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CONTENTS (cont'd)

1.0 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of detecting volatile organic compounds (VOCs) in the soil subsurface. Using this method, underground VOC contamination can be identified, and the source, extent, and movement of pollutants can be traced.

This standard operating procedure (SOP) outlines the methods used for the installation of soil gas points; the collection of soil gas using Tedlar bags, sorbent tubes, and/or SUMMA canisters; and measurement of organic vapor levels in the soil gas using a photoionization detector (PID), flame ionization detector (FID) and/or other air monitoring devices.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives (DQOs) listed in the QAPP for a particular site.

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

The Site, environment, and nature and depth of the VOCs of interest will determine the best way to collect the samples of interest. The actual methods used can be modified as needed based on the Site and project goals.

An appropriately-sized diameter hole is driven into the ground using manual (i.e., slam bar) or power-driven mechanical methods or the use of direct push sampling mounted on an all-terrain track unit. Small, shallow samples (less than 5 feet below ground surface) near the perimeter of a residential home, for example, would most easily be obtained using a slam bar while a direct push unit may collect samples in a field at a depth up to 50-feet (ft), or when frozen ground, very dense clays, pavement, etc. are present. The slam bar or rod is withdrawn after reaching the desired depth. The removal is done carefully to prevent collapse or otherwise compromise the hole. Afterwards a probe is carefully inserted into the hole. The top of the sample hole is sealed at the surface to prevent infiltration of ambient air, generally with modeling clay or wetted bentonite. More permanent or long-term installations may be sealed with sand, soil, and bentonite. The hole is allowed to equilibrate and a volume of air is first purged from the hole using a vacuum pump. The volume of the hole and/or tubing should be calculated to determine how much air will need to be purged. After returning to pressure, a sample can be withdrawn from the hole.

A monitoring instrument such as a MultiRAE Pro or TVA-2020 may be connected to the probe with a Teflon connector. VOC readings are recorded in the field on data sheets or in a logbook. Samples may then be collected with sorbent tubes, Tedlar bags or SUMMA canisters and then are typically sent to a laboratory for analysis. Bagged samples may be analyzed in a field laboratory using portable gas chromatography (GC) or gas chromatography/mass spectrometry (GC/MS) instrumentation, if available.

Other field air monitoring devices, such as a landfill gas meter (e.g., GEM 5000, measuring percent levels of oxygen, carbon dioxide and methane), can also be used, depending on specific site conditions and goals. Measurement of soil temperature using a temperature probe may also be desirable.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Soil gas samples are generally collected in 1.0-liter (L) Tedlar bags. Bagged samples should be stored in the dark (i.e., in opaque containers) and protected from mechanical damage during transit to the laboratory. Further, bagged samples should be maintained at ambient temperature by placing them in coolers and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours following sample collection. Refer to Environmental Response Team (ERT) SOP, *Tedlar Bag Sampling*, for additional information.

3.2 Sorbent Tubes

Soil gas can be drawn directly onto sorbent tubes (i.e., carbon tubes) and analyzed by GC or GC/MS methodologies. Bagged samples can also be drawn onto tubes. If sorbent tubes are to be used, special care must be taken to avoid contamination. Refer to ERT SOP, *Charcoal Tube Sampling in Ambient Air* for additional information. Samples should be refrigerated at less than or equal to (≤) 6 degrees Centigrade (˚C) during storage and analyzed within the holding time of the analytical method. For example, halogenated, aromatic and straight chain hydrocarbons typically have a 30-day holding time from date of collection to analysis using National Institute for Standards and Technology (NIOSH) methods 1003, 1500 and 1501. Samples collected on multi-sorbent tubes should be analyzed as soon as possible after sampling.

3.3 SUMMA Canisters

SUMMA canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being used in the field. After sampling is completed, they are stored and shipped in travel cases. Most volatile organic compounds (VOCs) can be recovered from canisters with minimal loss up to thirty days. Refer to ERT SOP, *SUMMA Canister Sampling,* for additional information.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 PID Measurements

A number of factors specific to soil gas can affect the response of a PID (e.g., MultiRAE Pro). High humidity can cause lamp fogging and decreased sensitivity. This can occur when soil moisture levels are high, or when a soil gas probe is in the saturated zone. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, and naturally occurring compounds, such as terpene hydrocarbons in wooded areas, will affect instrument response. Refer to ERT SOP, *Operation of the MultiRAE Pro Wireless Portable Detector* for additional information.

4.2 FID Measurements

A number of factors specific to soil gas can affect the response of an FID (e.g., TVA 2020). High humidity, percent levels of carbon dioxide (CO_2) or low oxygen (O_2) levels can cause the FID to flame out or not ignite at all. This can be significant when soil moisture levels are high, or when a soil gas probe is in the saturated zone. The FID can only read organic-based compounds (they must contain carbon in the molecular structure). The FID also responds poorly to hydrocarbons and halogenated hydrocarbons (such as gasoline, propane fuel). High and low temperature, electrical fields and FM radio transmission will also affect instrument response. Consult the instrument manual for additional information.

4.3 Factors Affecting the Concentrations of Organic Compounds in Soil Gas

Concentrations of organic compounds in soil gas can be affected by the physical and chemical characteristics of the soil and by soil moisture. Organic molecules can be tightly adsorbed to the surface of chemically active soil particles, such as clays, thus reducing the concentration in the soil interstitial spaces. Similarly, some organic compounds can be dissolved in the soil water or associated with soil organic components (i.e., humic acids).

Soil porosity and permeability will affect the movement of soil gas and the recharge rate of the soil gas well. The movement of organic vapors through fine textured soil may be very slow, thus limiting the sample volume available and the use of this technique. Existing information and soil surveys prepared by the Soil Conservation Service should be consulted prior to planning and designing a soil gas survey.

The presence of a high, or perched water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with the movement and sampling of the soil gas. Knowledge of site geology is useful in such situations and can prevent inaccurate sampling.

4.4 Soil Probe Clogging

A common problem with the soil gas sampling is clogging of the probe. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see Section 7.1.3.).

4.5 Underground Utilities

Prior to selecting sample locations, an underground utility search must be completed. The local utility companies can be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground metallic or ferro-magnetic pipes or drums are present.

4.6 Cleanliness of Tedlar Bags

If Tedlar bag samples will be analyzed by a GC/MS with detection limits lower than those of standard air monitoring instrumentation (0.1 to 1 parts per million [ppm]), each bag should be baked and purged with high purity nitrogen or zero air prior to usage. The ERT/SERAS Laboratory documents their Tedlar bag cleaning in their analytical SOP.

5.0 EQUIPMENT/APPARATUS

5.1 Slam Bar Method

- Slam bar
- Soil gas probes: stainless steel tubing, 1/4" O.D., 5-foot (ft) length
- Flexible wire or cable
- "Quick Connect" fittings
- Modeling clay
- Vacuum box
- Pumps, capable of drawing approximately 1.0 to 3.0 liters per minute (L/min)

- ¼" outer diameter (O.D.) Teflon tubing, 2-ft to 3-ft lengths
- ¼" inner diameter (I.D.) Tygon tubing
- Tedlar bags, (typically 1.0-L)
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID, or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument (optional)
- Summa canisters (plus shipping cases)
- Large dark plastic bags

5.2 Power Hammer Method

- Power (Demolition) hammer
- ½" O.D. steel probes, extensions, and points
- Dedicated aluminum sampling points
- ¼" I.D. Teflon tubing, 2-ft to 3-ft lengths
- "Quick Connect" fittings
- Modeling clay or Bentonite
- Vacuum box
- Pumps, capable of drawing approximately 1.0 to 3.0 L/min
- ¼" O.D. Tygon tubing
- Tedlar bags, (typically 1.0-L)
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument (optional)
- Summa canisters (plus shipping cases)
- Generator w/extension cords (optional)
- High lift jack assembly (optional)
- Large dark plastic bags

5.3 Direct-Push (Geoprobe) Method

- Tubing; polyethylene, Teflon, or stainless steel
- Gas sampling cap
- Robe rods
- Tubing adaptor(s)
- Expendable point holder, threaded
- Expendable drive point(s)
- O-rings for expendable point holder
- O-rings for adaptor
- O-rings for probe rods
- O-rings for gas sampling cap
- Vacuum pumps
- Tape
- Tedlar bags, (typically 1.0-L)
- SUMMA canisters (plus shipping cases)

- Sample documentation (soil gas labels, field data sheets, logbook, etc.)
- Metal detector or magnetometer
- Cooler(s)
- Large dark plastic bags
- Portable GC instrument (optional)
- Bentonite

6.0 REAGENTS

- Calibration gases, accompanied by certificates of analysis
- Deionized, organic-free water
- Methanol, High Performance Liquid Chromatography (HPLC) grade
- Ultra-zero grade compressed air
- Propane torch

7.0 PROCEDURES

7.1 Soil Gas Probe Installation

7.1.1 Slam Bar Method

1. Make a hole slightly deeper than the desired sampling depth. For sampling up to 5 feet, use a 5-ft single piston slam bar. For deeper depths, use a piston slam bar with threaded 4-ft-long extensions.

2. Place the tip of the rod on the ground; the piston of the slam bar is used to drive the rod to the desired depth. Record the number of blows required to reach the desired depth.

3. After the hole is made, withdraw the slam bar carefully to prevent the collapse of the walls.

4. Insert the soil gas probe carefully into the hole. To prevent plugging of the probe, insert a decontaminated metal wire or cable, slightly longer than the probe and with an O.D. slightly less than the I.D. of the rod, in the probe rod; 1- to 2-inches of wire should protrude from the end of the probe. Insert the probe to the full depth of the hole, then pull up three to six inches. Clear the probe by moving the cable up and down several times.

5. Seal the top of the sample hole at the surface to prevent infiltration of ambient air. Knead a golf-ball size lump of clean modeling clay until it becomes soft. Mold the clay carefully around the probe at the soil surface to seal the space between the probe and the hole.

6. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.2 Power Hammer Method

1. Use a power hammer to make holes when the soil is very hard, frozen or fine textured (clay), or when soil gas from beneath pavement or concrete is collected.

2. Drive the probe to the desired depth (up to 12 feet may be attained with extensions). Add threaded extensions until the desire depth is needed.

3. After the hole is made, withdraw the threaded rod carefully in such a manner to prevent collapse of the walls. If necessary, use a jack assembly to retrieve the rods.

4. Install the soil gas probe in the hole as described in Section 7.1.1, Steps 4 and 5.

5. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.3 Direct-Push Method

1. Direct-push sampling technology refers to soil gas samplers that are inserted into the ground without the use of slam bars, demolition hammers, or drilling rigs. The U.S. EPA/ERT utilizes a Direct-Push unit mounted on an all-terrain track mounted vehicle, and direct push tools. These tools are able to collect samples at depths greater than 50 ft, depending on soil conditions.

2. Drive sampling probes, consisting of 3-foot sections of flush-threaded, 1¼-inch hardened steel alloy steel rod tipped by an expendable steel point, into the ground to the target depth. Withdraw the probe tools to release the expendable tip and allow soil gas to flow into the tool's tubing.

3. To ensure a representative soil gas sample, purge a discrete volume of gas to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of removed gas is determined by the volume of tubing employed in the probe. (Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.)

4. After allowing the system to return to atmospheric pressure, withdraw an aliquot of soil gas from the probe. Collect duplicate samples as necessary and required.

5. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.2 Screening with Field Instruments

1. Consult appropriate SOPs and the manufacturers' manuals for the correct use and calibration of all instrumentation. Calibrate pumps prior to use in the field.

2. Calculate an amount of air, equivalent to the volume of the soil gas well, prior to sampling. Connect a vacuum pump to the sample probe using a section of Teflon tubing. Turn on the pump and adjust to a flow rate of between 1.0 and 3.0 L/min. Evacuate the calculated volume of air from the hole by pulling a vacuum through the probe for the specified length of time. Longer time is required for sample wells of greater depths.

3. After evacuation, connect a monitoring instrument (i.e. PID or FID) to the probe using a Teflon connector. Upon stabilization, record the reading on data sheets or in a logbook.

4. Readings may be above or below the range set on the field instruments. Reset the range, or the record the response as a greater than or less than value. Consider the recharge rate of the well with soil gas when screening at a different range setting.

7.3 Tedlar Bag Sampling

1. Follow step 2 of section 7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sample collection, evacuation is not necessary.

2. Use the vacuum box and sampling train (see an example in Figure 1) to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All internal surfaces (exposed to the sample) are either Teflon or stainless steel. Draw a vacuum indirectly to avoid contamination from sample pumps.

3. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve (if utilized). Attach the sample probe to the sampling port via Teflon tubing and a "Quick Connect" fitting or through a direct pass-through (liquid-tight cord connector).

4. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port, via Tygon tubing and a "Quick Connect" fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.

5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the bag valve. Record the date, time, sample location ID, and the PID/FID instrument reading(s) on sample bag label and on data sheets or in logbooks.

6. Do not label bags directly with a marker or pen (particularly those containing volatile solvents) or affix adhesive labels directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Tie labels to the metal eyelets provided on the bags or attached to the side portion (non-sample area) of the bag, folded in half and attached to itself.

7. Generate chain of custody sheets to accompany all samples to the laboratory.

7.4 Sorbent Tube Sampling

1. Select appropriate sorbent tube and sampling equipment based on desired analytes. Note: Sorbent tube sampling should only be used with media sampled at low flow rates (less than 1 liter per minute). Calibrate the pumps with the individual sampling trains.

2. Follow Section 7.2, step 2 to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.

3. Attach the sampling train inlet to the soil gas via the ¼" Teflon tubing.

4. Initiate sampling. After the desired time has elapsed, disconnect the sample train from the soil gas well, check and record the final flow rate. Process and label the samples for shipment to the analytical laboratory as specified in the SOP or analytical method.

5. Generate chain of custody sheets to accompany all samples to the laboratory.

7.5 SUMMA Canister Sampling

1. Follow Section 7.2, step 2, to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.

2. Attach a certified clean, evacuated 6-L SUMMA canister via the ¼" Teflon tubing.

3. Open valve on SUMMA canister. The sample flow rate should be determined based on soil conditions to ensure that there is time for adequate soil gas recharge to reduce the possibility of surface gas intrusion into the sample. Typical flow rates can range from 100 to 400 milliliters per minute.

4. Record sample number, sample location, date collected and work assignment number on a chain of custody form and on a blank tag attached to the canister.

5. Generate chain of custody sheets to accompany all samples to the laboratory.

8.0 CALCULATIONS

8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas location may be subtracted as follows:

Final Reading = Sample Reading - Background Reading

8.2 Probe Volume

The volume of the soil gas probe or sample tubing to be purged:

$$V = \pi r^2 h$$

V = volume
r = radius
h = height or length of probe or tubing

Calculations used to determine concentrations of individual components by field portable GC or GC/MS analysis are beyond the scope of this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 General QA/QC Procedures

- All data must be documented on field data sheets, logbooks or as per requirements dictated by field activities.
- Any instrument must be operated and maintained according to the instructions supplied by the manufacturer, unless otherwise specified in the UFP-QAPP.
- Records must be maintained, documenting the training of the operators that use instrumentation and equipment for the collection of environmental information.

- Maintain a chain of custody record from the time a sample is collected to its final deposition. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

9.2 Sample Probe Contamination

To avoid cross-contamination between samples, use discrete sample probes or decontaminate sample probes between uses.

Decontaminate sample probes simply by drawing ambient air through the probe until the PID reading is at background. Contamination can also be removed by decontaminating with methanol and deionized water, and then air-drying. For persistent contamination, use of a portable propane torch may be needed. Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes. Let the probe cool before handling. When using this method, make sure to wear gloves to prevent burns. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

9.3 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag, sorbent tube or SUMMA® should be changed for each new sample well.

9.4 FID/PID Calibration

The FID and PID must be calibrated before use and should be bump tested at least once a day using the appropriate calibration gases to confirm performance. It is not recommended to calibrate daily.

9.5 QA/QC Samples

Quality assurance/quality control (QA/QC) samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error or potential sources of sample bias. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies. Following the QA/QC sample analysis, a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, trip blanks and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and blank spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives. Refer to ERT SOP #2005, *Quality Assurance/Quality Control Samples*, for further details, and suggested frequencies for submittal of QA/QC samples. Additional information may be obtained from method-specific sampling or analytical SOPs or from the analytical method being followed.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives. The ERT contractor's Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project.

11.0 HEALTH AND SAFETY

Based on Occupational Safety and Health Administration (OSHA) requirements, a site-specific health and safety plan (HASP) must be prepared for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. Field personnel working for EPA's ERT should consult the Emergency Responder Health and Safety Manual currently located at https://response.epa.gov/_HealthSafetyManual/manual-index.htm for the development of the HASP, required personal protective equipment (PPE) and respiratory protection.

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D. Nevertheless, ambient air should be constantly monitored using a PID or FID to obtain background and breathing zone readings during the sampling procedure.

When conducting soil gas sampling, appropriate PPE (leather gloves, steel-toed shoes, Tyvek safety suit) should be worn, and proper slam bar techniques should be implemented. An underground utility search must be performed prior to sampling (See Section 4.5).

12.0 REFERENCES

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13.0 APPENDICES

A - Figure

APPENDIX A
Figure
SOP: ERT-PROC-2042-21
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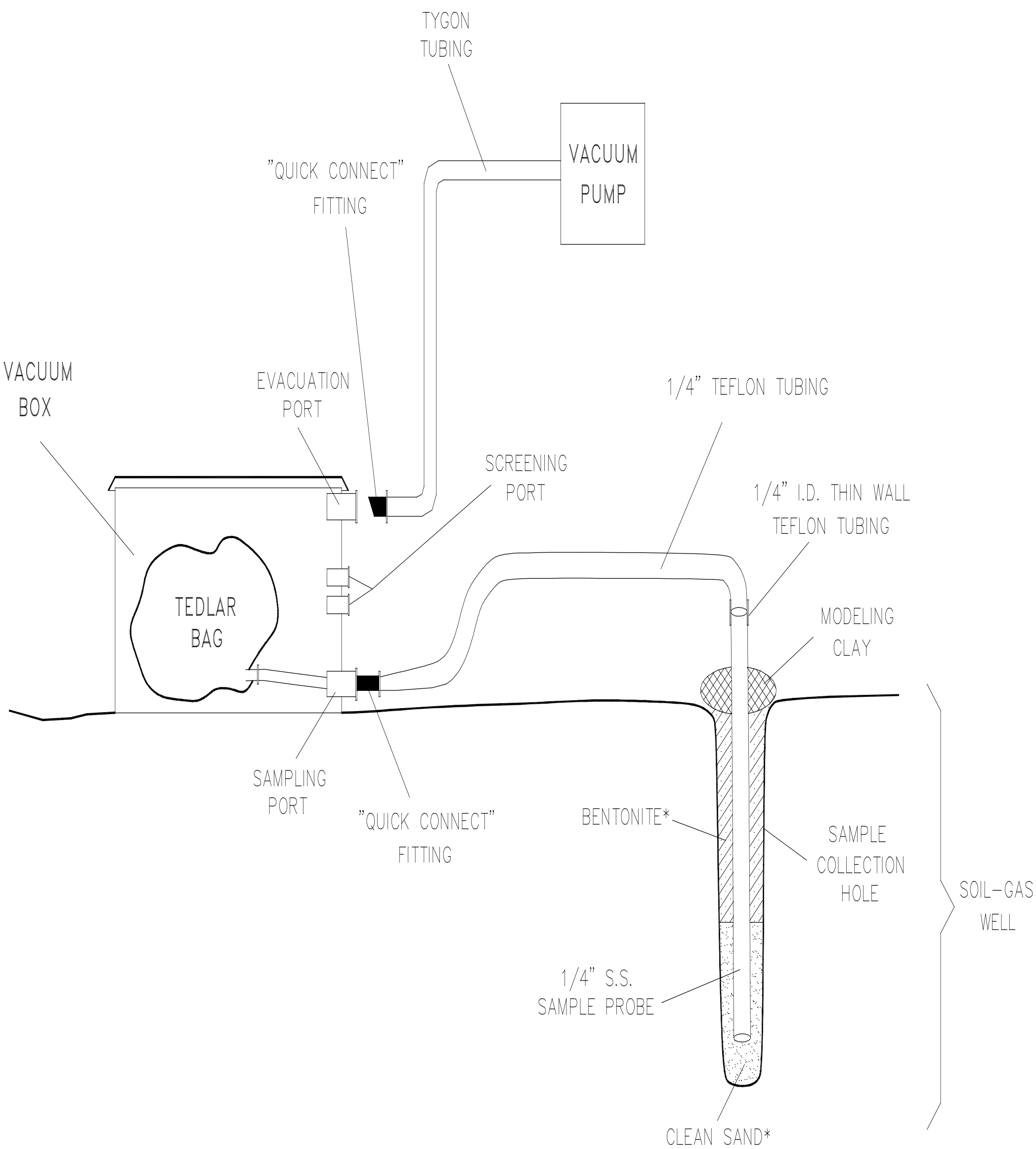
FIGURE 1. Sampling Train Schematic



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