PASSIVE SOIL GAS TESTING:

STANDARD FOR VAPOR INTRUSION EVALUATION

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Background and Introduction

Passive soil gas surveys utilize adsorbent samplers that are emplaced subsurface to adsorb compounds in soil gas without forcing the flow rate of soil gas, yielding a more representative sample than active soil gas methods. Samplers are typically placed in a grid pattern to simultaneously sample trace levels of compounds in soil gas that originate from contamination in the soil or groundwater. By sampling all locations at the same time, the temporal variations in soil-gas concentrations that are known to occur daily and even hourly are normalized. In addition, the spatial variability of contamination is better defined with a passive soil gas survey because the lower sampling and analytical costs of the method allow for more locations to be sampled than normally would be with a fixed budget. Passive soil gas methods have been demonstrated to be more sensitive and reproducible than active soil gas methods and are able to target a broad range of organic compounds from vinyl chloride to polynuclear aromatic hydrocarbons (PAHs) and other semivolatile organic compounds.

The analytical results for a passive soil gas method are not presented as a concentration, but in units of mass for comparison between sample locations to identify where vapor intrusion pathways are present; to identify source areas; to delineate the lateral extent of contamination, including migration pathways; and to monitor remediation programs. The soil gas concentration reported with an active soil gas method that uses a high flow pump may not represent the actual concentration in soil gas because of the forced movement of soil gas. However, valid soil-gas concentrations can be measured following EPA Method TO-17 using packed adsorbent tubes and a low-flow pump.

Passive soil gas (PSG) results are based on a higher level of QA/QC than can be achieved with other field screening methods. PSG results are based on a five-point initial calibration with the lowest point on the calibration curve at or below the practical quantitation limit of each compound. Internal standards and surrogates are included with each analysis – per EPA Method 8260B – to provide proof of performance that the system was operating properly for each sample and to provide consistent reference points for each analysis, which enables an accurate comparison of measured quantities. Trip blanks are analyzed with each batch of samples and because two sets of hydrophobic adsorbent cartridges are provided in each Sampler, duplicate or confirmatory analyses can be performed for any of the sample locations. A representative list of compounds that can be targeted with passive soil gas surveys is provided in **Table 1**.

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Table 1
Passive Soil-Gas Survey Target Compounds

TPH C_5-C_9	Bromoform
TPH C_{10}-C_{14}	1,1,2,2-Tetrachloroethane
Vinyl Chloride	o-Xylene
1,1-Dichloroethene	1,2,3-Trichloropropane
trans-1,2-Dichloroethene	Isopropylbenzene
Methyl-t-butyl ether (MTBE)	1,3,5-Trimethylbenzene
1,1-Dichloroethane	1,2,4-Trimethylbenzene
cis-1,2-Dichloroethene	1,3-Dichlorobenzene
Chloroform	1,4-Dichlorobenzene
2,2-Dichloropropane	1,2-Dichlorobenzene
1,2-Dichloroethane	n-Butylbenzene
1,1,1-Trichloroethane	1,2,4-Trichlorobenzene
1,1-Dichloropropene	Naphthalene
Carbon Tetrachloride	Hexachlorobutadiene
Benzene	Trichlorobenzenes
1,2-Dichloropropane	2-Methylnaphthalene
Trichloroethene	Tetrachlorobenzenes
1,1,2-Trichloroethane	Acenaphthylene
Toluene	Acenaphthene
1,3-Dichloropropane	Pentachlorobenzene
1,2-Dibromoethane (EDB)	Heptadecane
Tetrachloroethene	Hexachlorobenzene
1,1,1,2-Tetrachloroethane	Phenanthrene
Chlorobenzene	Anthracene
Ethylbenzene	Fluoranthene
p & m-Xylene	Pyrene

Note: Additional compounds may be added to meet project specific requirements. The reporting quantitation level (RQL) for each compound is 25 nanograms (ng) and the RQL for TPH is 2,500 ng; however, actual detection limits are lower.

The following document is broken into two separate parts:

1. General Overview of Passive Soil Gas Investigation for Vapor Intrusion Evaluation
2. Step-by-Step Passive Soil Gas Sampler Installation and Retrieval

For the complete assessment of vapor intrusion risks, Beacon Environmental recommends a passive soil gas survey be performed followed by an assessment of vapor intrusion and/or indoor risks to measure the concentration of compounds in soil vapor and/or air by using a low flow pump with sorbent tubes (EPA Method TO-17). The primary purpose of this document is to describe the methods and procedures used to perform a passive soil gas investigation.

Part 1: General Overview of Passive Soil Gas Investigation for Vapor Intrusion Evaluation

1.0 Survey Design

The survey design varies depending on the amount of historical and other site information that is available prior to initiating the passive soil gas (PSG) survey. Typically an unbiased grid is established across the site with additional biased sample locations to target specific features. The spacing between sample locations is dependent upon the expected depth of the chemicals of concern (CoC), the soil types, and the size of the area to be investigated. Global positioning system (GPS) equipment can be used to collect the sample location coordinate data.

Beacon Environmental provides a BESURE Sample Collection Kit™ with detailed instructions to allow samples to be collected by an environmental professional. Following collection in the field, the samplers are returned to Beacon Environmental's laboratory for analysis using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation following EPA Method 8260B, modified for the introduction of samples by thermal desorption and to target a broad range of compounds. A comprehensive survey report is provided by Beacon Environmental that includes results in tabular form as well as on color isopleth maps showing the distribution of compounds identified in the investigation (see **Figure 1** below).

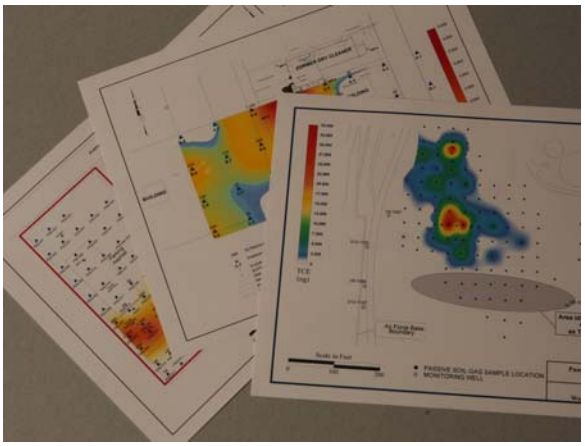


Figure 1 – Example Color Isopleth Maps

2.0 Soil-Gas Sampling Procedures

To perform the soil-gas investigation, Beacon Environmental provides a BESURE Sample Collection Kit™ with all the materials necessary to collect the requested number of soil-gas samples. To collect soil-gas samples, an approximately one-inch diameter hole is advanced to the appropriate depth to meet the objectives of the survey (typically four inches to three feet). The PSG Sampler (which contains two sets of hydrophobic adsorbent cartridges) is installed in the hole and covered with soils to seal the sampler in the ground. For locations covered by asphalt or concrete surfacing, an approximately 1 ½-inch diameter hole is drilled through the surfacing to the underlying soils, and the hole is sleeved with a sanitized metal pipe provided in the Kit. After the Sampler is installed inside the metal pipe, the hole is patched with an aluminum foil plug and a thin concrete patch to effectively protect the sampler.

Beacon Environmental provides pre-cleaned metal pipes when sampling through impermeable surfacing to protect the Samplers. These sleeves prevent any horizontal migration of vapors in the more porous subgrade from influencing the PSG samplers. The metal sleeves are advanced below the subgrade and tapped into the underlying soils so that the Samplers will only be adsorbing compounds in soil gas that is moving vertically through the soils beneath, and not in the vapors that may be migrating laterally through the more porous subgrade. By simply creating a hole 2 to 3 feet deep without sleeving the portion of the hole through the subgrade, samplers would be unprotected from the horizontal migration of vapors in the subgrade.

The samplers are exposed to subsurface gas for approximately three to 14 days, with the exact length of time appropriate to meet the objectives of the survey. The sampler is shipped to the site with a length of wire that is wrapped around the vial and twisted around the shoulder of the vial to expedite retrieval from the ground. Following the exposure period, the Samplers are retrieved and shipped to Beacon Environmental's laboratory for analysis. It is not necessary to use ice or preservatives during shipment; however, the samplers are sealed and shipped under strict chain-of-custody procedures. Trip blanks, which remain with the other samples during preparation, shipment, and storage, are included at a typical rate of five percent of the total number of field samples. **Figure 2** shows a PSG Sampler as it looks when received in the BESURE Kit™.

Figure 2 - PSG Subsurface Sampler

The adsorbent cartridges used by BEACON are hydrophobic, which allows the samplers to be effective even in water-saturated conditions. Extensive empirical evidence, which is supported by a government study, has proven that hydrophobic adsorbents work perfectly well in high moisture conditions and should not be encased by a hydrophobic membrane.[1]

A two-person team can install approximately 50 to 100 samplers per day depending on the number of sample locations that are covered with asphalt, concrete, or gravel surfacing. For retrieval of the Samplers, one person can retrieve approximately 50 samplers per day and patch the holes through the surfacing. If no impervious surfacing is present, one person can easily retrieve more than 100 samplers per day. **Figure 3** shows installation through asphalt and grass surfaces, respectively.

Figure 3 — Installation of Samplers with Beacon Environmental's BESURE Kit™

The amount of days required to complete the installation and retrieval procedures is dependent upon the number of personnel deployed for the execution of the fieldwork, weather conditions, and health and safety considerations.

3.0 Analytical Procedures

A chain-of-custody accompanies the field samples at all times from the time the samples are collected until final analysis. BESURE Kits™ are shipped with tug-tight custody seals to ensure that samplers are not tampered with during transport (see **Figure 4**). Once samples are received at the laboratory, the sample custodian receives the samples and logs the samples into the laboratory's Sample Receipt Log per the company's *Quality Assurance Program Plan for the Analysis of Soil-Gas Samples*.

Figure 4 – BESURE Sample Collection Kit™

Beacon Environmental's laboratory is maintained in a safe and secure manner at all times. The facility is locked when not occupied and is monitored for fire and unauthorized access. Beacon Environmental personnel escort all visitors at all times while inside the facility. Neither soil nor water analyses are performed at Beacon Environmental, so no solvents are stored or used. This ensures that a clean laboratory environment is maintained.

Soil gas samples are analyzed by Beacon Environmental using gas chromatography/mass spectrometry (GC/MS) instrumentation, following modified EPA Method 8260B procedures. Samples are routinely analyzed for a list of approximately 40 compounds, including total petroleum hydrocarbons (TPH). The laboratory performs an ***initial five-point calibration***. In addition, a BFB tune is performed daily and a method blank is run following the daily calibration. ***Internal standards and surrogates*** are included with each sample analysis. The laboratory's reported quantitation level (RQL) for each of the targeted compounds is 25 nanograms (ng); however, the actual detection limits are even lower. As an option, TICs additionally can be reported for each sample, with the results based on the closest internal standard to the TIC.

Beacon Environmental provides the highest level of accuracy and quality assurance and quality control (QA/QC) procedures for the analysis of soil gas samples in the industry. The table below summarizes these analytical procedures.

Description	**Included**
Analysis by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) following modified EPA Method 8260B	√
Analytical results based on 5-point initial calibration (10, 25, 50, 100, and 250 nanograms)	√
Internal standards and surrogates included with each run (100 nanograms per compound)	√
BFB tunes (5 to 50 nanograms through GC, per method)	√
Continuing calibration checks (50 nanograms per compound)	√
Method blanks	√

Analyses of the samples are performed at Beacon Environmental's laboratory using state-of-the-art instruments that are listed below. The Markes thermal desorption instruments outperform the Perkin-Elmer and other older thermal desorption equipment, which cannot target as broad a range of compounds with as much sensitivity or accuracy.

- Agilent 6890-5973 Gas Chromatograph/Mass Spectrometer,
- Markes Unity thermal desorber,
- Markes UltrA autosampler, and
- Markes Mass Flow Controller Module.

4.0 Reporting

Following analysis and a thorough data review, a comprehensive survey report is provided that contains:

project objectives,
the plan of investigation,
the QA/QC program and findings,
laboratory data (in nanograms),
color isopleth maps showing the distribution of detected compounds,
field procedures,
laboratory procedures,
Field Deployment Reports, and
Chain-of-Custody documentation.

Beacon Environmental requests that a CAD drawing of the site is provided with coordinate data for each location. Beacon Environmental can return the CAD drawing with the color isopleth maps provided as new layers to the file. Beacon Environmental will provide post survey support to assist in interpreting the data, when requested.

References

[1] The Marines Project: A Laboratory Study of Diffusive Sampling/Thermal Desorption/Mass Spectrometry Techniques for Monitoring Personal Exposure to Toxic Industrial Chemicals, April 2002, Warren Hendricks, Methods Developments Team, Industrial Hygiene Chemistry Division, OSHA Salt Lake Technical Center, Salt Lake City, UT 84115-1802.

Part 2: PSG Sampler Step-by-Step Installation and Retrieval Procedures

PSG Sampler Installation

1. At each survey point, use a hammer and the ¾" diameter metal stake provided in the sample collection kit to create a hole approximately four inches deep. As an option, a slide hammer, hand auger, hammer drill, or other comparable equipment can be used to advance the hole to a greater depth. For locations covered with asphalt or concrete, an approximately 1 1/2 -inch diameter hole is drilled through the surfacing to the underlying soils and the hole is sleeved with a metal pipe provided in the Kit.

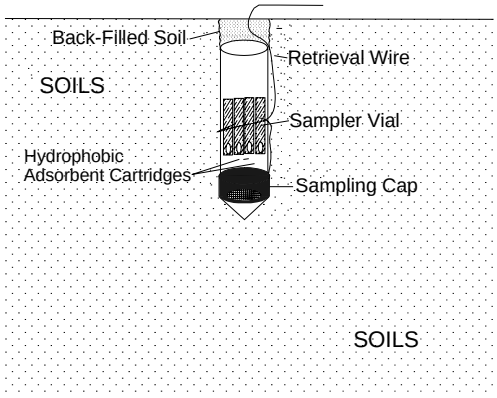
2. After the hole is created, remove a BeSure PSG Sampler (a borosilicate glass vial containing two sets of hydrophobic adsorbent cartridges) and unwind the retrieval wire wrapped around it. Holding the capped end of the vial in one hand, pull the wire tight (to straighten it) with the other hand. Remove the solid cap on the Sampler Vial and replace it with a Sampling Cap (a one-hole cap with a screen meshing insert). Store the solid cap in the Cap Storage Container. And seal to prevent cross contamination

3. Lower the Sampler with the screened-capped-end pointing down into the hole. If the hole was created to a greater depth it is only necessary to suspend the sampler in the upper portion of the hole because compounds in soil gas that enter the hole will migrate up to the sampler. With the retrieval wire extending from the hole, use a hammer to collapse the soils above the Sampler. Coil the wire and lay it flat on the ground surface. For those locations through concrete or asphalt, lower the Sampler into the metal pipe and plug the top of the hole with a aluminum foil and a thin concrete patch to effectively seal the Sampler in the ground.

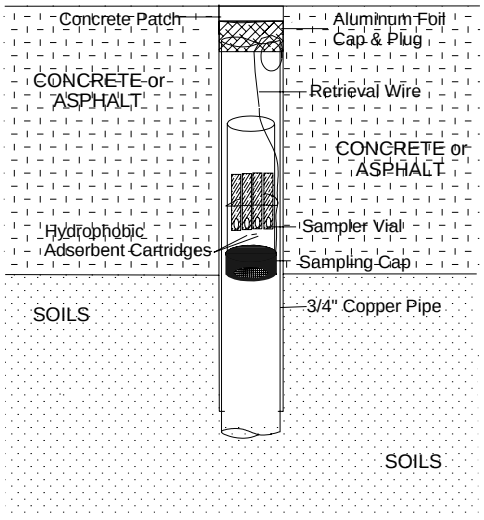
4. Close the Kit, and on the Field Deployment Report record: (a) sample-point number; (b) date and time of emplacement (to nearest minute); and (c) other relevant information (e.g., soil type, vegetation, proximity to potential source areas). Mark the sample location and take detailed notes (i.e., compass bearings and distances from fixed reference points or GPS coordinates). Move to next location.

BEACON PSG SAMPLER

DEPLOYMENT THROUGH SOILS



DEPLOYMENT THROUGH AN ASPHALT/CONCRETE CAP



PSG Sampler Retrieval

1. At each sample location open the sample collection kit and place it and the wire cutters within easy reach. Remove a square of gauze cloth and place it and a clean towel on the open Kit. Remove a solid cap from the Cap Storage Container and place it on the Kit, also.

2. Expose the Sampler by pulling on the wire when in soils or using a chisel and hammer to chip the thin concrete patch away when in asphalt/concrete. Retrieve the Sampler from its hole by pulling on the retrieval wire. Holding the Sampler upright, clean the sides of the vial with the clean towel (especially close to the Sampling Cap). Remove the Sampling Cap, cut the wire from the vial with the wire cutters, and clean the vial threads completely with the gauze cloth.

3. Firmly screw the solid cap on the Sampler Vial and with a ballpoint pen record the sample number, corresponding to the sample location, on the cap's label.

4. Return the sampling cap to the Sampling Cap container. Place the sealed and labeled Sampler Vial in a 3" x 4" plastic Sampler Bag. Then place the individually bagged and labeled sampler into the larger bag labeled "Return Shipment Bag." Each sampler is individually bagged and placed in a Return Shipment Bag, with approximately 40 Samplers and at least one trip blank per Return Shipment Bag.

5. On the Field Deployment Report, record: (a) date and time of retrieval (to nearest minute); and (b) any other relevant information. After all samples have been retrieved, verify that the caps on each Sampler are sealed tightly and that the seals on the Sampler Bags are closed. Verify that all Samplers are stored in the Return Shipment Bag, which contains an adsorbent pack. Seal the Return Shipment Bag and place it in the upper tray of the Kit, and place the provided tools and materials in the lower compartment of the Kit.

6. Complete the chain-of-custody for shipment of Samplers. Seal the BESURE Sample Collection Kit with the provided tug tight custody seal, provided in the Kit, which has a unique identification number that is documented on the chain-of-custody. Place the Kit and paperwork in a cardboard box and ship via overnight delivery to Beacon Environmental Services for analysis of the samples.