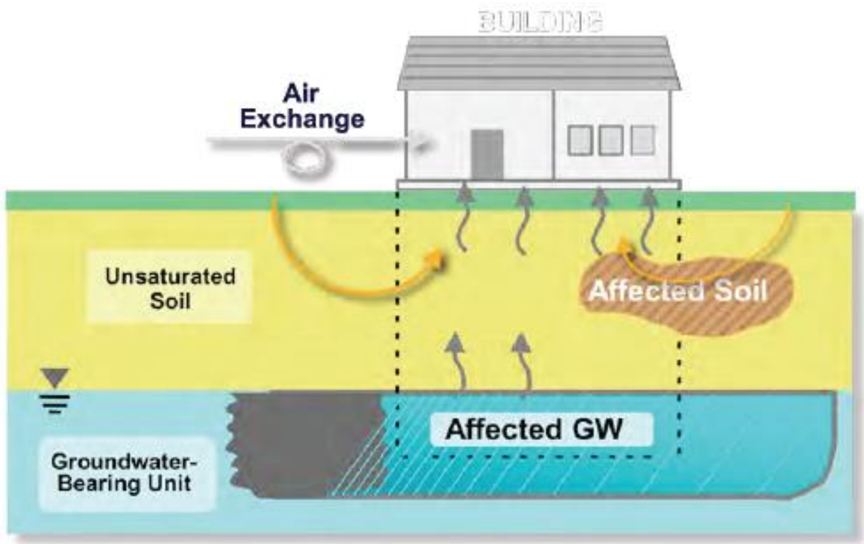
District of Columbia
Collection of Soil Gas Samples
Technical Guidance



Department of Energy & Environment
Toxic Substances Division
Underground Storage Tanks Branch

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DEPARTMENT OF ENERGY & ENVIRONMENT

FIGURES:

TABLE:

1.0 INTRODUCTION AND SCOPE

The DCRBCA guidance document requires evaluation of the indoor air inhalation pathway at sites having petroleum contamination in soil, groundwater, or both. For sites where the indoor air inhalation pathway is complete currently or in the future and soil and/or groundwater representative concentrations exceed either Tier 1 RBSLs or Tier 2 SSTLs for the indoor air inhalation pathway, the guidance allows the pathway to be further evaluated through soil gas sampling. Such sampling must be conducted under a work plan approved by the Underground Storage Tank Branch of the Department of Energy and the Environment (DOEE) prior to the occurrence of the soil gas sampling event.

This document is intended to provide guidance to LUST responsible parties, their consultants and contractors on appropriate procedures for collecting and interpreting soil gas data, when this sampling is conducted as part of the assessment of the vapor intrusion to indoor air pathway. Prior to making a decision to sample soil gas, a site conceptual model should be developed and the significance of the vapor intrusion pathway assessed, using available groundwater and soil data coupled with any knowledge about current and potential future structures and the presence of preferential pathways.

Note that this guidance does not specifically pertain to sub-slab vapor sampling (a means of collecting soil gas samples from beneath a building via the installation of monitoring points through the foundation of the building) or indoor air sampling. If site conditions warrant collection of sub-slab vapor samples or indoor air sampling, DOEE recommends following any published guidance documents by USEPA, ITRC, or other institution as an interim guidance documents until DOEE develops its own guidance. Sub-slab sampling, near slab or indoor air sampling, whether in accordance with USEPA or other guidance or procedures, must be conducted under a DOEE-approved work plan.

The guidance is designed to facilitate a quantitative evaluation of soil gas. Passive soil gas monitoring is generally a qualitative activity used to guide the installation of permanent sampling points. Therefore, passive soil gas monitoring should not be used to quantitatively monitor soil gas or assess risks associated with vapor intrusion. Passive soil gas monitoring may be used preliminarily to assist in planning a quantitative soil gas sampling event.

Given measured impacts to soil and/or groundwater by VOCs, soil gas sampling is often used to evaluate whether such impacts represent a concern relative to the vapor-intrusion-to-indoor-air pathway. While the potential effect of soil and/or groundwater contamination on indoor air can be directly modeled, such models are very conservative and will greatly overestimate the soil gas concentration at the source and the resultant indoor air risk. Using measured soil gas concentrations can give a more realistic, but still conservative, estimate of the potential for vapor intrusion to indoor air.

2.0 PRE-SAMPLING PLANNING ACTIVITIES

In many instances, soil vapor sampling should be collected outside the source property boundaries e.g. in front of residential buildings that are located outside the source property boundaries and are the potential receptors. Therefore, pre-sampling planning activities such as community interaction and sampling locations should be developed.

2.1 COMMUNITY INTERACTION

Sampling on properties not owned and operated by the responsible party or property owner, would require a communication plan. This plan should communicate appropriate information to those parties potentially impacted by the sampling program, and to those who may be concerned about vapor intrusion or other aspects of the project. Information such as the planned activities, number of staff involved, duration, start and end time, location, zone of influence, potential negative and positive impacts, corrective action/mitigation plan, access, and contact details for who to contact for additional information, should be included.

2.2 DEVELOPMENT OF SAMPLING PLAN

An appropriate workplan should be prepared and submitted to the UST Branch for review and approval at least thirty (30) days prior to its implementation. The soil gas workplan can either be incorporated as part of a comprehensive site investigation workplan or as a stand-alone document, depending on site-specific circumstances. Review and update the site conceptual model, and based on the final conceptual model, develop a sampling plan to ensure that the soil gas data collected will be sufficient for evaluation of the vapor intrusion pathway.

a. Ensure that the sampling plan is consistent with this guidance document. Any variations or deviations from this guidance should be specified in the workplan.

b. Identify the site specific COCs based on previous investigation work (e.g., Phase 1 or Phase 2 or CSA investigation).

c. Identify the locations of utilities and determine whether they may serve as preferential flow pathways.

d. If modeling is used to help interpret the sampling results, consider the collection of geotechnical data that can be used as site-specific model input values.

3.0 SOIL GAS SAMPLE POINT INSTALLATION

3.1 INSTALLATION REQUIREMENTS

The Water Quality Division of DOEE governs the installation and abandonment of soil borings and monitoring wells in the District. Refer to the District's Well Regulations prior to installing soil gas sampling points in the field.

3.2 LATERAL SPACING OF SOIL GAS SAMPLING POINTS

Following parameters should be considered to select soil gas sampling locations:

- The locations of the point and area of release,
- The location of the highest concentrations of volatile COCs in ground water,
- The location(s) of existing on-site building(s),
- The location(s) of potential future on-site building(s),
- The location(s) of existing off-site buildings, and
- The location(s) of potential future off-site building(s).

Soil gas sampling is proposed to assess vapor intrusion risk from the subsurface to the existing or potential future buildings. Therefore, sampling points should be laterally spaced to adequately represent soil gas concentrations proximate to such structures, taking into consideration the location of contamination relative to the structures. The actual number of soil gas sampling points necessary for a given site will depend on the size and number of buildings, the location of the buildings relative to soil and groundwater contamination, and, for the evaluation of hypothetical future structures, the extent or size of the contamination plume. The following provisions should be considered as general guidelines rather than specific requirements. The locations and spacing of soil gas sampling points will ultimately be dependent on site-specific characteristics.

3.2.1 Existing Building

For an existing building, such as a residence or small commercial structure, choose sample locations on all four sides of the building, or, at a minimum, on the two sides closest to the source area. In addition, for existing buildings, samples should be collected above the area of highest contamination. However, if contamination is located to one side of an existing structure, the collection of samples only from that side of the structure might be adequate. If any wall of the structure exceeds 50 feet in length, a minimum of two sampling points is required along that wall.

3.2.2 Future Building

To evaluate future building sites, choose at least three sample locations in the vicinity of the source or on a perpendicular transect located between the source and the likely position of the future building of concern. In addition, for future buildings, samples should be collected above the area of highest contamination. However, if the size of the plume exceeds 2,500 square feet, more than three sampling points will be required, with the total number dependent on the overall size of the plume. In general, sampling points should be spaced no greater than 50 feet apart and preferentially placed within the anticipated footprint of the future structure, if known.

3.3 VERTICAL SAMPLING DEPTH

The depth at which samples will be collected depends on the depth to soil contamination and the depth to groundwater (the latter only if vapors emanate from groundwater).

- To the extent possible, soil gas sample depths should be chosen to minimize the effects of changes in barometric pressure, temperature, or breakthrough of ambient air from the surface, and to ensure that consistent and representative samples are collected. In determining appropriate sampling depths, strong consideration should be given to the lithology of the subsurface. Under no circumstances may soil gas samples be collected from a depth of less than 3 feet.

- In general, soil gas samples must be collected at a minimum of two discrete depths at each sampling point. Where contamination in soil is very shallow or groundwater is very shallow (i.e., less than approximately 5 feet below the ground surface), one sample from a single depth might be sufficient.

- One of the two soil gas samples collected at each sampling point must be collected at a depth no greater than 3 feet below the foundation of the enclosed space or potential future enclosed space. The depth at which the second sample is collected will be dependent on site conditions, primarily the depth to contamination.

- For structures having basements, one or more soil gas samples must be collected adjacent to basement walls (i.e., no further than 5 feet from the wall and, generally, at a depth approximately equal to the midpoint of the wall; this depth might need to vary depending on the characteristics of the structure). Unless soil or groundwater contamination is found below the building, soil gas sampling adjacent to the basement walls need only occur on the side or sides of the building where the contamination is found (e.g., if the soil or groundwater contamination is south of the building, soil gas sampling must, at a minimum, occur on the south side of the building). If soil or groundwater contamination is found below the elevation of the basement floor, soil gas samples must also be collected just below the elevation of the floor.

- For structures without basements, soil gas samples should be collected below the depth of the foundation, with the first sample collected at a depth of no more than 3 feet.

- For potential future buildings, if there is no other information available to select depth, soil gas samples should be taken at target depths of approximately 3 feet and 10 feet below ground surface. This method assures that data is available to assess vapor intrusion threats to both "slab-on-grade" buildings and those having basements. If groundwater is too shallow to allow sampling at one or both of these depths, samples should be collected immediately above the capillary fringe or the top of soil contamination. If soil contamination extends to the surface, sample at a depth approximately equal to the anticipated depth of the future structure's foundation.

- In all cases, if groundwater is too shallow to allow soil gas sampling at the depths specified above, samples should be collected immediately above the capillary fringe. If soil contamination extends to the surface, sample at a depth just below the expected or actual foundation or floor of the structure.

3.4 PROBE CONSTRUCTION MATERIALS

- Sample probes consist of a probe tip through which the soil gas sample is collected, and probe tubing that extends from the probe tip to the ground surface.

- Sample probe tubing should be of a small diameter (1/8 to 1/4 inch). Diameter selection should consider site soil types. In general, smaller tubing diameters can result in higher sample vacuum conditions, which can make sample collection more difficult.

- Clean, dry tubing should be utilized at all times. If moisture, water, or an unknown material is present in the probe prior to insertion, the tubing should be decontaminated or replaced.

- The sample probe should be constructed of materials that will not react or interact with target compounds. Suggested materials are nylon, polyethylene, copper, poly vinyl chloride (PVC), or stainless steel. If copper is used, the copper must first be adequately cleaned to remove oil residue that might be present from the manufacturing process. Generally, nylon tubing should be used

- The probe tip should be covered with fine screen or connected to a short (< 2 feet) section of perforated pipe, glass frit, tubing, or screen mesh.

- A drawing of the proposed probe tip design and construction should be included in the project workplan.

3.5 PROBE INSTALLATION

DOEE recommends that permanent probes, wells, or other soil gas sampling devices be installed to allow for the assessment of seasonal variability. DOEE requires that a minimum of two soil gas sampling events occur at any site at which soil gas sampling is conducted. However, temporary sampling points, such as through the probe rods of a direct push drill machine, may be used with the permission of DOEE. The permanent probe installation steps are presented below:

- Boreholes may be installed using direct push or hollow-stem auger drilling equipment or hand-driven using a rotary hammer or a hand auger. Note, however, that direct push probes might not be suitable for all soil conditions, as smearing of the sidewalls can occur in fine-grained soils. Such smearing could preclude passage of gases from the soil into the borehole.

- Before any drilling activities, utility clearance for the installation area should be obtained. In addition, utilities proximate to the contamination must be identified and assessed as possible soil gas conduits. Utilities near or above contamination must be screened using a PID or FID (as appropriate) and the results recorded.

- The borehole is advanced to the target sampling depth. If samples will be collected at multiple depths within the same borehole, the borehole is initially advanced to the deepest sampling point and the deepest sampling point installed first.

- The probe tip is placed midway between the top and bottom of the sampling interval within a sand pack extending 6 inches above and below the sampling interval. The grain size of the sand pack should be appropriately sized (for example, no smaller than the adjacent formation) and installed to minimize disruption of airflow to the sampling tip.

- At least 1 foot of dry granular bentonite should be placed on top of the sand pack to preclude the infiltration of hydrated bentonite grout into the sand pack. Refer to Figure 1 for an illustration of this sealing method.

- The borehole should be grouted to the surface (or, for nested samplers, the bottom of the next sampling interval) with hydrated bentonite. 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. The surface seal should be a minimum of 2.5 feet thick. If conditions warrant shallow sampling depths, great care should be taken in installing the surface seal to limit atmospheric infiltration.

- If multiple sampling points are installed within a single borehole, the borehole must be grouted between sampling points. One foot of dry granular bentonite must be placed between the filter pack and the grout at each sampling location within the borehole, as illustrated by **Figure C-1**.

- Tubing must be properly marked at the surface to identify the probe location and depth. Particularly when multiple probes are installed within a single borehole, tubing must be labeled immediately upon installing each separate probe.

- To minimize any separation between the soils and the outside of the probe, avoid lateral movement of probes once they have been installed.

- Examples of a single depth soil gas probe and a multi-depth or “nested” soil gas probe are shown in **Figure C-1**. **Figure C-1** is only an example: soil gas sampling points need not necessarily be constructed in strict accordance with the figure.

- Documentation of subsurface soil stratigraphy via borehole logging and other methods can be very important in evaluating soil gas data. While delineation of contamination should be largely complete at any site undergoing soil gas sampling, DOEE recommends that soils be logged, field screened, and sampled for COC analysis during probe installation for the purpose of providing further information regarding the distribution of contamination. Soil stratigraphy data can be very important in determining soil gas fate and transport.

3.6 SURFACE COMPLETION

Soil gas probes must be properly secured, capped, and completed to prevent infiltration of water or ambient air into the subsurface and to prevent accidental damage or vandalism. The following components should be considered:

- Gas-tight valve or fitting for capping the vapor point;
- Fitting for connection to above ground sampling equipment;
- Protective flush mounted or above ground well vaults, and/or
- Guard posts.

3.7 PROBE EQUILIBRATION

During probe installation, subsurface conditions are disturbed. To allow for subsurface conditions to equilibrate, the following equilibration times are recommended:

- For probes installed using the direct push method, soil gas sampling should not be conducted for at least 30 minutes following probe installation.
- For probes installed with hollow stem drilling methods, soil gas sampling should not be conducted for at least 48 hours (depending on site lithological or drilling conditions) after the soil gas probe installation.
- Probe installation time should be recorded in the field log book.

3.8 DECONTAMINATION

After each use, drive rods and other reusable components should be properly decontaminated to prevent cross contamination. These methods include:

- 3-stage wash and rinse (e.g., wash equipment with a non-phosphate detergent, rinse with tap water, and finally rinse with distilled water); and/or
- Steam cleaning process.

3.9 PROBE ABANDONEMENT

Once an NFA or case closure is issued by DOEE or no additional soil gas samplings are required as approved by the DOEE's case manager, the probes must be abandoned as follows:

- All monitoring wells, including those used for soil gas monitoring, must be removed, grouted, and sealed properly in accordance with 20 DCMR § 6211.7.
- Note that approval from the DDOE Water Quality Division is required for well abandonment.

4.0 SAMPLING FREQUENCY

- At a minimum, two soil gas sampling events must occur at any given site, with no less than three months between events. In cases where measured soil gas values vary significantly from the first to the second event, DOEE requires that additional sampling be conducted. The maximum annual number of sampling events will be four, with the events spaced, unless mentioned otherwise.
- Uncontrolled parameters can affect soil gas values. For instance, temperature, barometric pressure, and precipitation can affect soil gas values as these factors fluctuate over time. Because these factors will fluctuate, actions must be taken to ensure soil gas data collected at a site is representative of a variety of atmospheric conditions. Therefore, multiple soil gas sampling events over time is recommended.
- Duplication of soil gas sampling may be required based on site conditions. A waiver request may be proposed within the sampling work plan.

5.0 PURGING

Prior to sampling, to ensure stagnant or ambient air is removed from the sampling system and to assure samples collected are representative of subsurface conditions, a purge volume versus contaminant concentration test should be conducted as the first soil gas sampling activity at the selected purge test point. The purge volume test is conducted by collecting and analyzing a sample for target compounds after the removal of appropriate purge volumes. The following purge procedure is recommended:

- The purge test location should be selected as near as possible to the anticipated or confirmed contaminant source, and in an area where soil gas concentrations are expected to be greatest based on lithology (e.g., coarse-grained sediments). The first purge test location should be selected through the workplan approval process or as a field decision in conjunction with DOEE's case manager.
- Calculate the volume of the sampling system by summing the volume of the probe screened interval (including filter pack void space, accounting for porosity of sand pack), the volume of tubing from the probe tip to the ground surface, and

the volume of above ground tubing connecting the soil probe to the sample collection device.

- Purge the monitoring point until at least three volumes of the full sampling system have been evacuated.
- Purging/sampling flow rates should not enhance compound partitioning during soil gas sampling. The purging or sampling flow rate should be attainable in the lithology adjacent to the soil gas probe. To evaluate lithologic conditions adjacent to the soil gas probe (e.g., where no-flow or low-flow conditions), a vacuum gauge or similar device should be used between the soil gas sample tubing and the soil gas extraction devices (e.g., vacuum pump, summa canister). Gas tight syringes may also be used to qualitatively determine if a high vacuum soil condition (e.g., suction is felt while the plunger is being withdrawn) is present.
- DOEE recommends purging or sampling at rates between 100 to 200 milliliters per minute (ml/min) to limit stripping, prevent ambient air from diluting the soil gas samples, and to reduce the variability of purging rates. The low flow purge rate increases the likelihood that representative samples may be collected. The purge/sample rate may be modified based on conditions encountered in individual soil gas probes. These modified rates should be documented in the soil gas report.
- The purge test data (e.g., calculated purge volume, rate and duration of each purge step) should be included in the report to support the purge volume selection.
- If the soil matrix is such that purging as recommended above is not possible due to low or no flow conditions (i.e., gas will not flow or flow is severely restricted), the probe should be advanced deeper to look for zones of higher permeability. If the deeper probe does not encounter a higher permeability zone and low or no flow conditions persist, the probe should be abandoned and a new probe advanced elsewhere on the site.

6.0 LEAK TEST

Leakage during soil gas sampling may dilute samples with ambient air and produce results that underestimate actual site concentrations or contaminate the sample with external contaminants. Leak tests should be conducted to determine whether leakage is present (e.g., the leak check compound is detected and confirmed in the test sample after its application).

- Leak tests should be conducted at every soil gas probe.
- For each sample, use a hand pump to vacuum test the sampling equipment after assembly.
- Select a leak check compound that is not known or suspected to be site related or otherwise associated with the site or nearby properties. Common gas-phase tracers include helium (most preferred, laboratory grade, if available), pentane, isopropanol, isobutene, propane, and butane. 1,1-difluoroethane is also a common tracer which is sprayed on the ground around the sample point, prior to collecting the soil gas sample. Avoid tracer compounds, such as isopropyl alcohol, that could cause elevated detection limits for target compounds if present in the

sample at elevated concentrations. Confirm with the analytical laboratory that the selected tracer compound will not interfere with the analysis for target compounds. Detection limit interference issues may be less important if an on-site lab is used for sample analysis.

- The shroud can be as simple as an inverted bucket or cardboard box or similar container designed to minimize exchange of gas between the inside of the shroud and ambient air. For helium, use an intermittent or continuous injection of tracer gas into the shroud to maintain a tracer gas concentration of approximately 1% to 10% by volume. Collect and analyze an air sample from inside the shroud to verify the concentration of leak tracer.
- Evaluate leakage in the field by collecting a soil gas sample into a Tedlar bag and analyzing the contents of the bag for the tracer. Helium can be analyzed in this way in the field using a portable helium detector. Other tracers will need to be collected in summa canisters concurrent with the other target analytes and analyzed in a laboratory in conjunction with the analysis of other target compounds. Use of a field analyzed leak tracer allows for leakage issues to be addressed immediately.
- Low concentrations of leak tracer compound may be detected in soil gas samples even in the absence of significant sample leakage. However, if leak tracer compound is detected greater than 10%, the cause of the leak should be evaluated, determined and corrected through confirmation sampling. If leakage is confirmed and the problem cannot be corrected, the soil gas probe should be properly decommissioned. A replacement probe should be installed at least five (5) feet from the original probe decommissioned due to confirmed leakage, or consult with DOEE's case manager. The leak check compound concentration detected in the soil gas sample should be included and discussed in the report.

7.0 SOIL GAS SAMPLING

After the soil gas probe is adequately purged, samples should be collected by appropriate methodologies.

7.1 SAMPLE CONTAINERS

Samples may be collected in Tedlar bags or gas-tight syringes if samples are analyzed on-site in a mobile laboratory. Syringes may not be used if samples are analyzed off-site at a fixed laboratory. For samples to be analyzed off-site at a fixed laboratory, summa canisters are strongly recommended. DOEE recommends working with the laboratory that will analyze the samples in choosing appropriate sample containers. DOEE prefers that summa canisters from 1L through 5L in volume be used. Certain situations might warrant the use of a larger summa canister but, in general, the small volume canisters may be considered.

The analytical laboratory or other supplier of sample containers must certify that all sample containers supplied by them are free of contaminants at concentrations exceeding contaminant detection levels.

7.2 SAMPLING FLOW RATE

Samples should be collected equal to the purge flow rate as mentioned in Section 5.0. A regulated flow meter should be placed between the probe and the sample container to control and measure the flow rate.

7.3 VACUUM CONDITIONS

- When a vacuum pump is used, samples should be collected on the intake side of the vacuum pump to prevent potential contamination from the pump. Vacuum readings or qualitative evidence of a vacuum should be recorded on field data sheets for each sample.
- To measure sample collection vacuum, a vacuum gauge must be placed between the probe and the sample container. DOEE recommends a sampling vacuum of less than 100 inches of water. Note, however, that, when using a summa canister, the vacuum gauge reading is dominated by the vacuum in the canister and does not reflect the vacuum at the probe tip. Therefore, with a canister, the vacuum gauge reading becomes meaningless as does the 100 inches of water requirement at mentioned below.
- To achieve the target sampling vacuum, the sampling flow rate should be adjusted using the flow regulator.
- If the sampling vacuum exceeds 100 inches of water, and a reduction in the sampling flow rate does not reduce the vacuum, continue to attempt to collect the sample, recording flow rate and vacuum conditions. Data for samples collected under a vacuum of greater than 100 inches of water must be flagged. DOEE will not necessarily reject or consider such data suspect. Flagging will simply facilitate a more thorough review of the data.
- If the sample container cannot be filled within an expected time frame, such time being dependent on the size and type of the sample container and sampling equipment (e.g., tube diameter), discontinue sampling and document vacuum observations. Generally, data from samples collected under such conditions will not be valid.

7.4 FIELD CONDITIONS

In general, soil gas sampling should not be conducted within 48 hours of a significant precipitation event (for example, 0.5 inch or greater of rain or snow) or comparable on-site watering. However, whether sampling is conducted is dependent on the depth to which soil is wetted relative to the planned depth of sample collection. The depth to which the soil is wetted is dependent, at least in part, on the ground cover, the type of soil, and the soil moisture content prior to the precipitation event. Sampling should not occur if soils are wetted at a depth equal to or greater than the planned sampling depth.

7.5 SAMPLE COLLECTION

- Aboveground sampling equipment consists of connector tubing, regulated flow meter, pressure gauge, and purging equipment.
- Connect aboveground sampling equipment to probe at the surface. Check all sampling system connections and fittings for tightness and obvious deterioration.
- Quick connect fittings and nylon tubing should be used to ensure vacuum tightness of the system and that chemicals in the air stream are not reacting with or adsorbing to the tubing. Compression fittings should be avoided for all connections except at the summa canister (if used).
- Purge at least three volumes of air from the sampling system as described at Section 5.0 above. After purging is complete, close the valve to the purge line and/or disconnect purge apparatus, as appropriate.
- Connect the sample container to the sampling line, using quick-connect, airtight fittings.
- Follow the leak test procedures described in Section 6.0 above.
- Open valve and collect sample into sample container, following the sample flow rate and vacuum guidelines discussed above. During sampling, measure and record sample flow rate and vacuum every two to five minutes.
- Disconnect sample container and immediately label the container with sample identification information.
- If summa canisters are used, measure the final pressure of the canister using a pressure gauge. Record the final canister pressure.
- Store sample containers out of direct sunlight, and do not chill.

7.6 QUALITY CONTROLS

The soil gas analytical laboratory should comply with the project Quality Assurance Project Plan (QAPP) and follow the QA/QC requirements of the most current ASGI and the employed EPA Method. If there is any inconsistency, the most restrictive and specific requirements should prevail. The analytical data should be consistent with the Data Quality Objectives (DQOs) established for the project. The Agency staff may inspect the field and/or laboratory QA/QC procedures. Copies of the QA/QC plan and laboratory calibration data should be presented to the Agency field staff upon request.

- The collection of at least one field duplicate per sampling event or one per twenty samples, whichever is greater, is required.
- Duplicate samples should be collected in separate sample containers, using the same procedures and at the same location and depth as the original sample.
- Preferably, duplicate samples should be collected simultaneous to collection of the primary sample using a sampling tee. Alternatively, the duplicate may be collected immediately after the collection of the primary sample.
- At least one equipment blank must be collected per sampling event or per 25 samples, whichever is greater.

7.7 RECORD KEEPING

The following information should be recorded in a field notebook or on sampling forms (**Figure C-2** shows an example field form) and reported to DOEE as necessary to facilitate DOEE's understanding of the procedures utilized at a specific site to collect soil gas data.

- DOEE recommends that the evaluator construct a relatively simple conceptual site model related to the indoor inhalation pathway. Such a model can be very useful before, during, and after a soil gas sampling investigation. The conceptual site model should, at a minimum, include information on the location of utility corridors and other potential preferential pathways for soil gas migration, depth to groundwater, distances between sources and receptors (include both current and potential future structures), and soil type and soil stratigraphy.
- Sample identification information, including the locations and depths at which the samples were collected, sample identifiers, date, and time.
- Field personnel involved in sample collection.
- Weather conditions (e.g., temperature, wind speed, barometric pressure, precipitation, etc.).
- Sampling methods, devices, and equipment used.
- 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.
- Volume of soil gas extracted (i.e., volume of each sample).
- Vacuum of canisters before and after samples collected.
- If observable, the apparent moisture content of the sampling zone (e.g., dry, moist, saturated). An alternative to a qualitative measurement of soil moisture is to collect a soil sample from the soil gas sampling interval for laboratory measurement of soil moisture. If a soil sample is collected for this purpose, include a copy of the laboratory data sheet.
- Shipment information, including chain of custody protocols and records.

8.0 LABORATORY ANALYSIS

Most of the analyses can be conducted to the off-site fixed-location laboratory. However, for larger investigations and where real-time results are helpful, an on-site mobile laboratory may be appropriate. Ensure that the laboratory can achieve the required analytical detection and reporting limits for all COCs and that the laboratory has all appropriate certifications required for regulatory acceptance of analytical results.

Below are the recommended procedures for on-site mobile labs and offsite fixed labs. Additional analysis methods are provided in **Table C-1**.

8.1 MOBILE/OFFSITE LABORATORY

Samples may be analyzed either off-site in a fixed laboratory or on-site in a mobile laboratory. On-site analyses can provide for a more timely indication of problems with sample system leaks or short-circuiting, thus allowing corrections to be made and resampling to occur while drilling and sampling equipment remains on the site. If samples are analyzed on-site, the probes from which the samples are collected should either be installed as permanent sampling points or clearly and durably marked so that sampling can be duplicated during subsequent gas sampling events. Procedures for on-site sampling and analysis must be clearly documented in the work plan submitted to DOEE and approved by DOEE prior to implementation.

8.2 REQUIRED ANALYSIS

- Samples collected in syringes or Tedlar bags for routine monitoring should be analyzed by USEPA Method 8260 or equivalent for VOCs and USEPA 8015 Modified or the equivalent for methane.

- Samples collected in summa canisters should be analyzed by USEPA Method TO-15 or equivalent for all VOCs. **Table C-1** provides a typical TO-15 list and identifies those constituents on the list that may be associated with petroleum products.

- Request the complete TO-15 analyte list unless site-specific considerations or regulatory guidance indicate reporting of only site COCs. If there are follow-up sampling rounds, it may be possible to significantly reduce the analyte list based on initial results.

- Leak test compound using applicable method.

- The entity performing the work may also analyze vapor samples for oxygen, carbon dioxide, nitrogen, methane, and other indicators of the biodegradation of hydrocarbon vapors, though these analyses are not required but recommended.

- Analyze methane samples by a GC using modified EPA Method 8015B, EPA Method TO-3, or ASTM 3416M (EPA 3C), or by an appropriate hand-held instrument (e.g., Land Tech Gas Analyzer GA-90, Gas Emissions Monitor GEM-500, GEM-2000).

- Analyzed hydrogen sulfide by a EPA Method 16, or by an appropriate hand-held instrument (e.g., LTX-310 calibrated for hydrogen sulfide or Jerome 631-X).

- Field multi-gas meters calibrated per manufacturer's instructions (at a minimum daily) should be used to analyze oxygen and carbon dioxide.

8.3 HOLDING TIME

All soil gas samples (e.g., samples of VOCs, methane, fixed gases, or biogenic gases), with the exception of hydrogen sulfide samples, should be analyzed within 30 minutes by an on-site mobile laboratory. Hydrogen sulfide samples should be extracted directly into a hand-held analyzer within 30 minutes of collection to minimize the risk of losing the hydrogen sulfide due to reaction with active surfaces. If a hand-held instrument is not used, hydrogen sulfide samples should be analyzed either within 30 minutes of collection, using the GC procedures or within 24 hours of collection (if a surrogate is added to the samples or 100 percent duplicate samples are collected). Soil gas samples collected in summa canisters may be analyzed within 72 hours after collection. Tedlar bags may be used for collection of methane samples with a holding time of no more than 24 hours.

9.0 DOCUMENTATION

A soil gas investigation report that includes a discussion of field operations, deviations from the approved work plan, data inconsistencies, and other significant procedural and analytical details must be prepared and submitted to DOEE. The report should stand alone, though the document may be included as an attachment or appendix of a risk assessment report.

The soil gas investigation report must contain at least the following information:

- A site plan map, a map identifying soil gas probe locations, and a map showing soil and groundwater contamination relative to the locations of the soil gas probes and any current or future structures;
- A site map on which soil gas concentration data has been plotted. The map must be at the same scale as the maps discussed above;
- A narrative description of probe installation and sampling procedures, including leak check testing;
- Analytical data summary tables;
- Laboratory data sheets;
- A table showing applicable target levels and appropriate documentation showing how the target levels were calculated;
- A narrative discussion of analytical results, including a comparison of soil gas sampling results to soil vapor target levels;
- Legible copies of field forms, logs, and associated notes pertinent to probe installation and soil gas sampling;
- As-built diagrams of probes or wells showing overall construction and depth of each sampling point;
- QA/QC data; and
- Conclusions and recommendations.

Figure C-1: Soil Gas Probe Emplacement Methods

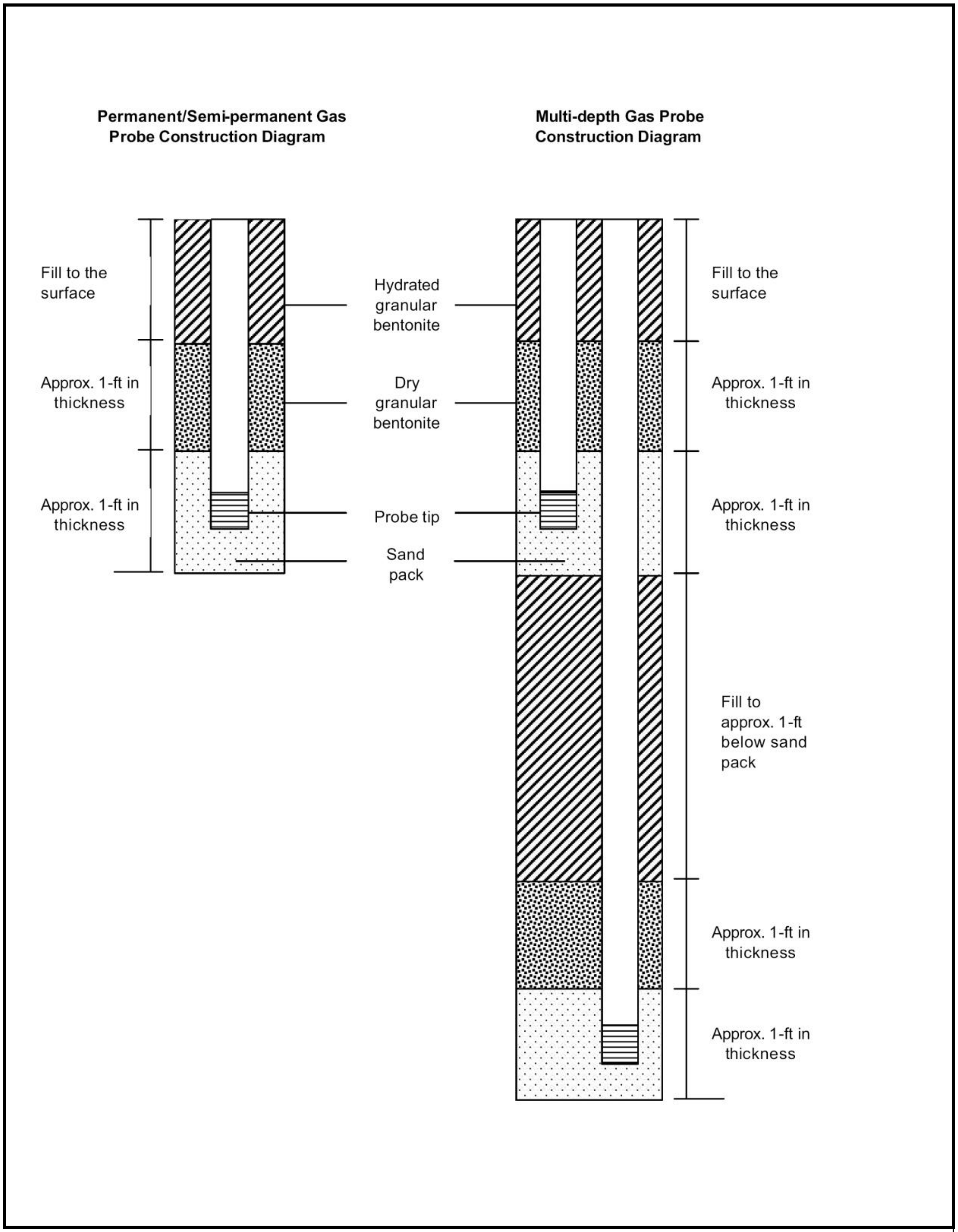

Figure C-2: Soil Gas Sampling Form (Example)

Date		Sampler	
Client		Project#:	
Container Type:		Container ID:	
Sample ID:			
Weather Conditions:	Temperature: Precipitation:		
Sampling Device:			
Purge Start Time:		End Time:	
Sample Start Time:		End Time:	
Canister start pressure:		End pressure:	
Volume gas extracted:			

Field Measurements

Time	Flow (mL/min)	Pressure (in H20)	Comments

Comments:

Table C-1: Methods for Analysis of Air and Gas Samples

Summary of Analytical Methods for Soil Gas, Indoor and Ambient Air Samples[1]

Parameter	Method	Sample Media/ Storage	Description	Method Holding Time	Reporting Limit
VOCs					
Methane, BTEX, MTBE	TO-3(M)	Tedlar Bag or Canister	GC/FID	30 days for Canister	Methane: 1-10 ppmv BTEX, MTBE: 1-3 ug/m^3
Non-Polar VOCs	TO-14A	Canister	GC/ECD/FID or GC/MS	30 days for Canister	1-3 ug/m^3
Polar & Non-Polar VOCs	TO-15	Canister	GC/MS	30 days for Canister	1-3 ug/m^3
Low Level VOCs	TO-15 SIM	Canister	GC/MS	30 Days	0.011-0.5 ug/m^3
Polar & Non-Polar VOCs	TO-17	Sorbent Tube/Chilled <4C	GC/MS	30 Days	Varies depending on sample volume
VOCs	8260B modified	Syringe, Tedlar bag, Glass Vial	GC/MS	30 Days	50-100 ug/m^3
Fixed Gases					
Fixed Gases (Methane, Nitrogen, Oxygen)	EPA 3C	Canister or Tedlar bag	GC/FID	3 days for Tedlar bag 30 days for Canister	1000 ppmv
Fixed Gases (Methane, Nitrogen, Oxygen, Carbon Dioxide, Carbon Monoxide)	ASTM D-1946	Canister or Tedlar bag	GC/TCD/FID	3 days for Tedlar bag 30 days for Canister	1000 ppmv[2]
Natural Gases	ASTM D-1945	Canister or Tedlar bag	GC/FID	3 days for Tedlar bag 30 days for Canister	1000 ppmv

[1]Adapted from ITRC Vapor Intrusion Guidance Table D.3.
[2]Reporting limits are compound specific and can depend upon the sample collection and the nature of the sample. Detection limits shown are for the range of compounds reported by the analytical methods.

GC/MS = Gas chromatography/mass spectrometry
GC/FID = Gas chromatography/flame ionization detector
GC/TCD = Gas chromatography/thermal conductivity detector
VOC = Volatile organic compounds

REFERENCES:

American Petroleum Institute, 2004, Soil Gas Sampling – Draft for Review Only, July 16, 2004.

API Publication Number 4741, November 2005, for more detailed guidance on soil gas sampling strategies. (http://www.api.org/ehs/groundwater/vapor/index.cfm).

California Environmental Protection Agency, Department of Toxic Substances Control and California Regional Water Quality Control Board, Los Angeles Region, 2003, Advisory – Active Soil Gas Investigations, January 28, 2003.

Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division, 2004, Draft Indoor Air Guidance, September 2004.

Hartman, Blayne, 2002, How to Collect Reliable Soil-Gas Data for Risk-Based Applications, Part 1: Active Soil-Gas Method. LUSTLine Bulletin 42, October 2002.

Hartman, Blayne, 2004, How to Collect Reliable Soil-Gas Data for Risk-Based Applications – Specifically Vapor Intrusion, Part 3: Answers to Frequently Asked Questions. LUSTLine Bulletin 48, November 2004.

H&P Mobile Geochemistry, 2004, Soil Vapor Standard Operating Procedures for Vapor Intrusion Applications, June 2004.

H&P Mobile Geochemistry, 2004, Vapor Monitoring Wells/Implants Standard Operating Procedures (for Vapor Intrusion Applications), August 2004.

LARWQCB re-issued the "Interim Guidance for Active Soil Gas Investigation" (ASGI), February 25, 1997.

Nelson, D. W. and Sommers, L. E., 1982. Total Carbon, Organic Carbon, and Organic Matter, In: Page, A. L. et al, (Editors), Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties, ASA [American Society of Agronomy, Inc.] Monograph Number, pp. 539-579.

Reynolds, Peter A. (2007) "The Use Of Tracer Gas In Soil Vapor Intrusion Studies," Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy: Vol. 12, Article 39.

United States Environmental Protection Agency (U.S. EPA), 2002a. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, November.