

Field Sampling Plan

Soil and Groundwater Sampling Procedures

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1.0 Executive Summary

The Field Sampling Plan (“FSP”) is designed to provide detailed step-by-step procedures for the field activities associated with soil and groundwater sampling. This plan will serve as the field procedure manual that will be strictly followed by all Wenck personnel. Adherence to these procedures will help ensure the quality and defensibility of the field data collected.

2.0 General Documentation

A field notebook to record all field activities and events will be initiated at the start of on-site work and be maintained by the on-site geologist. The field notebook will include, at a minimum, the following daily information, regardless of what activity is being performed:

- Date
- Weather conditions
- Crew members
- Brief descriptions of field activities
- Locations where work is performed
- Problems and corrective actions taken
- All field measurements or descriptions recorded
- All modifications of the FSP
- Site visitors

3.0 Drilling and Soil Sampling Procedures

3.1 GENERAL

The subsurface investigation program will provide information necessary for the hydrogeologic evaluation of the site, which will be used in the site rehabilitation plans.

A list of applicable investigation and monitoring well installation procedures, and the appropriate section where they are discussed, follows:

- Hollow-stem auger drilling procedures (Section 3.2);
- Split-spoon sampling procedures (Section 3.3);
- Borehole Abandonment Activities (Section 3.4);
- Groundwater Monitoring Well Construction Procedures (Section 3.5);
- Test Pits (Section 3.6);
- Headspace Organic Vapor Screening (Section 3.7);
- Soil Sample Collection for Laboratory Analysis (Section 3.8); and
- Sample Methodology (Section 3.9).

3.2 HOLLOW STEM AUGER DRILLING PROCEDURES

Hollow-stem auger (HSA) drilling is a standard method of subsurface drilling which allows the recovery of representative subsurface samples for identification and laboratory testing.

Procedure:

- Advance the boring by rotating and advancing the augers the desired distance into the subsurface. The borings will be advanced incrementally to permit continuous or intermittent sampling as required.
- Remove center plug from augers and sample subsurface per method stipulated by the project geologist or hydrogeologist. Sampling methods are presented in Section 3.3.

Reference: American Society of Testing Materials (ASTM), 1988, "Standard Practice for Soil Investigation and Sampling by Auger Borings," ASTM D1452-80, and "Standard Method for Penetration Test and Split Barrel Sampling of Soils," ASTM D1586-84.

3.3 SPLIT-SPOON SAMPLING PROCEDURES

Split-spoon sampling is a standard method of soil sampling to obtain representative samples for identification and laboratory testing, as well as to serve as a measure of resistance of soil to sampler penetration.

Procedure:

- Measure the sampling equipment lengths to ensure that they conform to specifications. Confirm the weight of the hammer (140 lbs.).
- Clean out the auger flight to the bottom depth prior to sampling. Select additional components as required (i.e., leaf spring core retainer for clays or a sand trap for non-cohesive sands).
- Lower the sampler to the bottom of the auger column and check the depth against length of the rods and the sampler.
- Attach the drive head sub and hammer to the drill rods without the weight resting on the rods.

- Lower the weight and allow the sampler to settle up to 6 inches. If it settles more, consider use of another sampler.
- Mark four 6-inch intervals on the drill rods relative to a drive reference point on the rig. With the sampler resting on the bottom of the hole, drive the sampler with the 140-pound hammer falling freely over its 30-inch fall until 24 inches have been penetrated, or 100 blows have been applied.
- Record the number of blows per 6 inches. Determine the "N" value by adding the blows for the 6 to 12 inch and 12 to 18 inch interval of each sample attempt.
- After penetration is complete, let the sampler sit for a minimum of 3 minutes, then rotate the sampling rods clockwise three full turns and remove the sample.
- Open sample. Describe the soil and collect a moisture content sample from the nose of the spoon if only one soil type is present, and additionally if more than one soil type is present. Place moisture content sample in an appropriate container and label the container. Monitor sample jar headspace for organic vapor content at appropriate intervals (if desired).
- Document all properties and sample locations on the boring log form.
- Place sample in suitable container, label, and store on-site until on-site work has been completed.

Reference: American Society of Testing Materials (ASTM), 1988, ASTM D1586-84, "Standard Method for Penetration Test and Split Barrel Sampling of Soils."

3.3.1 Unified Soil Classification System

Soils are classified for engineering purposes, according to the Unified Soil Classification System (USCS) adopted by the U.S. Army Corps of Engineers and Bureau of Reclamation. Soil properties which form the basis for the USCS are:

- Percentage of gravel, sand, and fines;
- Shape of the grain-size distribution curve; and
- Plasticity and compressibility characteristics.

According to this system, all soils are divided into three major groups: coarse-grained, fine-grained, and highly organic (peaty). The boundary between coarse-grained and fine-grained soils is taken to be the 200-mesh sieve (0.074mm). In the field, the distinction is based on whether the individual particles can be seen with the unaided eye. If more than 50% of the soil by weight is judged to consist of grains that can be distinguished separately, the soil is considered to be coarse-grained.

The coarse-grained soils are divided into gravelly (G) or sandy (S) soils, depending on whether more or less than 50% of the visible grains are larger than the No. 4 sieve (3/16 inch). They are each divided further into four groups:

- W: Well graded; fairly clean (<5% finer than 0.074mm)
- P: Poorly graded (gap-graded); fairly clean (<5% finer than 0.074mm)
- C: Clayey (>12% finer than 0.074mm); plastic (clayey) fines. Fine fraction above A-line with plasticity index above 7.
- M: Silty (>12% finer than 0.074mm); nonplastic or silty fines. Fine fraction below A-line and plasticity index below 4.

The soils are represented by symbols such as GW or SP. Borderline materials are represented by a double symbol, such as GW-GC.

The fine-grained soils are divided into three groups: Inorganic silts (M), inorganic clays (C), and organic silts and clays (O). The soils are further divided into those having liquid limits lower than 50% (L), or higher (H).

The distinction between the inorganic clays, C, inorganic silts, M, and organic soils, O, is made on the basis of a modified plasticity chart. Soils CH and CL are represented by points above the A-line, whereas soils OH, OL, and MH correspond to positions below. Soils ML, except for a few clayey fine sands, are also represented by points below the A-line. The organic soils O are distinguished from the inorganic soils M and C by their characteristic odor and dark color.

3.3.2 Visual Identification

Soil properties required to define the USCS classification of a soil are the primary features to be considered in field identification. These properties and other observed characteristics normally identified in describing a soil are defined below:

- A. Color
- B. Moisture conditions
- C. Grain size
 - 1) Estimated maximum grain size
 - 2) Estimated percent by weight of fines
(material passing No. 200 sieve)
- D. Gradation
- E. Grain shape
- F. Plasticity
- G. Predominant soil type
- H. Secondary components of soil
- I. Classification symbol
- J. Other features such as:
 - organic, chemical, or metallic content;
 - compactness;
 - consistency;
 - cohesiveness near plastic limit;
 - dry strength; and
 - source - residual, or transported (aeolian, water-borne, glacial deposit, etc.)

3.3.3 Documentation

Each subsurface boring will be logged in a bound field logbook during drilling by the supervising geologist. Field logs will include descriptions of subsurface material encountered during drilling, sample numbers, and types of samples recovered from the borehole. The

supervising geologist's log will be compared with the driller's log and discrepancies will be noted. Additionally, the geologist will note time and material expenditures for later verification of contractor invoices.

Upon completion of daily drilling activities, the geologist will complete the daily drilling record form, and initiate chain of custody on any samples recovered for geotechnical or chemical laboratory testing. Following completion of the drilling program, the geologist will transfer field logs onto standard boring log forms for the final investigation report.

Procedure:

The proper completion of the following forms/logs will be considered correct procedure for documentation during the drilling program:

- Field Log Book - weatherproof hand-bound field book which will be used by the project geologist;
- Daily Drilling Record will be filled out daily by the project geologist whenever drilling activities are occurring;
- Test Boring Log will be filled out for each boring from the project geologist field book; and;
- Monitoring Well Construction Detail - will be filled out for each well installation.

3.4 BOREHOLE ABANDONMENT PROCEDURES

Boreholes that do not have a well installed are sealed (plugged) prior to abandonment to prevent downhole contamination. Sealing can be achieved by backfilling the borehole with bentonite grout. The grout is introduced from bottom to top using either a tremie pipe or the drill rods.

Procedures:

- Determine most suitable seal materials. Sealing material can be 100% bentonite grout; or “neat cement” grout, which is simply cement and water, with a minimum of 2% bentonite added by weight. Grout specifications generally have mixture ratios as follows:

Grout Slurry Composition (% Weight)

20% - Bentonite (Quick Gel)
80% - Water

- Calculate the volume of the borehole based on the bit or auger head diameter plus 10% and determine the volume of grout to be emplaced. Generally, the total mixed volume is the borehole volume plus 20%.
- Identify the equipment to be used for the preparation and mixing of the grout. Ensure the volume of the tanks to be used for mixing has been measured adequately. Document these volumes.
- Identify the source of the water to be used for the grout and determine its suitability for use. In particular, water with high sulfate or chloride levels, or heated water, should not be used. These types of waters can cause operational difficulties or modify the set-up for the grout.
- Identify the equipment to be used for emplacing the grout. Ensure that the pump to be used has adequate pressure to enable complete return to surface.
- Identify the volumes to be pumped at each stage, or in total if only one stage is to be used.
- Prepare the borehole plugging plan and discuss the plan and activities with the drilling contractor prior to beginning any mixing activities.
- Begin mixing the grout to be emplaced.
- Record the type and amount of materials used during the mixing operation. Ensure that the ratios are within specification tolerance.
- Begin pumping the grout through the return line bypass system to confirm that all pump and surface fittings are secure.
- Initiate downhole pumping. Record the times and volumes emplaced on the form.

- Document the return circulation of grout. This may be facilitated by using a colored dye or other tagging method if a mudded borehole condition exists prior to grout injection.
- Identify what procedures will be used for grouting in the upper 3 feet. When casing exists in the borehole, decisions are required as to the timing for removal and final disposition of the casing. Generally it will not be removed prior to grouting because of the potential for difficult access and loss of circulation in the upper soil or rock layers. Accordingly, when cement return is achieved at surface, the casing is commonly removed and the borehole is topped off with grout or soils. If casing removal is not possible or not desired, the casing left in place is cut off one to two feet below the ground surface. If casing is not present during grouting, the grout level in the borehole is topped off after the rods or tremie pipes are removed.
- Clear and clean the surface near the borehole. Level the ground to about the pre-existing grade. Add grout or cement as necessary to the area near the borehole.

Note: On occasion, there may be some settling of the grout that takes place over several days. If this settling occurs, the natural soils from the immediate vicinity are used to put the level at grade.

A follow-up check at each site should be made within 7 to 10 days of completion. Document the visit and describe any action taken.

3.5 GROUNDWATER MONITORING WELL CONSTRUCTION PROCEDURES

The monitoring well network will conform to the program and design specifications set forth in the Work Plan. The construction of monitoring wells will enable monitoring of groundwater elevation and acquisition of groundwater samples for laboratory testing, as well as allowing aquifer testing.

Procedure:

- Advance subsurface boring to the desired depth using HSA. Collect soil samples.
- Set 2-inch PVC screen and casing in place through HSA.
- Install filter pack, removing augers as work proceeds to 1 to 3 feet above screened interval.
- Install 2 to 3-foot thick bentonite pellet seal above filter pack by dropping pellets down HSA (or alternatively, use a bentonite slurry seal, tremied from the surface), withdrawing augers as the work proceeds.
- Install bentonite grout, or neat cement grout, to within 3 feet of the surface. Remove remaining HSA from boring.
- Top off bentonite grout, or neat cement grout, in borehole. Grout should extend to approximately 2 feet below ground surface.
- Backfill remaining 2 feet of borehole with concrete.
- Install protective casing over well riser pipe and set into concrete backfill.
- Lock protective casing cap.

3.5.1 Initial Well Development Procedure

Following completion of drilling and well installation, each monitoring well will be developed by overpumping, surging, or bailing until the discharged water is relatively sediment-free, and the indicator parameters (pH, dissolved oxygen, temperature, and specific conductance) have reached steady state. Developing the well not only removes any sediment, but also may improve the hydraulic properties of the sand pack. All discharged water will be disposed at least 20 feet away from the well. The effectiveness of the development measures will be closely monitored in order to keep the volume of discharged waters to the minimum necessary to obtain sediment-free samples. A portable turbidimeter will be used to aid in monitoring effectiveness of development.

A turbidity reading of 50 NTU (10 NTU if possible) and steady state pH, temperature, dissolved oxygen, and specific conductivity readings will be used as a guide for discontinuing well development.

Procedure:

- An appropriate well development method should be selected, depending on water level depth, well productivity, and sediment content of water. Well development options include: (a) bailing; (b) manual pumping; (c) powered suction-lift pumping; (d) air-lift; (e) air-surge; and (f) surge block development.
- Equipment should be assembled, decontaminated, if necessary, and installed in the well. Care should be taken not to introduce contaminants to the equipment during installation.
- Well development should proceed by repeated removal of water from the well until the discharged water is relatively sediment-free, and pH, temperature, dissolved oxygen, and specific conductance readings have stabilized. Development water will be discharged onto the ground at least 20 feet away from the well. Effectiveness of development should be monitored at regular intervals (preferably after each well volume) using a portable turbidimeter, DO meter, pH meter, thermometer, and specific conductance meter. Volume of water removed, turbidity, dissolved oxygen, pH, temperature, and conductivity measurements are recorded on a "Well Development/Purging Log" form.
- Well development may be discontinued when the turbidity level reaches 50 NTU or below (10 NTU if possible), and pH (± 0.1 pH units), temperature ($\pm 0.5^\circ$ C), dissolved oxygen (± 0.5 mg/l), and conductivity ($\pm 5\%$ of the specific conductance meter range, temperature corrected) stabilize (as shown by three successive well volumes).

3.6 TEST PITS

Test Pit exploration is a standard method of soil investigation to obtain representative samples for identification and laboratory testing, as well as to serve to reveal greater certainty about the potential for physical contaminants in the subsurface, particularly within fill.

Procedure:

- Move excavator equipment into position. Ensure that the bucket is free from soil from other locations.
- Remove bituminous pavement or Class V (if present) and stockpile separately to restore land surface.
- Advance the excavator bucket in approximately one-foot lifts to ensure appropriate profiling of subsurface.
- Document observations (odors, free liquids, etc.) and soil characteristics on the test pit log form.
- Collect designated soil samples either from a fresh surface of the test pit or from the excavator bucket. Note sample depth and locations on the test pit log form.
- Place samples in suitable container, label, and store on-site at <math><4^{\circ}\text{C}</math> until on-site work has been completed.
- Complete test pit to desired depth as above. Collect additional samples as called for in work plan.
- Restore test pit by back-filling and compacting soil removed from test pit in one-foot lifts

3.7 HEADSPACE ORGANIC VAPOR SCREENING

This section provides procedures for field screening of soils suspected of containing volatile organic compounds, and collection of soil samples for laboratory analysis.

3.7.1 Field Headspace Screening

The following equipment will be used to conduct headspace organic vapor screening: photoionization detector (“PID”) or a flame ionization detector (“FID”), clean pint-sized polyethylene bag baggies, log book, or record sheet, and approved personal protective equipment as described in the Site Specific Health and Safety Plan.

Procedure:

1. PIDs will be equipped with a 10.2 eV (+/-) or greater lamp source. Perform PID or FID instrument calibration on site and at least daily to yield "total organic vapors" in volume parts per million (ppm) of an isobutylene equivalent. Follow the manufacturer's instructions for operation, maintenance, and calibration of the instrument. Keep calibration records in the field book.
2. Collect soil sample from split-barrel or equivalent (eg., Macro-Core[®]) sampler immediately after opening the coring device. Collect samples from excavation walls, soil piles, or backhoe buckets from freshly exposed surfaces.
3. Using a stainless steel spoon or gloved hand, half-fill a new polyethylene bag with sample (the volume ratio of soil to air is equal), then immediately seal it. Manually break up the soil clumps within the bag.
4. Allow headspace development for at least 10 minutes at approximate room temperature. Vigorously shake bags for 15 seconds at the beginning and end of the headspace development period. When temperatures are below the operating range of the instrument, perform headspace development and analysis in a heated vehicle or building. Keep the sample in a shaded area out of direct sunlight. Record the ambient temperature during headspace screening. Complete headspace analysis within approximately 20 minutes of sample collection.
5. After headspace development, introduce the instrument sampling probe through a small opening in the bag to a point about one-half of the headspace depth. Keep the probe free of water droplets and soil particles.
6. Record the highest meter response on a sampling form. Maximum response usually occurs within about two seconds. Erratic meter response may occur if high organic vapor concentrations or moisture is present. Note any erratic headspace data in the field book.

Note: Samples will not be collected for analysis from the polyethylene bag.

3.8 SOIL SAMPLE COLLECTION FOR LABORATORY ANALYSIS

Procedure:

1. Prior to collecting sample, label sample container in the field using a waterproof permanent marker. Labels will include the following information:
 - Site name
 - Sample identification code
 - Project number
 - Date/time
 - Sampler's initials
 - Preservation added (if any)
 - Analysis to be performed
1. To minimize the possibility of cross-contamination a new pair of disposable (i.e., nitrile or latex) gloves will be used for each sample collected. When using a split-spoon or similar sampler, wash it with a detergent solution (e.g. Liquinox[®], Alconox[®] or equivalent) rinse, and dry it before each use. Samples collected for non-volatile laboratory analyses will be immediately placed in appropriate containers, placed on ice and shipped to the laboratory for analysis.
2. If sampling excavation sidewalls or floors, remove at least one foot of exposed soil prior to collecting the sample to ensure collection of a fresh sample.
3. Collect samples from split-spoon samplers or a soil sample liner immediately after opening the sampler, minimizing losses due to volatilization.
4. Method 5035 is required when sampling soil for volatile contaminants. Method 5035 contains four (4) separate methods for analyzing volatiles in soil. In all cases, the sample vials will be provided from the laboratory performing the analytical services. The vials/glassware will either contain in them, or be provided in a separate vial, all necessary preservatives. The different methods include the following:
 - I. *Methanol preservation* – This method is used when a soil is suspected of containing high concentrations of volatile constituents. The method consists of placing a

measured amount of soil (typically 5 to 15 grams) into a pre-weighed vial containing methanol. A minimum of two sample vials with preservative and one 2-ounce soil jar with zero headspace will be collected for this method in case reanalysis. In addition, a dry weight sample must also be collected for this method. The sample is then immediately placed on ice and sent to the laboratory for analysis.

- II. *Sodium bisulfate preservation* – This is a low level method similar to the methanol procedure, but instead, sodium bisulfate is the preservative eliminating the dilution and giving a lower detection limit (i.e., usually less than 100 ug/kg). The method consists of placing a measured amount of soil (typically 5 grams) into a pre-weighed vial containing the sodium bisulfate preservative. A minimum of two sample vials with preservative and one 2-ounce soil jar with zero headspace will be collected for this method in case reanalysis. In addition, a dry weight sample must also be collected for this method. The sample is then immediately placed on ice and sent to the laboratory for analysis.
- III. *No preservation method* – This method is used for oily samples or samples of very high concentrations. The sample is immediately collected from the coring device and placed in a lab-provided container with zero headspace, placed on ice, and shipped to the laboratory.
- IV. *EnCore Sampler* – The EnCore sampler allows for the collection of a zero headspace sample. The sampler is used to collect either a 5 or 25 gram sample with no preservative. The sampler is plunged into the soil sample until the sampler core is filled with desired amount of soil. The sampler is then capped and sent to the laboratory on ice. The laboratory is then required to preserve the sample within seven (7) days of collection. In addition, a dry weight sample must also be collected for this method.

Note: Samples previously used for soil screening or soil classification for analytical samples will not be used for laboratory analysis.

3.9 SAMPLE METHODOLOGY

Analyte	Method	Sample Container	Sample Volume	Field Preservation	Hold Time
RCRA Metals	Method 6010/7471	4 oz. glass	150 grams	None	180 days
TCLP RCRA Metals	Method 6010/7471	4 oz. glass	250 grams	None	180 days
PCBs	Method 8082	4 oz. glass	250 grams	None	14 days
PAHs	Method 8270	4 oz glass	250 grams	None	14 days
DRO	WI Method	60 ml amber glass	25-35 grams	None (lab preserved w/methylene chloride)	14 days
GRO	WI Method	60 ml amber glass	25-35 grams	Methanol	14 days
Oil & Grease	Method 9071	4 oz. glass	30 grams	None	28 days
Herbicides	Method 8151	4 oz. glass	250 grams	None	14 days
Pesticides (organophosphate compounds)	Method 8141	4 oz. glass	250 grams	None	14 days
Pesticides	Method 8081	4 oz. glass	250 grams	None	14 days
Total Organic Carbon	Method 415.1/9060	2 oz glass	30 grams	None	28 days
Nitrate + Nitrite, Nitrogen	Method 353.2	2 oz. glass	30 grams	None	28 days
VOCs	Method 5035 Method 8260 MN466	40 ml amber glass	5 grams	Methanol (1:1 ratio)	14 days
VOCs	Method 5035 Method 8260 MN466	40 ml amber glass	(1:4 ratio) 1 gram sodium bisulfate to 4mls water	Sodium Bisulfate	14 days
VOCs	Method 5035 Method 8260 MN466	2 oz glass	Full jar- no headspace	None (zero headspace)	14 days

4.0 Groundwater Sampling Procedure

4.1 GENERAL

To collect representative groundwater samples, groundwater wells must be adequately purged prior to sampling. Purging will require the removal of at least three volumes of standing water in rapidly recharging wells, and at least one volume from wells with slow recharge rates. Shallow wells in which the screen intersects the water table should require a minimum amount of purging since the groundwater would flow through the screen and not be entrapped in the casing. Sampling will commence as soon as adequate recharge has occurred.

The samples will be labeled and shipped following standard corporate-wide procedures, and analyzed according to the analytical program outlined in the Work Plan.

4.2 FIELD CONDITIONS

Field conditions during the sampling event will be recorded on the SIF (using the “comment” field on the reverse side, if necessary). The Sampling and Analysis Report will include a statement regarding the likelihood that any unusual field conditions had a significant impact on the integrity of results. Field conditions reported will include but not be limited to the following:

- Air temperature
- Wind speed and direction
- Precipitation/moisture
- Ambient odors
- Airborne dust

4.3 WATER-LEVEL MEASUREMENTS

Prior to any well evacuation or sampling, initial static water levels will be measured and recorded for all wells. This is done to facilitate selection of the proper pump intake depths for purging and sampling and calculation of the ground water flow direction.

Field personnel will make water-level measurements at all applicable site monitoring wells and piezometers within the shortest time interval practical to provide comparable numbers by which to calculate the ground water gradient (typically within one hour).

Water level probes will be decontaminated by rinsing with clean control water and drying with a clean cloth before use in each well. Water levels will be measured with an electric water level sensor probe that records to the nearest 0.01 foot. The electric water level sensor probe will be lowered down the well until the meter sounds indicating contact of the probe with the water surface.

The depth-to-water will be referenced to the measuring point marked at the top of the innermost well casing. Where a measuring point has not been marked at the top of the casing, the measuring point will be assumed to be at the top of the innermost casing on the north side of the casing. When reporting absolute water level elevation, this measurement will be converted to water level elevation ("MSL") from the surveyed elevation of the top of the well casing. Data will be entered in field book.

4.4 FIELD WATER QUALITY MEASUREMENTS

Specific conductance, pH, temperature, turbidity, dissolved oxygen ("D.O.") and oxygen reduction potential ("ORP") will be measured in the field after each well volume has been removed. All probes will be calibrated prior to the collection of any samples. Calibration information and all measurements will be recorded on the field book.

All measurements except for turbidity will be taken within a closed flow cell designed to allow measurement of these parameters while minimizing changes in temperature, pressure, and dissolved gases from the in-situ aquifer environment. The flow cell has the following characteristics:

- Airtight fittings for installation of all probes.
- Intake is connected directly to the pump discharge line.
- Resides in a water bath kept at a temperature close to the in-situ ground water temperature.
- A discharge line at least 3 feet long that is connected to the flow cell with an air tight connection.
- A maximum volume of no greater than five times the per minute volumetric rate of inflow to the cell to maintain measurement sensitivity to temporal changes in water quality.
- A minimum volume of 500 ml to provide enough thermal mass to minimize external temperature effects.
- The flow cell will be shielded from strong winds and on hot days it will be shielded from direct sunlight.

The operation of the probes will be as follows:

1. The flow of extracted ground water through the flow cell will be maintained as continuous and steady as practical throughout the measurement period.
2. Discharge velocities through the flow cell are kept low enough to prevent streaming potential problems with probes.
3. All probes will be fully immersed without touching the sides of the air tight, non-metallic flow cell.
4. All probes will be allowed to equilibrate with fresh well water for five minutes before recording measurements.

4.5 WELL PURGING PROCEDURE

Steps include the following:

- Using an electronic water level indicator, the water level below top of riser will be measured. Knowing the total depth of the well, it will be possible to determine the volume of water in the well. The end of the probe will be soap-and-water-washed and deionized-water-rinsed between wells.
- A low-flow submersible pump will be used to remove at least three times the well volume, measured into a calibrated pail. (A well volume will be defined as the volume of water standing inside the casing measured prior to evacuation.) Dedicated new polyethylene discharge and intake tube will be used for each well.

During this evacuation of the well, the intake opening of the pump tubing will be positioned just below the surface of the well water. If the water level drops, then the tubing will be lowered as needed to maintain flow. Pumping from the top of the water column will ensure proper flushing of the well. Pumping will continue until the well has stabilized.

4.5.1 High Yield/High Permeability Wells

Stabilization of moderate to high yield/high permeability formation wells (i.e., those that cannot be purged dry), will be demonstrated in the following manner. An initial set of conductivity, pH, ORP, D.O., and temperature readings will be taken and recorded in the field data log book and thereafter upon each well volume removed. The well will be considered stable and ready for sample collection when three successive sets of stabilization readings vary no more than: ± 0.01 pH unit, ± 20 mv ORP, $\pm 0.5^{\circ}\text{C}$, ± 0.5 mg/l D.O. or $\pm 5\%$ of the specific conductivity meter range.

4.5.2 Low Yield/Low Permeability Wells

Low yield wells (i.e., wells that are screened in low permeability formations and/or can be readily purged dry) can't be stabilized using the same procedure as used in high yield wells. A recovery test is therefore substituted for the stabilization test in these cases. A low yield well standard recovery test will consist of the following steps:

- Calculate and record the standing water column volume of both the total volume and the volume of standing water less the screen section volume.
- Rapidly pump the well until the static water level is down to the top of the screen.
- Collect a grab sample and analyze for the stabilization parameters during the purge process.
- Measure and record static water levels at increasing time intervals as the well recharges.
- Continue measuring the static water levels. The recovery test is complete when the static level has returned to the original level.
- Purge the well down to the top of screened section again.
- Collect a grab sample and analyze for the stabilization parameters early in the second purge process.
- Collect another grab sample for stabilization analysis as the well begins to recover again.
- Collect the required samples as the well recovers to a sufficient volume to allow the collection of all the samples.

Well purging data are to be recorded in the field notebook.

4.6 GROUNDWATER SAMPLE COLLECTION FOR LABORATORY ANALYSIS

4.6.1 Objectives and Considerations

During sampling, primary objectives and considerations include minimizing sample disturbance, avoiding sample exposure to air and extraneous contamination, and preserving sample integrity throughout collection.

4.6.2 Sample Collection Procedures

Groundwater sample collection procedures are as follows:

- Well sampling should be performed on the same date as purging at any time after the well has recovered sufficiently to sample, or within 24 hours after evacuation, if the well recharges slowly. If a well does not yield sufficient volume for all required laboratory analytical testing (including quality control), then a decision will be made to prioritize analyses. If a well takes longer than 24 hours to recharge, then a decision will be made to prioritize analyses. If a well takes longer than 24 hours to recharge, then a decision will be made after consultation with MPCA whether or not the sample will be considered valid.
- After well purging is completed and all field water-quality measurements have been made, a sample will be collected and placed in appropriate containers using the same low flow pump and tubing that was used for purging.
- All sample bottles will be labeled in the field using a waterproof permanent marker. Labels will include:

- Site name
- Sample identification code
- Project number
- Date/time

- Sampler's initials
 - Preservation added (if any)
 - Analysis to be performed
- Before opening and filling sample containers, check the sampling area for potential sources of extraneous contamination. Remove any possible sources of contamination, including engine exhaust, blowing dust and organic fumes (e.g., gas cans) prior to sample collection. During sample collection, Wenck personnel will wear clean, disposable gloves. The gloves will be replaced for each sampling location or when the gloves are soiled or torn. Samples will be collected into lab-provided containers (containing required preservatives) and placed on ice in coolers for shipment to the analytical laboratory (discussed in Section 4.5.5). Once the first sample is collected the chain of custody ("COC") will be initiated. COC procedures are discussed in Section 4.6.2.5.
 - Sample containers shall remain closed until it is time to fill them. Immediately after filling the container, add preservative (if required), replace the cap, label, and immediately place on ice in a cooler. Sample preservation is discussed in Section 4.6.2.4

4.6.2.1 Filtering Procedures

Sample filtration will be completed as follows:

1. A 0.45-micron pore size filter will be used.
2. The new filter will be flushed with fresh sample water for a minimum of two minutes before collecting samples.
3. The filter will be connected directly to the well sampling pump discharge line using *positive pressure* to force the sample through the filter.
4. From the filter, the flow will be routed directly into the sample collection container.
5. The flow rate will not exceed 500 ml per minute.
6. Agitation and aeration of the sample will be minimized.

Filtration procedures, including any deviations to the above technique, will be recorded in the filed book

4.6.2.2 Order of Filling Sample Containers

Field staff will collect sample parameters in the following order:

- VOCs,
- Non-filtered, non-preserved samples,
- Non-filtered, preserved samples,
- Filtered, non-preserved samples,
- Filtered preserved immediately, and
- Miscellaneous parameters

4.6.2.3 Trip Blanks, Field Blanks, and Field Duplicates

Sample blanks, will be collected to detect background or method contamination. Duplicate samples will be collected to evaluate variability in analytical methods. QA/QC samples will be collected at sampling points suspected to have relatively higher levels of contamination to provide meaningful information for blank or duplicate sample evaluation. All QA/QC samples will be collected in the same type of container as the corresponding primary samples. All QA/QC samples will be assigned identification aliases on the sample bottle label and on the chain of custody sheet to avoid alerting laboratories that the sample is a blank or duplicate sample. The true identity of the QA/QC samples will be recorded in the field book.

The collection schedule for QA/QC samples will be as follows:\

- one (1) trip blank (composed of a minimum of one {1} replicate vial) for each cooler of VOC samples. Trip blanks will be provided by laboratory.
- one (1) field (equipment) blank will be collected each day by field personnel (or one field blank for every ten {10} samples collected).

- one (1) duplicate set for every ten sets of samples collected

4.6.2.4 Sample Preservation

Samples will be preserved as shown in the above table. All Chemical preservatives, added to containers in the laboratory or field will be produced and controlled within the laboratory's QA/QC program. Field supplies of preservatives and sample containers with pre-dosed preservatives will be discarded and replaced with fresh preservatives no later than 14 days after receipt from the laboratory. All samples will be thermally preserved in the field immediately after sample collection by placing the samples in an insulated ice chest containing uncontaminated ice cubes. The ice will be placed inside uncontaminated leak proof plastic containers and the COC record will be placed inside a plastic bag. The ice chest temperature will be checked by measuring the temperature of the water within the temperature blank container at the laboratory to verify whether or not samples were kept refrigerated at approximately 4 degrees C. Temperature will be noted on the COC.

4.7 SAMPLE METHODOLOGY

Analyte	Method	Sample Container	Field Preservation	Hold Time
Total RCRA Metals	Method 6010/7470	250 ml plastic	Nitric Acid	180 days
Diss. RCRA Metals	Method 6010/7470	250 ml plastic	None	180 days
PCBs	Method 8082	1 liter glass	None	7 days
PAHs	Method 8270	1 liter glass	None	7 days
DRO	WI Modified	1 liter glass	Hydrochloric Acid	7 days
GRO	WI Modified	(3) 40 ml glass	Hydrochloric Acid	14 days
Oil & Grease, Hydrocarbons	Method 418.1	1 liter glass	Hydrochloric Acid	28 days
Herbicides	Method 8151	1 liter glass	Sodium thiosulfate + hydrochloric acid	7 days
Pesticides (organophosphate compounds)	Method 8141	1 liter glass	None	7 days
Pesticides	Method 8081	1 liter glass	None	7 days
Total Organic Carbon	Method 415.1/9060	125 ml amber glass	Sulfuric Acid	28 days
Dissolved Solids	Method 161.1	250 ml plastic	None	7 days
Nitrate, Nitrite, Nitrate + Nitrite	Method 353.2	125 ml plastic	Sulfuric Acid	28 days
VOCs	Method 8260 465F	(3) 40 ml glass	Hydrochloric Acid	14 days

4.8 IN-SITU PERMEABILITY TESTING

4.8.1 Slug Testing

Slug tests are performed on monitoring wells to determine the in-situ hydraulic conductivity of the hydrostratigraphic unit screened. This is accomplished by analyzing the water level response in the well following an instantaneous change in water level.

In-situ permeability tests will be performed on each of the monitoring wells shown in the Work Plan. Tests will be logged on an In-Situ Company, Inc., Hermit Model 2000/3000 Data Logger.

Procedure:

- Measure dimensions of the slug to be used to displace water in the well, and predetermine volume of water which will be displaced and corresponding initial water level change which will occur by adding or removing the slug.
- Record appropriate initial data using the data logger.
- Clean water level meter probe and cable, and the slug and line, following standard decontamination procedures.
- Measure the static water level in the well and record on the form (only wells which have fully recovered to static level conditions should be tested). Determine the initial-response water level based on Step 1 and record on the form.
- Set up data logger with pre-cleaned (decontaminated) pressure transducer and cable. Insert transducer and allow static level to stabilize. Input necessary functions to logger including monitoring well identification, date, static level, etc. Record transducers static water level value.
- Insert or withdraw the slug and activate the data logger. Continue test until at least 90% recovery (preferably) is attained.

5.0 Sample Labeling, Chain of Custody and Sample Shipping Procedures

5.1 SAMPLE LABELING

All samples will be labeled with:

- A unique sample number with consistent format;
- Date;
- Parameters to be analyzed;
- Preservative (if any);
- Site ID; and
- Sampler's initials.

Labels will be secured to the bottle and will be completed in indelible ink. The field sample numbering system will be as follows:

MMDDYYNN

Where:

MM = month number for sample collection date (e.g. May is "05")

DD = date number for sample collection date (e.g. 2nd is "02")

YY = year number for sample collection date (e.g. 2003 is "03")

NN = consecutive sample numbers (01, 02, 03, etc.)

Trip blanks, equipment rinsate blanks, and field duplicates use consecutive sample numbers (NN) just like any other environmental sample.

Samples that are collected as field duplicates will be collected, numbered, packaged, and sealed in the same manner as other samples and submitted "blind" to the laboratory.

5.2 CHAIN OF CUSTODY

Field personnel are responsible for sample custody from the time of collection until the time of sample shipment. Samples must be kept in the secure possession of the sampler, meaning that they are either within sight of the sampler, in the sampler's secure vehicle, or within the secure office of the sampling firm.

The following procedures for chain-of-custody forms will be followed:

- Chain-of-custody forms will be ESC standard forms (see attached example), or other sampling firm standard forms, if similar to ESC's.
- Chain-of-custody forms will include the project name or number, signature of sampler, receiving laboratory, sample ID numbers, date and time of collection, sample location, number of containers, analyses requested, sample matrix, and custody transfer signatures, including the name of the shipping company. Signature of personnel from the shipping company is not required. The shipping bill number will be recorded on the chain-of-custody form.
- One chain-of-custody form will be supplied per cooler.
- Chain-of-custody forms will be completed in ink.
- Mistakes will be lined out with a single line and initialed and dated.
- Entries will be sequentially numbered.
- Repetitive entries made in the same column may be simplified with a continuous vertical arrow between the first entry and the next different entry. A "ditto" or quotation marks indicating repetitive information will not be used.
- Multiple chain-of-custody forms for a single shipment will be consecutively numbered using the "Page ___ of ___" designation.
- At least one copy of the chain-of-custody form will be filed with the sampling firm for tracking and laboratory communication purposes.

The laboratory will retain a copy of the shipping bill as proof of custody during transit.

5.3 SAMPLE SHIPMENT

Sample coolers will be prepared for shipment as follows:

- Each cooler will be wiped clean of all debris and water.
- Each cooler will contain a corresponding chain-of-custody form sealed in a "zip lock" baggie.
- Each cooler with VOC samples will contain a trip blank.
- Each cooler will contain a temperature blank that will be checked by the laboratory when the cooler arrives at the laboratory.
- Each cooler will be packed with bubble pack or similar packing media and contain a sufficient volume of ice to maintain a temperature of $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$.
- Cooler ice will be double bagged.
- Coolers will be secured with at least two cooler custody seals (see attached example) and covered with clear plastic packing tape.
- Each cooler will be taped and sealed shut with clear plastic packing tape around each end of the cooler.
- Each cooler will be shipped to the laboratory by overnight courier.

6.0 Vapor Sample Collection

6.1 EXTERIOR SOIL VAPOR SAMPLES

The following soil gas sampling procedures will pertain to both permanent and temporary installations exterior to buildings. In general soil gas samples will be collected in the following manner:

- Prior to initiating any sampling activities prepare a field form for documentation purposes.
- Advance the soil gas sampling point to the necessary depth (using Table 1 in the MPCA's Guidance document 40-01a) using direct push technology, or manual probes if site conditions warrant.
- Soil gas sampling points will be fitted with inert tubing (e.g., polyethylene, stainless steel, or Teflon®) of the appropriate size. If the sample point is temporary the tubing will be guided through the push-probe tooling or if the sample point is permanent the tubing will be inserted into the casing and extended to the approximate midpoint of the portion of the sample point that is exposed to the formation.
- Prior to collecting the sample, a minimum of two volumes (i.e., total volume of the sampling point and tube) will be purged. This procedure will be completed using a graduated syringe. This will ensure samples collected are representative of sub-surface vapors.
- An in-line moisture trap shall be installed to prevent moisture from entering the Summa® canister.
- Attach the top end of the tubing to a Summa® canister instrumented with a vacuum gauge. The vacuum gauge will be used monitored to ensure the sample canister contains the appropriate amount of sample.

- Record the time and vacuum gauge pressure, slowly open the canister valve.
- Close the Summa® canister valve after an adequate volume of soil gas has been collected. Record this time and final pressure onto the filed form, canister label and chain of custody form. Note: Prior to initiating the sampling activities check with the laboratory supplying the canisters to obtain the vacuum gauge readings corresponding to an acceptable canister volume.
- Collect an organic vapor reading via a photoionization detector (PID). Connect the PID to the tubing that was used to fill the canister to a field instrument and record the organic vapor measurement on the field form and chain of custody form, and submit the canisters for laboratory analysis.

6.2 SUB-SLAB VAPOR SAMPLES

The following soil gas sampling procedures will pertain to both permanent and temporary installations. These samples are collected to characterize the nature and extent of soil gas contamination immediately beneath a building with a basement foundation or slab-on-grade. These samples will be using the following general procedures:

- Prior to installation of the sub-slab probe, the building floor will be inspected and any penetrations (cracks, floor drains, utility perforations, sumps, etc.) will be noted and recorded.
- Remove a concrete core from the floor using a concrete coring device or similar.
- Advance the soil gas sampling point to the necessary depth using direct push technology, or manual probes if site conditions warrant.
- Seal the drilling tool or well casing (if a permanent sample point) with grout, cement or other non-VOC-containing and non-shrinking products at the surface to ensure an appropriate seal between the ambient air and the subsurface.
- Soil gas sampling points will be fitted with inert tubing (e.g., polyethylene, stainless steel, or Teflon®) of the appropriate size. If the sample point is temporary the tubing will be

guided through the push-probe tooling or if the sample point is permanent the tubing will be inserted into the casing and extended to the approximate midpoint of the portion of the sample point that is exposed to the formation.

- Prior to collecting the sample, a minimum of two volumes (i.e., total volume of the sampling point and tube) will be purged. This procedure will be completed using a graduated syringe. This will ensure samples collected are representative of sub-surface vapors.
- An in-line moisture trap should be installed to prevent moisture from entering the Summa® canister.
- Attach the top end of the tubing to a Summa® canister instrumented with a vacuum gauge. The vacuum gauge will be used monitored to ensure the sample canister contains the appropriate amount of sample.
- Record the time and vacuum gauge pressure, slowly open the canister valve.
- Close the Summa® canister valve after an adequate volume of soil gas has been collected. Record this time and final pressure onto the filed form, canister label and chain of custody form. Note: Prior to initiating the sampling activities check with the laboratory supplying the canisters to obtain the vacuum gauge readings corresponding to an acceptable canister volume.
- Collect an organic vapor reading via a photoionization detector (PID). Connect the PID to the tubing that was used to fill the canister to a field instrument and record the organic vapor measurement on the field form and chain of custody form, and submit the canisters for laboratory analysis.

6.3 INDOOR AIR SAMPLES

The method for indoor air investigation, when deemed necessary, involves the collection and analysis of an actual sample using the EPA TO-15 method. All air samples shall be analyzed for the Minnesota Soil Gas list using EPA method TO-15 (full-scan) for the compounds in the Minnesota Soil Gas List (see below) and THC.

Chemical name	CAS #
dichlorofluoromethane	75-71-8
chloromethane (methyl chloride)	74-87-3
vinyl chloride	75-01-4
Bromomethane	74-83-9
chloroethane (ethyl chloride)	75-00-3
trichlorofluoromethane (freon 11)	75-69-4
1,1-dichloroethene	75-35-4
methylene chloride (dichloromethane)	75-09-2
1,1-dichloroethane	75-34-3
cis-1,2-dichloroethene	156-59-2
chloroform	67-66-3
1,1,1-trichloroethane (methyl chloroform)	71-55-6
carbon tetrachloride	56-23-5
benzene	71-43-2
1,2-dichloroethane	107-06-2
trichloroethene	79-01-6
1,2-dichloropropane	78-87-5
toluene (methylbenzene)	108-88-3
1,1,2-trichloroethane	79-00-5
tetrachloroethene	127-18-4
1,2-dibromoethane	106-93-4
chlorobenzene	108-90-7
ethylbenzene	100-41-4
m-xylene	108-38-3
p-xylene	106-42-3
o-xylene	95-47-6
styrene	100-42-5
1,1,2,2-tetrachloroethane	79-34-5
1,3,5-trimethylbenzene	108-67-8
1,2,4-trimethylbenzene	95-63-6
1,3-dichlorobenzene	541-73-1
1,4-dichlorobenzene	106-46-7
1,2-dichlorobenzene	95-50-1
1,2,4-trichlorobenzene	120-82-1

Chemical name	CAS #
hexachloro-1,3-butadiene	87-68-3
dichlorotetrafluoroethane Freon 114	76-14-2
trichlorotrifluoroethane - Freon 113	76-13-1
cis-1,3-dichloropropene	10061-01-5
trans-1,3-dichloropropene	10061-02-6
benzyl chloride	100-44-7
propylene (methylethylene or propene)	115-07-1
1,3-butadiene	106-99-0
carbon disulfide	75-15-0
acetone	67-64-1
methyl <i>tertiary</i> -butyl ether	1634-04-4
vinyl acetate	108-05-4
2-butanone (methylethylketone - MEK)	78-93-3
cyclohexane	110-82-7
n-hexane	110-54-3
ethyl acetate	141-78-6
tetrahydrofuran	109-99-9
n-heptane	142-82-5
methyl isobutyl ketone (4-methyl-2-pentanone)	108-10-1
methyl butyl ketone (2-hexanone)	591-78-6
bromoform	75-25-2
4-ethyltoluene	622-96-8
trans-1,2-dichloroethene	156-60-5
bromodichloromethane	75-27-4
dibromochloromethane	124-48-1
naphthalene	91-20-3
ethanol	64-17-5
2-propanol	67-63-0

Prior to collecting indoor samples, a pre-sampling indoor inspection will be performed to evaluate the physical layout and conditions of the building being investigated, to identify conditions that may affect or interfere with the proposed sampling, and to prepare the building for sampling by ensuring temporary mitigation of those conditions. An indoor air quality survey will be conducted if applicable. The survey will be completed at least two weeks prior to sample collection so that cooperation can be requested from the building occupants in making alterations to building usage or their behaviors. This is required to provide adequate time for the reduction of potential background sources prior to sampling.

At the time of sample collection the Summa® canister sample port will be placed in the breathing zone, approximately 3-5 feet from the floor. The sample will be collected from the center of the room if possible. Ideally, samples will be collected from the lowest level of the structure (e.g., basement) near the suspected source and from the main floor and/or other commonly used spaces to assess worst-case exposures and the distribution of contaminants within the structure.

Samples will be collected under conditions representative of the use of the structure, (i.e., doors open or closed depending on their typical condition and the heating system in use if winter). During the summer months, windows will be closed in order to minimize the contribution of outside air. It feasible a sample will be collected directly from the point of suspected vapor entry such as a sump or other enclosed space to better define the potential route of entry and the maximum concentrations. The sample will be collected over a 24-hour period using an appropriate regulator.

In general soil gas samples will be collected in the following manner:

- The sample will be collected by placing a Summa® canister in the appropriate sampling location (in the breathing zone as mentioned above).
- A flow controller will be affixed to the canister prior to sampling. The flow controller will be pre-set by the laboratory to collect the sample over a 24-hour period.

- An in-line moisture trap will be installed to prevent moisture from entering the canister.
- Open the valve on the canister to begin sample collection.
- After approximately 24 hours have passed, close the valve on the canister and record the time on the Air Sampling Form and on the Chain-of-Custody.
- The canister(s) and flow controller(s) are then to be transported to the laboratory.
 - 1) If the MCPA requires that a grab sample be collected, the same procedure should be followed without the use of a flow controller.

6.4 OUTDOOR (AMBIENT) AIR SAMPLES

Outdoor air samples are collected to characterize site-specific background outdoor air conditions. If necessary, these samples will be collected simultaneously with indoor air samples and be collected in the same manner as the indoor samples (see above).

Outdoor air samples will be collected from a representative upwind location, away from wind obstructions (e.g., trees or buildings), and at a height above the ground to represent breathing zones (3 to 5 feet).

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

- Outdoor plot sketches will be drawn to include the building site, area streets, outdoor air sample locations (if applicable), location of potential interferences (e.g., gasoline stations, factories, lawn movers, etc.), and compass orientation (north).
- Weather conditions (e.g., precipitation, indoor and outdoor temperature, barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) will also be reported.
- Any pertinent observations such as odors, field instrument readings, and significant activities in the vicinity (e.g., operation of heavy equipment or dry cleaners) will be recorded.

6.5 GENERAL FIELD QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Appropriate QA/QC protocols will be followed for sample collection and laboratory analysis, such as use of certified clean sample devices, meeting sample holding times and temperatures, chain of custody, etc. Samples will be delivered to the analytical laboratory as soon as possible after collection. All appropriate laboratory procedures must be followed for field documentation (sample collection information/locations), chain of custody, field blanks, field sample duplicates and laboratory duplicates, as appropriate.

The field sampling personnel will maintain a sample log sheet summarizing the following:

- a) sample identification,
- b) sample location,
- c) date and time of sample collection,
- d) sampling depth (soil gas or sub-slab),
- e) sampling height (indoor or outdoor),
- f) identity of samplers,
- g) sampling methods and devices,
- h) purge volumes and devices used,
- i) the vacuum (pressure) of the Summa canister which will be recorded on the chain of custody and sampling forms,
- j) apparent moisture content (dry, moist, saturated, etc.) of the sampling zone,
- k) type of soil present in the sampling zone (e.g., clay, sand, gravel, etc.), and
- l) chain of custody records to track samples from sampling point to analysis.