER, first aid, etc. Field personnel should also note any health and safety training required for the specific site.

## 4.0 SUPPLIES AND EQUIPMENT

### 4.1 Supplies

- 1L Bottlevac® sampler devices (laboratory supplied)
- Leak tested Bottlevac® flow controllers (laboratory supplied)
- Leak tested Masterflex® tubing
- HMA Soil Vapor Field Sheets
- Sample Bottle Labels
- Site-Specific Yellow Log Book(s)
- Laboratory Chain-of-Custody

### 4.2 Equipment

- Hand tools (for opening soil vapor wells and/or VaporPin® caps)
- Site keys (where applicable)
- GEM5000 Landfill Gas Analyzer
- MiniRAE 3000+ PID (10.6ev lamp for pVOC sites, 11.7ev lamp for cVOC sites)
- Acrylic Leak Test Chamber
- 50 mL syringe
- Compressed Ultra High Purity Argon Gas
- Argon Gas Analyzer

## 5.0 PURGING PROCEDURE

5.1 Power on GEM5000 landfill gas analyzer. Power on PID. Insert GEM5000 effluent hole into PID tip. Run GEM5000 for one 30 second interval to confirm functionality. Gas concentrations should be representative of atmospheric concentrations, and PID values should be zero.

5.2 Record weather conditions in both yellow log book and each field sheet. Determine if a rain event has occurred in 24 hours. If so, contact the Project Manager for further instructions.

5.3 Open the soil vapor well or VaporPin® cap. Note any abnormalities to the sample point (damage, pavement staining, etc.).

5.4 Connect GEM5000 influent tubing to soil vapor well tubing or VaporPin®. Insert PID tip to GEM5000 effluent hose.

5.5 Allow GEM5000 to run for 30 seconds, monitoring PID fluctuations during the vapor purging. Simultaneously, monitor the GEM5000 intake tubing to determine if water is present at the sample location. If water is present during purging, quickly remove the intake tubing from the back of the GEM to avoid water being drawn into the device.

5.6 After GEM has finished the 30 second run time, record the volume percentages of oxygen, carbon dioxide, and methane. Also record the approximate highest PID reading. For soil vapor wells, repeat process for three times, and for VaporPins® repeat process only twice.

5.7 Following completion of the GEM5000 and PID readings, return the protective white cap to the tip of the soil vapor implant or VaporPin®

## 6.0 LEAK TEST PROCEDURE

6.1 Power on the argon leak detection device. Allow the device to automatically perform a warmup procedure for approximately 90 seconds.

6.2 Gather an unused 1L Bottlevac® and unused regulator flow controller. Cut a three-inch piece of leak test tubing and connect to the end of regulator flow controller.

6.3 Record the Bottlevac® I.D. and regulator I.D. in the HMA field sheet, and yellow logbook.

6.4 Set aside the Bottlevac® and connect the regulator to the sample port by use of the leak test tubing. If regulator is equipped with a value, make sure it is in the off position.

6.5 Utilizing the leak detection chamber, connect the male push-to-connect fitting on the chamber into the female quick connect regulator port.

6.6 Open the valve on the regulator and then cover the entire sample train (regulator, sample port) with the acrylic chamber.

6.7 Connect a three-way valve to the chamber tubing connected to the regulator. Position the regulator so both of the open sides are closed.

6.8 Open the main valve on the argon tank and connect the other chamber tubing to the barb fitting on the tank regulator. Open the valve on the sampling regulator (if applicable).

6.9 Introduce a 10 second blast of argon into the leak test chamber. Then draw a vacuum on the sampling train by connecting the syringe to the three-way valve, and set the valve to the on position.

6.10 Allow the regulator and sample port to achieve equilibrium (no resistance on the syringe).

6.11 Insert the argon detector tip into the other side of the three-way valve. Close the syringe valve leaking only the section with the argon tip open. Monitor the percent of argon on the meter and confirm no argon is present inside the tubing connected to the regulator. Record the results on the field sheet. If argon is detected repeat the process with a new regulator noting the failure on the field sheet.

6.12 If the second regulator fails, evaluate the leak chamber connections and/or sample port connections. Repeat the test a third time, and if failure is encountered, cease testing and contact the Project Manager. If the test passes proceed onto step 6.13

6.13 Once confirmation on the integrity of the sample train is completed, close the sample regulator valve (if equipped) and set aside the leak chamber.

6.14 Proceed by swiftly connecting a new 1L Bottlevac® via the push-to-connect fittings and open the sample regulator (if equipped). Note the sample start time and initial pressure on the Bottlevac® on the field sheet and yellow logbook. Monitor throughout collection if the presence of water in the tubing is present. If seen, quickly disconnect the Bottlevac® and regulator and cease sampling the location. Note on the field sheet and logbook the presence of water during sampling.

6.15 Allow the Bottlevac® sample to fill with soil vapor for approximately 5-10 minutes depending on the regulator used. Allow Bottlevac® to reach a final pressure of approximately -3 inches of mercury (inHg). If Bottlevac® reaches the final pressure within 90 seconds or a consistent pressure drop is seen, repeat steps 6.3 through 6.14 with a new Bottlevac® and flow controller. Note the observation in the field sheet and logbook.

6.16 Once a final pressure of -3 inHg is achieved. Close the regulator (if applicable), and in a swift motion, disconnect the Bottlevac® sample from the regulator. Note the final pressure (-3 inHg) and final sample time in the field sheet and logbook. Record final sample time on the laboratory COC.

6.17 Disconnect the sample regulator and insert the PID tip to record a final PID reading. Note PID reading on the field sheet and logbook. If elevated PID is noted (greater than 5 PPM), note on comment section of laboratory COC.

6.18 Fill out a label for the Bottlevac® to include the location I.D., site, date and time of sample, and analysis. There is no preservative for TO-15 Bottlevac® sampling.

6.19 Replace white cap to sample port and reinstall protective cover.

# 7.0 DOCUMENTATION PROCEDURES

7.1 A yellow logbook should be taken to each specific site.

7.1.1 The date, onsite time, weather conditions, equipment used (HMA owned or rental) should be noted in the logbook. Any abnormal conditions at the site (odors, chemicals in use or identified, etc.) should be noted as these may affect sample analytical results. Note in the logbook if a rain event has occurred in the past 24 hours.

7.1.2 If a rain event in the past 24 hours has been identified, contact the Project Manager as conditions may influence sample analytical results.

7.2 HMA generated field sheets should be used and filled out at each sample location.

## 8.0 REFERENCES

*May 2013 Guidance Document For The Vapor Intrusion Pathway*, Michigan Department of Environment, Great Lakes, and Energy, Remediation and Redevelopment Division, 2023 (212-217).

DiGiuio, Dominic. *DRAFT Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations*. United States Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Groundwater and Ecosystem Restoration Division, Ada, Oklahoma.

# Sampling Utilizing USEPA Method TO-15 for Bottle-Vac® Sample Collection

Hamp, Mathews and Associates, Inc. **(HMA)**

**Standard Operating Procedure (SOP)**

## 1.0 Scope and Application

This SOP outlines HMA's process for collecting soil vapor samples via soil gas wells/points and VaporPins® for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999).

## 2.0 Required Equipment

| | |
|---|---|
| • Bottle-Vac® and regulator for each location. | • Lab chain of custody (COC) |
| • ¼" Teflon tubing | • Soil gas sample sheets |
| • Pre-cleaned Masterflex tubing | • Field logbook |
| • Tubing cutter | • Cell phone (weather updates) |
| • Spare tubing caps | |
| • PID | |
| • GEM landfill gas meter | |
| • Helium leak kit (MEGLE, Fibertec, etc.)<br>o Includes: helium tank, regulator, helium shroud, syringes, necessary fittings, adjustable wrench, leak detector | |

## 2.0 Important Sampling Information

- Refrain from filling vehicles with fuel, handling any VOC containing products, wearing freshly dry-cleaned clothing, or cosmetic frangrances.
- Keep Bottle-Vacs® at a consistent room temperature. Avoid leaving them out in the sun or cold. Preferably leave in a climate-controlled vehicle or room until ready to sample.
- Regulators are one-time use for each Bottle-Vac®.
- If moisture is in the tubing line, note this on the soil gas sample sheets. If moisture comes into the line when purging or sampling, IMMEDIATELY remove the GEM® or Bottle-Vac®, depending on the point in the sampling process.
- Bottle-Vacs® and regulators each have a unique code and should be listed on both the soil gas sample sheets and the COC.
- Labeling of samples should be done with a ballpoint pen and not a Sharpie®.

## 3.0 Pre-Sampling Procedure

- Hook the GEM® unit up to sample point. Instructions for hooking up and running the GEM® are included in the case. The GEM® should run for 3 cycles. Typically pumping for 30 seconds each cycle for soil gas points, and 15 seconds for Vapor Pins®. The PID should be hooked up to the GEM® exhaust port. Record both PID and GEM® results on the soil gas sampling sheet.
- Disconnect the GEM® unit, then hook up a regulator with a section of pre-cleaned Masterflex tubing to the sample tubing or VaporPin®.

HAMP MATHEWS & ASSOCIATES, INC.

# SOIL VAPOR SAMPLING FIELD DATA SHEET

**Project Name**: ________________________ **Date**: ____________

**Project Number**: ________________________ **Sample ID**: ____________

**Location / Building**: ________________________

**Weather Conditions**

**Personnel**: ________________________ Temp: ____________

**Equipment**: GEM, Bottle Vacs, Regulators, PID, Helium Leak Kit Wind: ____________

B.P.: ____________

**PRESSURE** **[ * Only applicable to subsurface vapor treatment operations ]**

Pressure Difference: ________ Inches Water Column Positive or Negative (Circle One)

Rain in Last 24 Hours? ________

**PURGING** **[ * If Vapor Pin only collect two GEM readings at 15 second intervals ]**

Soil Gas Port Depth: ________ feet Purge Method / Equipment: GEM 2000/5000

Tubing Volumes

Total Tubing Length: ________ feet Purge Rate: ________ ml / minute

¼" Tubing ~ 10 ml / foot

Tubing Inside Diameter: 1/4 inch Purge Time: ________ minutes

⅜" Tubing ~ 22 ml / foot

Purge Volume: ________ ml

½" Tubing ~ 39 ml / foot

**LEAK TESTING**

Tracer Gas: Helium Tracer Setup: Hood / Other (If Other, specify)

Field Instrument / Meter: 1% Detector 1st Meter Reading: ____________

2nd Meter Reading: ____________

Corrective Actions: ________________________

Leak Test Results: Pass / Fail (Circle one)

**SAMPLING**

Time: ____________ Meter Model: ____________ Regulator No.: ____________

Tubing Type: ____________ Pump Model: ____________ Pump Serial No.: ____________

Sample Collection Device: Sorbent Tube / Tedlar Bag / Canister / Bottle Vac (Circle One)

Sample Rate: 200 ml / minute Reading: 1 / 2 / 3 / 4

1st Sample Device ID: ________ Sample Volume: 1,000 ml % Oxygen: / / /

2nd Sample Device ID: ________ Sample Volume: ________ ml % Carbon Dioxide: / / /

3rd Sample Device ID: ________ Sample Volume: ________ ml % Methane: / / /

PID: / / /

Laboratory: ________________________

Laboratory Analytical Parameters: ________________________

**NOTES** **I.P. =**

**F.P. =**

**PID =**

Signature: ____________

# APPENDIX F.1

# Installation of a Soil Gas Probe/Vapor Monitoring Point to Support Vapor Intrusion Investigations

*Remediation and Redevelopment Division*

Standard Operating Procedure

# INSTALLATION OF A SOIL GAS PROBE/VAPOR MONITORING POINT TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

**Original Date of Issuance: April 30, 2012**

**Revision #: 1** **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

**Robert Wagner, Chief**
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

Written by: **Matthew Williams, Vapor Intrusion Specialist**
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

*The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines the generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.*

*PLEASE NOTE:*

*This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.*

*This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.*

*The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.*

## 1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a Soil Gas Probe/Vapor Monitoring Point. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Soil gas samples collected less than five feet below ground surface must be referenced as shallow soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil gas samples collected at depths greater than five feet below the surface.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

## 2.0 SAMPLING POINT INSTALLATION

Prior to selecting sample locations, an underground utility search is required. Miss Dig and, if necessary, the local utility companies must be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened in the field with a metal detector or magnetometer to verify that no underground utilities or structures exist.

### 2.1 Boring Advancement

There are many methods to advance a boring intended to install a soil gas sampling point. It is highly recommended that the methodology utilized have the following characteristics:

- Nominal in diameter (less than three inches is recommended)
- Provide minimal disturbance to the surrounding soil
- Does not inject air or water fluids
- Provides a soil core that can be screened, visibly classified, and if necessary collected for chemical analysis

A hydraulic probe is often utilized to advance a boring utilizing two different sampling devices. Those are:

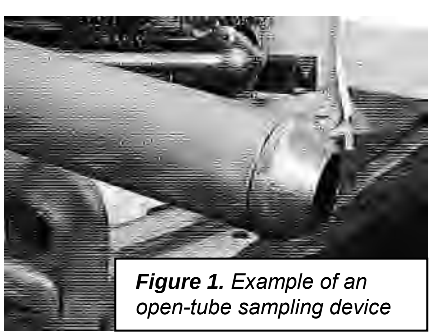

***Figure 1.*** *Example of an open-tube sampling device*

- **Open-tube sampling device** – A direct push sampler for collecting continuous core samples of stable, unconsolidated materials. Although other lengths are available, a standard macro-core sampler (MC5) available from Geoprobe® is available in lengths between 48 and 60 inches with an outside diameter of 2.25 inches (Figure 1). Soil is collected inside a removable liner. Macro-core samplers are readily available and easy to use in most unsaturated soil conditions to at least ten feet below ground surface.

*Figure 2. Example of a dual-tube sampling device*

- **Dual-tube sampling system** – Dual-tube sampling systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole. Dual-tube sampling is beneficial in loose or unstable soils as a casing is advanced that prevents soil samples from falling into the boring (Figure 2).

Other methods for advancing boring include the use of hand augers, slab bars, and electric hammers. Each methodology has benefits and drawbacks and should be evaluated before a specific use is decided upon. The hydraulic probe methods identified above can be deployed in a wide variety of site conditions that allows the probe to be driven past some dense stratigraphic horizons.

### 2.2 Soil Gas Well Materials (General List of Materials)

**Tubing** – Sample probe tubing should be of a small diameter (1/8 to 1/4 inch) and made of materials that will not react or interact with target compounds. The size should also correspond to the size and construction of the sample point. Suggested materials are nylon, Teflon®, polyethylene, copper, polyvinyl chloride (PVC), or stainless steel. The choice of tubing type depends on site-specific considerations, but in general, nylon tubing is preferred as it <u>exhibits lower adsorption rates and is more flexible and easier to work with than stainless steel</u>

***Figure 3.*** *Vapor point examples*

**Soil Gas Well Screen** – Screens must be less than six inches in length and configured to allow soil gas to enter along the entire length (Figure 3). This typically results in a fine mesh or screen being utilized to prevent dirt or other debris from entering into the sample tubing.

**Sand Pack** – The grain size of the sand pack should be sized appropriately (i.e., no smaller than the adjacent formation) and installed in a manner to minimize disruption of airflow to the sampling tip.

**Bentonite** – Bentonite is utilized to form a chemically resilient, low-permeability, flexible seal from above the well screen to the ground surface. In single vapor point well construction, granular bentonite or bentonite crumbles can be utilized. If multiple well screens are to be utilized, then a coated and compressed bentonite pellet or “tablet” must be utilized (1/4 inch) to prevent any bentonite dust from sealing portions of the borehole. It must be noted that adequately sealing soil gas sampling probes is very important to minimize the exchange of atmospheric air with the soil gas and to maximize the representativeness of the sample.

### 2.3 Soil Gas Well Installation

The following procedure does not account for the advancement of the boring due to the number of available methodologies available; however, it is imperative that for each boring a soil boring log is competed that provides details on the soil conditions and potential contamination encountered. The procedure below starts after the boring has been advanced and may need to be modified based on the boring methodology utilized. Construction details for each point must be documented in a field log.

A. Inspect the borehole to ensure that it has remained open and is free of water to the depth were the well screen is to be placed.
B. Place four to six inches of sand pack on the bottom of the boring.
C. Pre-assemble screen and tubing and lower into borehole in an upright position on top of the sand pack. If the boring is deep and narrow, adding a small inert weight (e.g., nut) may be utilized to facilitate the tube reaching the bottom.
D. Cut the tubing and temporarily terminate the surface end with a Swagelok cap or other fitting to prevent debris from entering into the line.
E. Mark tubing using tape and a ball-point pen to identify the probe location and depth. All marks should be on tags attached to the tubing and not on the tubing itself. Note: Permanent markers must not be used.
F. Place sand pack around the screen and extend the sand pack to six inches above the top of the screen.
G. Confirm the depth to the top of the sand pack.
H. Record all measurements on the field log.
I. Place one foot of dry granular bentonite or bentonite pellets on top of the sand pack.
J. Avoid lateral movement between the tubing and the bentonite as much as possible once a point has been installed.
K. Install bentonite pellets until six inches below the next screen interval and then hydrate with minimal water or one foot from the ground surface ensuring that the bentonite does not bridge during the placement. If an additional vapor point in the same boring is to be installed, return to Step A and repeat.
L. Ensure that the final bentonite seal is at least 2.5 feet thick.
M. Cut the protruding lengths of tubing successively shorter so the deepest sample tube is the longest length and the others progressively shorter. This is helpful if the labels on each tube are lost or illegible upon resampling.
N. Terminate surface ends of tubes with Swagelok caps, valves, or other desired terminations.
O. Complete all required field documentation.
P. Unless soil gas points are to be abandoned the same day they are installed, probes must be properly secured, capped, and completed to prevent infiltration of water or ambient air into the subsurface. For surface completions, the following components may be installed, as necessary:
    1. Fitting for connection to above ground sampling equipment
    2. Protective flush-mounted or above ground well vaults; and/or
    3. Guard posts

Examples of a single depth soil gas probe and a multi-depth or “nested” soil gas probe are shown in Figure 4. Figure 5 shows example pictures of surface completion.

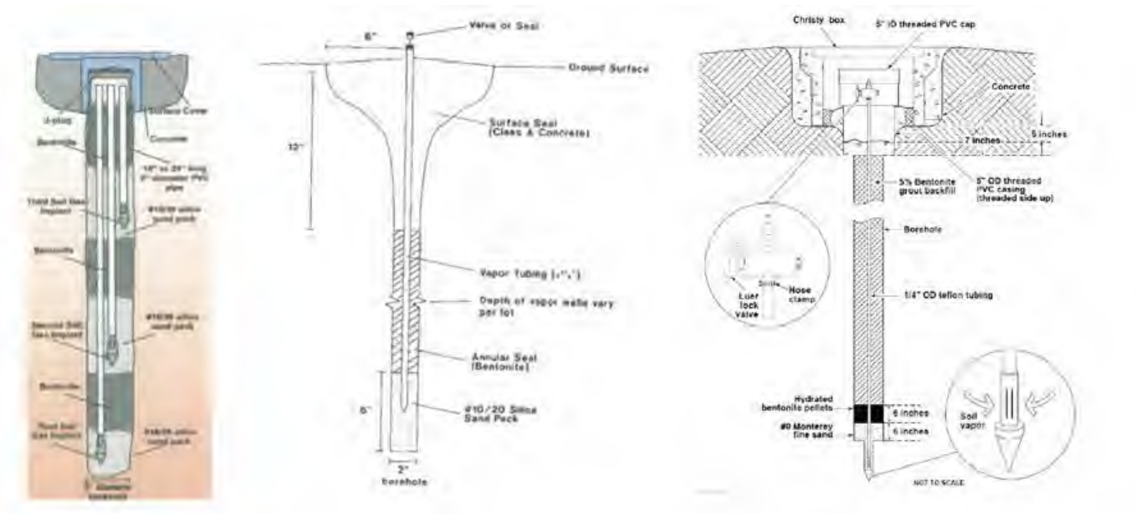


***Figure 4.*** *Examples of complete vapor monitoring points*
*[Hartman, 2004 (left and center) and* Vonder Haar, S.*, 2000 (right)]*

***Figure 5****. Examples of various surface completions for vapor wells. (Hartman, 2004)*

### 2.4 Soil Gas Well Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified above and that are less than 20 feet in depth may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to original site conditions.

If the tubing cannot be removed, the tubing should be filled with liquid grout and cut off at least one foot below the ground surface. All surface protective covers must be removed and the boring annulus backfilled with uncontaminated native material or grout and returned to as close as possible to original site conditions.

## 3.0 SOIL BORING LOGS AND VAPOR COMPLETION DIAGRAM

Boring logs and diagrams may be completed utilizing a variety of programs. The following information must be included for every vapor point installed:

- Project information
- Boring location
- Date Installed
- Total depth
- Project personnel including drilling contractor, driller, and geologist
- Drilling method
- Boring diameter
- Soil sampler utilized for lithology
- Sample recovery
- Soil description
- Field screening performed
- Samples sent for analysis
- Unified soil classification system classification
- Boring coordinates (state plane)
- A diagram representing installed sampling point that includes:
    - Surface completion
    - Bentonite seal used
    - Probe and screen construction materials and specifications
    - Depth of all installed materials including screen, bottom of screen, sand pack, tubing, and various bentonite seals

## 4.0 REFERENCES

Hartman, B., 2004. Vapor Monitoring Wells/Implants Standard Operating Procedures.

Vonder Haar, S., 2000. ERD SOP 1.10: Soil Vapor Surveys - Revision: 4.

*Remediation and Redevelopment Division*

**Standard Operating Procedure**

**SAMPLING UTILIZING USEPA METHOD TO-15**
***VIA***
**BOTTLE-VAC® TO SUPPORT**
**VAPOR INTRUSION INVESTIGATIONS**

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**Robert Wagner, Chief**
Remediation and Redevelopment Division
Michigan Department of Environmental Quality


Written by: **Matthew Williams, Vapor Intrusion Specialist**
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality


*The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.*

*PLEASE NOTE:*

*This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.*

*This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.*

*The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.*

## 1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for collecting a vapor sample through either a soil gas probe/vapor monitoring point and/or sub-slab monitoring point for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999). Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. Considerations must be given to the types of chemicals of concern, lithology encountered, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

The Method TO-15 in this procedure has been modified for use with one-liter Bottle-Vac® samplers by Entech Instruments, Inc. Bottle-Vacs® are utilized by the MDEQ's Laboratory in all soil gas sampling applications. Bottle-Vac® has been shown by internal testing performed by the MDEQ Laboratory to be reliable for both holding times and reporting requirements in soil gas sampling applications.

## 2.0 SOIL GAS COLLECTION

Most vapor wells are installed at relatively shallow depths (less than ten feet below ground surface) so minimum purge volumes and low-volume samples must be performed to minimize potential breakthrough from the surface or between sampling intervals. Tracer/leak gas is necessary to ensure breakthrough does not occur and that a leak does not occur at any fitting above grade. Samples must not be collected after any rain event and until site conditions (including moisture content) return to typical site conditions.

Samples from wells with multiple points installed must not be collected simultaneously and approximately 30 minutes must elapse between each sampled interval which should be documented on the field log. Sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize the potential for vacuum extraction of contaminants from the soil phase. Volumes of various tubing sizes are provided in Table 1 in order to aid in calculating purge volumes.

**Table 1**
**Volumes for Select Tubing Sizes**

| *Tubing Size (inches ID)* | *Volume/ft. (liters)* |
|---|---|
| 3/16 | 0.005 |
| 1/4 | 0.010 |
| 1/2 | 0.039 |

Care must be used during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. Care must also be taken to avoid excessive purging prior to sample collection and prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. The sampling team must avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which could potentially cause sample interference in the field.

**IMPORTANT SAMPLING NOTES:**

- An initial vacuum test must be performed on each point. This is done by attaching a 50-ml syringe and pulling back on a point to ensure that the point is able to provide adequate vapor without obtaining a vacuum. If a point is installed in which the syringe cannot be withdrawn without generating a vacuum, the sampling point may not be valid and may need to be replaced.
- If water droplets are observed in the tubing or in a Bottle-Vac®, the sampling crew must note the presence of water on the sample label and Chain of Custody and recollect the sample.
- Bottle-Vac® must remain out of the sun and not placed on ice or chilled.
- Collected Bottle-Vac® samples must be stored at room temperature and not left in a hot vehicle or freezing vehicle.
- Label all samples with the label provided by the lab using a ballpoint pen. *Do not use a Sharpie*!
- Wash hands or replace sampling gloves between samples to ensure the leak/tracer compound is not on your fingers when connecting fittings.
- Disposable equipment and supplies must not be used for multiple sampling points.
- *Do not write* on boxes provided by the MDEQ Laboratory.
- *Do not remove* the green tape from the flow regulator. Do not adjust; the flow regulator has been calibrated to the correct flow rate of 100 to 200 ml/min.
- The MDEQ provides a dedicated regulator for each sample that is collected. The ID of each regulator should be referenced on the sampling form and any issues reported to the MDEQ Laboratory.

### 2.1 Soil Gas Collection General List of Materials

The equipment required for soil gas sample collection is as follows:

| Tooling and Supplies | Flow Meters and Detectors: |
|---|---|
| • Bottle-Vac® (one per location)<br>• Regulated flow meter assembly set to a maximum of 200 ml/min (one per location)<br>• 1/4 inch tubing (suggested materials are nylon, Teflon® polyethylene, or similar) and assorted fittings<br>• Plastic housing for using tracer gas<br>• 50 ml syringe (for purging)<br>• Camera<br>• Adjustable crescent wrenches, small to medium size, and/or open end combo wrenches 9/16 to 1/2 inch<br>• Scissors/snips to cut tubing<br>• Ballpoint pens<br>• Nitrile gloves<br>• Compound to be used as tracer gas - lab grade helium | • Flow regulator with vacuum gauge. Flow regulators provided by the MDEQ Laboratory are pre-calibrated to a specified flow rate (e.g., 100 ml/min).<br>• Photoionization detector (with appropriate lamp<br>• Helium detector<br>• Methane meter for petroleum sites that is capable of also measuring percent of methane ($CH_4$), carbon dioxide ($CO_2$), and oxygen ($O_2$)<br>• Optional meter to measure %LEL of methane<br><br>**Forms:**<br>• Chain of Custody forms<br>• Soil gas sample collection log (example attached)<br>• Field notebook |

### 2.2 Soil Gas Tracer Compounds

A leak in the sampling assembly may allow ambient air into the system and dilute the soil gas results (Benton, 2007). Therefore, tracer gases must be utilized during the collection of soil gas samples to verify that the sample collected is from the installed sampling point. The presence of a tracer compound, whether liquid or gaseous, can confirm a leak in the sampling train and the usability of the sample will need to undergo further evaluation.

Careful thought and consideration must be used when choosing a leak check compound as a tracer as each compound utilized can have specific benefits and drawbacks that should be considered. Figure 1 depicts a typical sub-slab sampling setup utilizing helium as a tracer gas. Though other compounds may be utilized, the MDEQ Laboratory has identified a preference for helium.

Helium used as a tracer gas beneath a shroud as shown in Figure 1 allows for the screening of the sampling train in the field. The use of a field meter capable of detecting helium may be able to resolve and correct any leaks by reevaluating the sampling train and retightening all fittings prior to collecting the sample for analysis. If a leak has been detected and is unable to be resolved, the sampling point may need to be decommissioned and a new one installed. Lab grade helium must be utilized to eliminate possible contribution issues as helium available at general merchandise stores may contain secondary contaminants such as benzene (Figure 2).

Understanding the relationship between a leak and the concentration detected of the tracer gas used to check for leaks, the potential for absorption of the tracer gas (i.e., helium) onto sample train tubing, and the potential for interference by the tracer gas compound with VOCs is important in answering the data usability. An ambient air leak up to ten percent may be acceptable if quantitative tracer testing is performed. Otherwise, the soil gas vapor well should be decommissioned if the leak cannot be corrected. Replacement vapor wells should be installed at least five feet from the location where the original vapor well was decommissioned due to a confirmed leak.

***Figure 1**. Sampling shroud being pressurized with helium.*


***Figure 2**. Use Ultra High Pure (UHP) grade helium to avoid background contaminants.*

### 2.3 Sample Collection Procedure

***Figure 3**. Sampling equipment.*

1. Allow for subsurface conditions to equilibrate and vapor concentrations to stabilize after vapor point installation:
   - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 45 minutes.
   - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 48 hours after vapor probe installation with augers.
   - Do not conduct the purge volume test, leak test, and soil gas sampling after any rain event until site conditions return to normal.

2. Assemble the aboveground sampling equipment which consists of new connector tubing, a designated regulated flow meter assembly including pressure gauge for each sample, purging equipment, and Bottle-Vac® (Figure 3).

3. Place the completed sampling label on the Bottle-Vac®.

***Figure 4**. Connect sampling line to point.*

***Figure 5**. Connect regulator to sampling line.*

***Figure 6**. Connect regulator assembly to shroud.*

4. Connect the above ground sampling line to the vapor monitoring point (Figure 4).

5. Connect the regulated flow meter assembly to sampling line (Figure 5).

6. Connect the regulated vapor flow meter assembly to the sampling shroud (Figure 6).

7. Calculate volume of air contained within the vapor point and sampling assembly up to the point where the sample will be collected and record on the field sampling form.

8. Check all sampling system connections and fittings for tightness and/or obvious deterioration.

***Figure 7***

***Figure 8***

***Figure 9***

9. Run all sampling lines through the helium shroud and place the enclosure on the ground (Figure 7). It may be appropriate to seal the enclosure to the ground using VOC-free plumbers putty, modeling clay, or hydrated bentonite.

10. Connect the sampling port line to the outside of shroud, making sure that the valve is closed (Figure 8).

11. Connect the helium cylinder to the tracer gas port. Opening the valve on the line from helium to the shroud, begin the flow of helium into the enclosure (Figure 9).

***Figure 10***

***Figure 11***

12. Confirm that the enclosure contains helium through the use of the helium detector.

13. Connect a 50 cubic centimeter (cc) syringe to the sampling port line and purge at least three volumes of air from the sampling system (Figure 10). After purging is complete, close the valve to the sampling line, disconnect the syringe, and close valve to the helium cylinder.

14. Calibrate the helium detector and zero for existing site conditions.

15. Connect the helium detector to the sampling port, collect, and record a reading (Figure 11).

16. If helium is detected, return to Step 5 and repeat process until no helium is detected. If a leak is unable to be resolved, the sampling point may need to be decommissioned and a new one installed.

17. Reaffirm that the enclosure contains helium through the use of the helium detector. If helium is not detected in the sampling enclosure, identify how the helium is leaving the enclosure and return to Step 6 and seal the enclosure as appropriate.

*Figure 12*

*Figure 13*

18. Disconnect or remove the sampling lines from the sampling enclosure leaving the flow regulator assembly and the lines connecting it into the sampling point in place (Figure 12).

19. Open the valve on sampling line.

20. Immediately connect the flow regulator assembly to the Bottle-Vac® using the quick connect adaptor and record the start time and vacuum gauge reading (Figure 13). The vacuum gauge should register about -28 millimeters mercury when it is first attached.

21. Check every two minutes and record the time at which the vacuum gauge reaches 0 pounds per square inch.

22. Calculate and confirm that the sampling rate is less than 200 ml/min. Record the flow regulator number on the sampling form and note any sampling discrepancies in the field notes and sampling form.

23. Disconnect the quick connect adaptor from the Bottle-Vac® and place paraffin on the top of the Entech Micro-QT® Valve.

24. Confirm the container has the proper label with the sample identification information.

25. Remove the flow regulator from the tubing and record the regulator number on the sampling form.

26. Complete the air volatiles request form. Be sure to circle Bottle-Vac® in the upper right.

27. Return everything including the Bottle-Vac®, adaptor, vacuum gauge, flow regulator assembly, and notes on equipment issues to the MDEQ Laboratory for analysis, cleaning, and calibration.

## 3.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND FIELD RECORDS

The Quality Assurance/Quality Control (QA/QC) procedures are an integral part of any sampling activities. The most important QA/QC procedures in collecting soil gas sampling are ensuring that the samples are representative of the subsurface conditions. For soil gas sampling, that means the QA/QC program identify procedures that verify that the sample is properly collected. Recording the pressure reading throughout the process is a critical component. Unlike soil or groundwater sampling, most of the containers and sampling devices utilized for sampling are verified clean. Upon request, the laboratory can provide laboratory batch cleaning results.

Trip blanks are typically not collected due to the sampling process and sampling devices that prevent the intrusion (or introduction) of air or other media into the sampling device. In addition, the failure of one flow regulator sampling assembly on a specific Bottle-Vac® does not provide an indication that any of the other sampling assemblies or Bottle-Vacs® have failed. Sampling blanks for soil gas sampling equipment including tubing and fittings may be collected if the source of the material is unknown or suspected to be contaminated.

Duplicate samples including blind duplicates are recommended to be collected to verify laboratory procedures and should include the collection of at least one field duplicate per sampling event or one per 20 samples, whichever is greater. When collecting duplicate samples in the field, it is imperative that the duplicate samples are collected simultaneous to collection of the primary sample using a sampling tee and at a combined sample rate to not exceed 200 ml/min from each point. Laboratory duplicate samples can also be collected from the same sampling Bottle-Vac® if the duplicate is not required to be a blind sample.

### 3.1 Soil Gas Sampling Record

The following information should be recorded in a field notebook or on sampling forms similar to those shown in Attachment 1 to document the procedures utilized at a specific site to collect soil gas data. In general, the fields should include the following information:

1. Sample identification information including the locations and depths at which the samples were collected, sample identifiers, date, and time
2. Identify the field personnel involved in the sample collection
3. Weather conditions (e.g., temperature, wind speed, barometric pressure, precipitation, etc.)
4. Sampling methods, devices, and equipment used
5. Purge volumes prior to sample collection. Relate the purge volumes to the volume of the sampling equipment, including the tubing connecting the sampling interval to the surface.
6. Volume of soil gas extracted (i.e., volume of each sample)
7. Vacuum of canisters before and after samples collected
8. Tracer gas utilized and whether it is a liquid or a solid
9. Field screening of any tracer gas

## 4.0 REFERENCES

Benton, Diane and Shafer, Nathan. 2007. Evaluating Leaks in a Soil Gas Sample Train, Paper #45 Extended Abstract, Air Toxics, Ltd.

United States Environmental Protection Agency. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, United States Environmental Protection Agency. Document No. EPA/625/R-96/010b.

**Attachment 1**

*Remediation and Redevelopment Division*
*Soil Gas Sampling Form*

**General Site Information:**

| | | | |
|---|---|---|---|
| Site Name: | | Sample ID: | |
| Location: | | Sampling Crew: | |
| Date: | | Project Manager: | |
| Bottle No: | | Regulator No: | |

**Weather Conditions:**

| | | | |
|---|---|---|---|
| Last rain: | | Bar. pressure: | |
| Current temp: | | Current weather: | |

**Volume Calculations:**

| Volumes for Tubing Sizes Per Foot | | Calculations: | | |
|---|---|---|---|---|
| | | | Vapor Point ID: | |
| | | | Depth of Vapor Point: | |
| | | | Extra Tubing to Bottlevac: | |
| (liters) | (inches ID) | | Diameter: | |
| 3/16" | 0.005 | | Estimated Volume: | |
| 1/4" | 0.01 | | Purge Method: | |
| 1/2" | 0.039 | | Purge Volume: | |

**Instrument Readings:**

| | | | |
|---|---|---|---|
| *GEM* | | | |
| $O_2$: | | $CO_2$: | |
| % $CH_4$: | | Other: | |
| *MultiRAE* | | | |
| VOCs: | | $CO_2$: | |
| $O_2$: | | % LEL: | |
| *Other:* | | | |
| Other: | | | |

**Miscellaneous:**

| | | | |
|---|---|---|---|
| Vac Test Completed: | ☐ Yes ☐ No | Starting Time: | |
| Tracer Gas Utilized: | ☐ Helium ☐ IPA ☐ N/A | Initial BottleVac Pressure: | |
| Suspected COCs: | ☐ Petroleum ☐ Solvent | Ending Time: | |
| Moisture Identified: | ☐ Yes ☐ No | Final BottleVac Pressure: | |

**General Boring Location and Notes:**