Procedures for Active Soil Gas Sampling Using Direct-Push Systems
FSOP 2.4.1 (March 9, 2017)
Ohio EPA Division of Environmental Response and Revitalization

1.0 Scope and Applicability

1.1 Vapor intrusion is defined as vapor phase migration of volatile organic compounds (VOCs) into occupied buildings from underlying contaminated ground water and/or soil. Soil gas surveys provide information on the soil atmosphere in the vadose zone that can aid in assessing the presence, composition, source, and distribution of contaminants. The purpose of this document is to provide guidance for conducting soil gas sampling, and shall pertain to active soil gas surveys, whereby a volume of soil gas is pumped out of the vadose zone into a sample collection device for analysis.

1.2 Detection of individual constituents by active soil gas sampling is limited by the physical and chemical properties of individual contaminants of concern* and the soil characteristics of the site. In general, chemical parameters or criteria to be considered prior to selecting soil gas sampling activities are as follows:

- Vapor Pressure > 0.1 mm Hg
- Henry's Law Constant > 0.1
- Degree of soil saturation (chemical and/or water) < 80%
- Sampling zone is permeable and permits vapor migration

Please refer to Appendix A (Chemicals of Concern for Vapor Intrusion) of the Sample Collection and Evaluation of Vapor Intrusion to Indoor Air, Guidance for Ohio EPA'S Remedial Response and Voluntary Action Programs (Ohio EPA DERR, May 2010) for a complete list of the volatile chemicals which can be detected using soil gas sampling techniques.

1.3 Results from soil gas surveys are used in both qualitative and quantitative evaluations. The quality and application of the data is dependent upon many factors, including but not limited to: the DQO's used to develop the sampling plan, the number of sample locations and data points, the selection of the sample locations, the soil characteristics of the site, the distribution of the contaminants in both the vadose and saturated zones, the equipment and personnel used to gather the data, etc. The work plan should be finalized before any sampling is conducted. The work plan will provide specific information on the type and quality of data gathered during the soil gas sampling event. Any questions regarding data needs and usage should be resolved prior to sampling.

1.4 The evaluation of the indoor inhalation pathway at contaminated sites is a significant concern at sites/properties where contamination is known or expected to exist. As a result, procedures and technology related to evaluating the pathway continue to evolve. This procedure pertains to the active collection of soil gas using direct-push techniques (i.e., driven probe rods/tooling). With respect to the use of other appropriate methods, procedures, and equipment for measuring concentrations of chemicals of concern in soil gas, please refer to Appendix D, Section 4 of the Vapor Intrusion Guidance: A Practical Guide (ITRC, January 2007).

2.0 Definitions

Terms specific to soil gas sampling using direct-push systems are defined throughout this FSOP.

3.0 Health and Safety Considerations

3.1 Follow the site specific health and safety plan (HASP). If a site-specific HASP is not available, follow the health and safety procedures in FSOP 1.1, Initial Site Entry.

3.2 The use of direct push systems on a site within the vicinity of electrical power lines and other utilities requires that special precautions be taken by the operators. Underground electrical utilities are as dangerous as overhead electricity. Be aware and always suspect the existence of underground utilities (water, natural gas, cable and phone lines, fiber optic cables, storm water and sewer lines, etc.).

REMEMBER.....Call B-4-U Dig:
Ohio Utilities Protection Service (OUPS): 800-362-2764
&
Oil & Gas Producers Underground Protection Service (OGPUPS):
800-925-0988

4.0 Procedure Cautions

A soil gas survey is only applicable to volatile contaminants. Geological barriers may exist that interfere with vapor migration such as perched water, clay or man-made structures. Interference from these geological barriers can lead to non-representative sampling with low or false negative readings, or may produce localized areas of high concentrations. In addition, heavy precipitation, 24 to 48 hours prior to sampling can result in a significant reduction in volatile concentrations.

5.0 Personnel Qualifications

Ohio EPA personnel working at sites that fall under the scope of OSHA's hazardous waste operations and emergency response standard (29 CFR 1910.120) must meet the training requirements described in that standard.

6.0 Equipment and Supplies

Personal Protective Equipment (PPE):

6.1 Hearing protection
6.2 Safety glasses
6.3 Nitrile (or similar) disposable gloves
6.4 Steel-toed boots

Equipment/Tooling/Supplies for Probe Installation:

6.5 Direct push rig
6.6 4-foot probe rods
6.7 2-foot probe rods
6.8 Inner Extension Rods (48")
6.8 Rod Grip Pull System
6.10 Drive Cap
6.11 Miscellaneous tools
6.12 Log book/Data sheets
6.13 Bentonite granules

Soil Gas Sampling:

6.14 Expendable Point Holder
6.15 Implant Expendable Point Holder
6.16 Expendable Drive Points (w/ O-ring)
6.17 6.25 Expendable Point Popper
6.18 PRT Adapter for ¼“ tubing w/ O-ring
6.19 ¼“ OD x 3/16” ID tubing (Teflon™ or Nylon)
6.20 20/40 grade sand (#5 quartz silica sand, or equivalent)
6.21 1L Evacuated canisters (i.e., Summa®), with grab flow-choke regulators
6.22 Implants (stainless steel, aluminum, ceramic, or plastic)
6.23 Funnel
6.24 Tubing cutter
6.25 Polycarbonate 2- & 3-way valves
6.26 Disposable 60cc Syringe
6.27 Photoionization detector (FSOP 3.1.1, Photoionization Detector), ppb capable
6.28 Multi-gas meter (FSOP 3.1.2, Multiple Gas Detection Meters)
6.29 Field documentation equipment and supplies, including pens, markers, field log book and data sheets, chain-of-custody forms, camera, etc.

7.0 Procedures: Summary of Probe Installation Methods

7.1 Using the Post-Run Tubing System for Grab Sample Collection

This is a temporary, single use application for collecting a soil gas grab sample. Using the post-run tubing system (PRT), probe rods are driven to the desired depth, and then internal tubing, with PRT fitting attached, is inserted and seated for soil gas sampling. Using the inner tubing for soil gas collection has many advantages - potential for leakage is reduced, dead air volume that must be purged is reduced, and decontamination problems are reduced as the sample does not contact the rod bore.

7.1.1 Clean all parts prior to use. Inspect all probe rods and clear them of obstructions. Install O-ring on the PRT expendable point holder and the PRT adapter.

7.1.2 Test fit the adapter with the PRT fitting on the expendable point holder to assure that the threads are compatible and fit together smoothly. Ensure the threads are clean of debris.

NOTE: PRT fittings are left-hand threaded and must be rotated counter-clockwise to engage the point holder threads.

7.1.3 Push the PRT adapter into the end of the selected tubing. Tape may be used on the outside of the adapter and tubing to prevent the tubing from spinning freely around the adapter during connection - especially when using Teflon™ tubing.

NOTE: The sample will not come into contact with the outside of the tubing or adapter.

7.1.4 Attach the PRT expendable point holder (with O-ring) to the female end of the leading probe rod.

7.1.5 Attach an O-ring to an expendable soil vapor drive point and insert into the expendable point holder. Attach the drive cap to the male end of the drive rod and position rod under probe.

7.1.6 Drive the PRT rod configuration into the ground, connecting probe rods as necessary to reach the desired depth.

7.1.7 After desired depth has been achieved, disengage the expendable drive point. Using the inner extension rods, insert the expendable point popper to the bottom of the rod string and then slowly pull up on the probe rods using the rod grip pull system. Retract the rods approximately 4"- 6" up to create a void from which to sample the soil gas. Position the probe unit to allow room to work around the sample location.

7.1.8 Insert the PRT adapter end of the tubing down the inside diameter of the probe rods.

7.1.9 Feed the tubing down the rod bore until it hits bottom on the expendable point holder. Allow approximately 4-6 ft. of tubing to extend out of the hole before cutting it. Grasp the excess tubing end and lightly apply downward pressure while turning it in a counter-clockwise motion to engage the adapter threads with the expendable point holder. Continue turning until the PRT adapter O-ring bottoms out in the expendable point holder.

7.1.10 Pull up lightly on the tubing to test the engagement of the threads. Failure of the PRT adapter to thread could mean that intrusion of soil may have occurred during driving of the rods or disengagement of the expendable drive point. Once tubing has been connected, finish the surface end with a 2-way valve in the closed position.

7.1.11 Sampling at the location can commence following an equilibrium period (minimum of 15 minutes). Connect the sampling tubing and follow appropriate purging and sampling procedures. Refer to “Procedures for Collection of Indoor Air, FSOP 2.4.3” for reference for use of evacuated

canisters for sample collection; and refer to Section 7.3.1 below, for sampling procedures using the bag sampler (e.g., Lung Box).

7.1.12 Prior to sample collection and screening, ensure that the implant is in a porous soil zone that will freely give up soil gas. Connect a 60 cc syringe to the implant tubing, open the 2-way tubing valve, and gently pull the plunger out to fill the syringe with gas. Let go of the plunger and observe whether it holds position where released, or if it can be observed moving back due to an induced vacuum. Should a vacuum be present, the soil zone at the end of the probe rods may be too tight to get a representative soil gas sample. Should this occur, the probe rods can be pulled up 1 to 2 feet at a time, retesting each interval until soil gas can be freely obtained. If not, abandon the location, seal the borehole with bentonite, and reposition the probe; or relocate to another position.

7.2 Installation of Soil Gas Implants

For long-term soil gas monitoring applications (multiple sampling events from the same location), a stainless steel, aluminum, polycarbonate or ceramic implant can be installed at any depth by direct push. Implants are inserted down inside the probe rods when the appropriate sampling depth has been achieved. When installing soil gas implants, knowledge of the local geology and soil types is paramount to the success of any soil gas survey. For sites where geology or soil characteristic information is not available, the collection of soil borings to target depth may be helpful in identifying zones or soil horizons in which to set soil gas implants.

7.2.1 Drive probe rods to the desired depth using the implant expendable point holder and an expendable drive point. Disengage the drive point using the point popper. Using the inner extension rods, insert the expendable point popper to the bottom of the rod string and then slowly pull up on the probe rods using the rod grip pull system. Retract the rods approximately 1”- 2” to push the expendable point out with the point popper. Remove all extension rods and point popper. Check end of last inner rod or point popper for evidence of moisture. Implants should not be installed in moist zones as these can inhibit vapor migration as well as, given enough time for water to accumulate, may result in water being drawn up and into sample containers (evacuated canister or Tedlar® bag).

7.2.2 Attach implant to one end of appropriate sample tubing (Teflon™, or nylon). Depending on implant type and diameter of sample tubing, a very short length of silicone tubing of appropriate size may be used to securely connect the implant to the sample tubing.

7.2.3 Lower the implant and tubing down the inside of the probe rods until the implant hits the top of the anchor/drive point. Note the length of the tubing to assure that proper depth has been reached. Cut the tubing flush with the top of the probe rod.

7.2.4 Using an inner extension rod, place one end of the rod on top of the fresh cut tubing. While holding the rod in place, slowly retract the rods, 4 feet at a time, and remove the drive rod. Continue this action of using the extension rod to hold the tubing in place until all the drive rods have been removed from the borehole.

7.2.5 Slowly pour sand (20/40 grade or #5) down the borehole around the outside of the tubing so that the sand extends several inches above the implant. Use the tubing to "stir" the sands into place around the implant. Do not lift up on the tubing. It should take less than 250 mL of sand to fill the space around the implant. The sand therefore will act as a grout barrier, inhibiting the grout from impacting the implant. Slowly pouring sand and bentonite will lessen the chance for the materials to bridge in the borehole.

NOTE: Implants come in various sizes and the drive rods can vary in diameter, so it is best to calculate the necessary volume of sand for each implant installation. Placement of the grout barrier by backfilling the borehole can only be performed in the vadose zone, not below the water table.

7.2.6 Once the sand is in place, slowly add the bentonite granules on top of the sand. After approximately 0.5 L of bentonite has been added, hydrate the bentonite in the hole. Hydration can be accomplished using a pump sprayer, or by using a section of tubing connected to the 60 cc syringe filled with water. Depending on borehole depth, the bentonite should be hydrated at a minimum of 3-5 intervals. Allow bentonite to come to ground surface, saturate the bentonite with water to create a bentonite "mud" and, using a finger, push this mix around the tube and back down the hole to enhance the closure. This results in a tight seal preventing gas migration down the column.

NOTE: Use caution not to over hydrate, as the water may flow out into the soil formation and travel down to the implant, causing it to become wet and potentially loose diffusivity

7.2.7 After sealing the borehole, cut the tubing to a manageable length (~12" - 18"), attach a 2-way valve connector (in the OFF position) or air tight (e.g., Swagelok®) plug, and mark the location with a pin flag or stake. Attach a label or tag to the tubing indicating the sample location identifier and depth at which the implant was set for future reference when sampling. Example: SG-3-18, meaning a soil gas point at location #3 with an implant set at 18 feet bgs.

7.2.8 Check the viability of the sample point just installed following the procedures outlined in section 7.1.12 using a 60 cc syringe. A multi-gas meter with a PID is also a very good way to purge and check the sample point's viability and usefulness. Stable field screening measurements for VOC's, oxygen, and hydrogen sulfide can be good indicators on a well-sealed and sampling-ready implant. Should the meter's pump motor labor, or if the syringe plunger recedes back into

syringe after pulling, a vacuum has been induced and the point is not viable for sample collection. The induced vacuum would be too much to overcome to obtain a gas sample using either an evacuated canister or a bag sampler.

7.2.9 A minimum equilibrium time should be established prior to sampling the implant (preferably stated in the work plan). While a 24-hour equilibrium period will ensure adequate equilibration, four to eight hours is generally sufficient. After equilibration, the implant is ready for sampling. Refer to Section 7.3 for sampling procedures using a vacuum canister (*e.g.,* Summa® or Silco).

7.2.10 To provide long term security to the sampling port, the installation of a flush mount or above ground protective casing with a cap can be installed and finished with a concrete pad. For temporary, short-term finishing of a sampling port, 4-6" (ID) PVC pipe sections with associated caps can be installed.

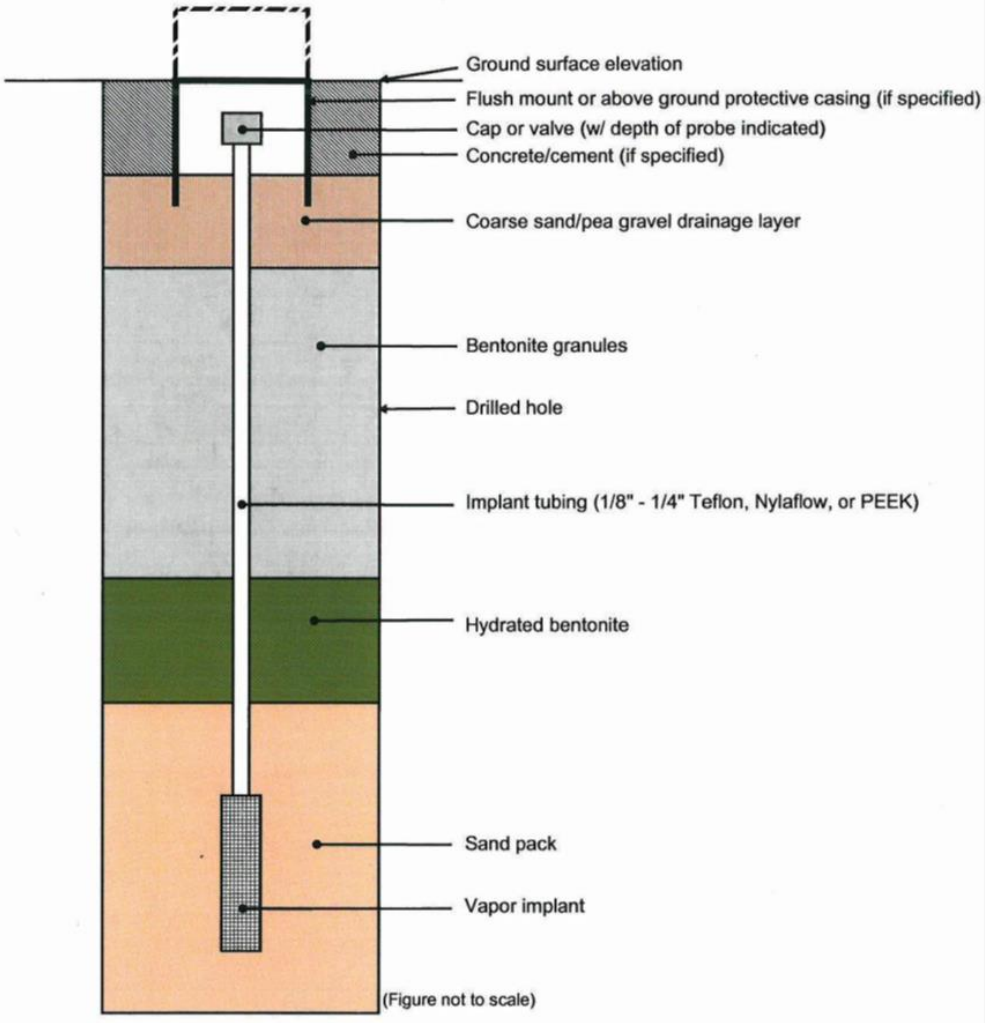

Figure 3: Permanent Soil Gas Probe Schematic

7.3 Sample Collection Methods

Two common methods of sample collection for vapor intrusion contaminants of concern (COCs) are discussed in this FSOP. The lung box sampler uses Tedlar® bags as sample containers. Collection of samples on adsorbents is performed by using a small external pump to pull air through adsorbent media cartridges and/or tubes. Data Quality Objectives (DQOs) for the project will determine which sample collection method to use. Field data should be recorded on the Soil Gas Sampling Data Sheet (attached) or in a field notebook.

7.3.1 The Lung Box Sampler (Bag Samplers)

The Lung Box allows direct filling of a Tedlar® air sample bag using negative pressure without passing gas through the pump. This eliminates the risk of contaminating the pump or the sample. The Lung Box, pictured below, includes an in-line pump. Other types of bag samplers may require the use of a separate air pump or hand pump.

The recommended holding time for samples collected into Tedlar® bags is 24 to 48 hours. Therefore, soil gas samples collected in Tedlar® bags should be analyzed as quickly as practical or samples can be transferred to another container with longer holding times (i.e., Summa canister). If this method of sampling is performed, ensure that the laboratory can accept Tedlar® bags, and can meet the holding time requirements.

Semi-permanent soil gas probe location with multi-depth implants. The lung box sampler is used to collect soil gas samples using 1-liter Tedlar bags. Note that each tube is labeled with the sampling depth; the PVC pipe is used to protect the soil gas tubing.

7.3.1.1 Prior to sampling, and after an appropriate equilibrium period (typically 8 – 24 hrs. depending on DQOs), ambient air needs to be removed from the sample train by purging. Purging of the filter pack is required if sampling occurs within 24 hours of installation. At least three volumes should be removed. For example, the sample tubing can be purged using a 60 cc syringe with an attached 3-way valve (~4 cc/ft for ¼" ID tubing/volume). Other methods may be used as long as a minimum of 3 volumes are purged from the tubing. Once purging is complete, the sample may be collected. Field screening may be performed using a direct reading instrument after sample collection.

7.3.1.2 Install new tubing in the bag sampler before collecting each sample. Place a new Tedlar® sample bag (already labeled) inside the bag sampler. Attach the inside portion of the tubing to the inlet valve on the sample bag. Open the sample valve on the sample bag following the manufacturer's instructions. Close sampler lid and secure. (DO NOT use any type of permanent marker, i.e., "*Sharpie"* pens)

7.3.1.3 Attach external part of the inlet tubing to the sample tubing. Make sure that the purge valve on the side of the box is closed (closed for fastest fill rate, open for slower fill rate).

7.3.1.4 Turn on the sample pump or initiate hand pumping. While filling, watch through the observation window of the Bag sampler as the Tedlar® bag fills with gas. Avoid filling bag more than 80% of its maximum volume. Turn the pump off when the bag has filled to the desired volume. Do not over fill sample bags. The vacuum pump may be strong enough to break a sample bag.

NOTE: Be sure to watch the sample line for the first sign of water coming up the line. Pulling water up the line is not uncommon, especially in cases where the position of the water table is unknown. This is a good reason why ample lengths of tubing should be used for the sample line. If water is drawn up the tubing, the tubing can be cut before the water reaches the sampling equipment.

NOTE: Exercise extreme caution if filling sample bags with explosive gases.

7.3.1.5 Once filling of the sample bag is complete, turn off the pump, open the purge valve to equalize the pressures, unlatch the bag sampler lid and open. Close the sample bag inlet valve by holding the side stem and turning the entire upper portion of the fitting clockwise until snug. Remove the filled sample bag from the internal inlet tubing.

NOTE: In an effort avoid any photochemical reactions, keep filled Tedlar® bags out of sunlight. Store and ship bag samples

in a protective box at room temperature. Do not chill to avoid condensation.

7.3.1.6 If measurements with a portable meter are to be made (*e.g.,* oxygen), conduct measurements after collecting the soil gas sample(s).

7.3.2 Collection of Samples on Adsorbents

7.3.2.1 An alternative approach to collecting soil gas in a sample container is to concentrate the soil gas on an adsorbent media. This type of method is required for SVOCs and is often used for mercury (generally compounds heavier than naphthalene). Typically, a pump is used to draw soil gas through the adsorbent matrix, and the adsorbent is then analyzed by a laboratory.

7.3.2.2 A variety of adsorbent cartridges and pumping systems are available from commercial vendors. In addition, it is essential that the soil gas be drawn through the adsorbent by the pump, not pumped through the adsorbent to eliminate the chance for cross-contamination by the pump. It is often recommended that two tubes be used in series to avoid breakthrough losses in areas of suspected higher concentrations. The adsorbent, purge rate, and sample volume must be determined by discussion with the analytical laboratory.

7.4 Soil Gas Sample Field Screening

7.4.1 Following sample collection, field-screen the borehole or soil gas probe atmosphere with a PID in accordance with FSOP 3.1.1, Photoionization Detector, to estimate the bulk concentration of VOCs present in the soil gas sample. The PID field screening data should be recorded with the sample information on the chain-of-custody form. The analytical laboratory needs to be aware of any samples potentially containing high concentrations of VOCs that may need to be diluted prior to analysis.

7.4.2 If desired, to perform the field-screening, attach an appropriate length of tubing to the PID sampling tip with a small piece of silicon tubing and extend it at least halfway into the boring or attach PID directly to tubing on a soil gas probe to obtain readings.

7.4.3 The PID field screening data may also be collected for sampler health and safety concerns or to use as real-time screening information to help evaluate the need for additional sampling or other site assessment activities while in the field.

7.4.4 In addition to a PID, a multi-gas meter (FSOP 3.1.2, Multiple Gas Detection Meters) may be used to field screen the borehole or soil gas probe atmosphere to collect gas concentration field screening data. This information may be provided to the analytical laboratory, used to monitor health and safety concerns, or used as real-time screening

information to help evaluate the need for additional sampling or other site assessment activities while in the field. Parameters often include VOCs (ppb), Oxygen (% O_2), Lower Explosive Level (% LEL), Carbon monoxide (ppm CO), and Hydrogen sulfide (ppm H_2S)

8.0 Data and Records Management

Refer to FSOP 1.3, Field Documentation.

9.0 Quality Assurance and Quality Control

Refer to the Site Specific Work Plan

10.0 Attachments

Soil Gas Sampling Data Sheet

11.0 References

FSOP 1.1, Initial Site Entry

FSOP 1.3, Field Documentation

FSOP 3.1.1, Photoionization Detector

FSOP 3.1.2, Multiple Gas Detection Meters

Interstate Technology & Regulatory Council (ITRC) Vapor Intrusion Team, January 2007, Vapor Intrusion Pathway: A Practical Guideline

Ohio EPA Division of Environmental Response and Revitalization, May 2010, Sample Collection and Evaluation of Vapor Intrusion to Indoor Air for Remedial Response and Voluntary Action Programs (Guidance Document)

SOIL GAS SAMPLING DATA SHEET

GENERAL INFORMATION

Site Name:_____

Site Address:_____

City:_____

County/District_____

Contact Name:_____

Phone #:_____

Sampling Address:_____
(if other than site address)

Grab Sample:_____ **Canister Sample:**_____

Sample ID #: _____

If canister used, complete info below:

Canister ID #:_____

Regulator ID #:_____

SAMPLING INFORMATION

(mm/dd/yy) ***(military)***

Soil Gas port installed: Date:_____**Time:**_____
Depth :_____

If canister used for sample collection, complete following info:

Sample Collection Start: Date:_____**Time:**_____

Sample Collection End: Date:_____ **Time:**_____

Regulator Calibrated for:

_____ **8-hr** _____ **12-hr** _____ **24-hr** _____ **grab (no regulator)**

Laboratory & Analytical Method: _____

Sample Delivered: Date_____ **Time:**_____

Method of Delivery: _____
(ex. Lab courier, UPS, delivered by sampler, etc.)

Canister Info:

Initial canister vacuum:

_____ **"Hg or mm Hg**

Final canister vacuum:

_____**"Hg or mm Hg**

Temperature:

_____ **°F**

Field Screening Info:

PID (ppm):_____

% O_2 :_____

CH_4 (%LEL):_____

CO_2:_____

CO:_____

H_2S:_____

List instrument (and ID#) used to collect parameters:

_____

NOTES: (include any information on the installation of the soil gas port, or problems with sampling/canister etc.)

Signature of Sampler: _____ **Date:**_____

Note: If a diagram of the sample location(s) is sketched on the back of this data sheet, check here ☐