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TECHNICAL MEMORANDUM

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# Passive Soil Gas Testing: Standard for Site Characterization

## Background and Introduction

Passive soil gas surveys utilize adsorbent samplers that are emplaced subsurface to adsorb volatile and semi-volatile organic compounds (VOCs and SVOCs) in soil gas without forcing the flow rate of gas, which can yield 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 soil or groundwater. By sampling all locations at the same time, the temporal variations in soil-gas concentrations 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 (PSG) 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 SVOCs.

The analytical results of a passive soil gas method are presented in units of mass (e.g., nanograms of each individual compound) for comparison between sample locations to identify source areas, identify the potential for vapor intrusion, to delineate the lateral extent of contamination, including migration pathways, and to monitor remediation programs. When requested, the mass measured (ng) can be converted to a concentration by dividing the mass (ng) by the sampler uptake rate (ml/min) and the sampling period (min), which is then multiplied by a value of 1,000 to convert ng/ml to ug/m3. The Beacon PSG Sampler has verified uptake rates when sampling in air for a suite of chlorinated and BTEX compounds. For soil gas sampling, the concentrations reported represent the concentration of the identified compounds under steady state (natural) conditions by passive sampling, as opposed to active sampling with a pump or evacuated canister that may create a momentary vacuum in the soil during the time of sampling. If the soils at the site have low porosity, the formation itself could limit transport of soil gas to the samplers resulting in the reported concentration being biased low. In order to limit this bias from occurring, the Beacon sampler has a low and controlled uptake rate.

Passive soil gas (PSG) results are based on a higher level of QA/QC than can be achieved with other field screening methods. Measurements 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 8260C – 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.

## Table 1

| Passive Soil Gas Survey<br>Representative List of Target Compounds | |
|---|---|
| TPH C5-C8 | Ethylbenzene |
| TPH C9-C15 | p & m-Xylene |
| Vinyl Chloride | o-Xylene |
| 1,1-Dichloroethene | 1,2,3-Trichloropropane |
| Methylene Chloride | Isopropylbenzene |
| 1,1,2-Trichlorotrifluoroethane (Freon 113) | 1,3,5-Trimethylbenzene |
| trans-1,2-Dichloroethene | 1,2,4-Trimethylbenzene |
| Methyl-t-butyl ether (MTBE) | 1,3-Dichlorobenzene |
| 1,1-Dichloroethane | 1,4-Dichlorobenzene |
| cis-1,2-Dichloroethene | 1,2-Dichlorobenzene |
| Chloroform | 1,2,4-Trichlorobenzene |
| 1,2-Dichloroethane | Naphthalene |
| 1,1,1-Trichloroethane | Hexachlorobutadiene |
| Carbon Tetrachloride | Trichlorobenzenes |
| Benzene | 2-Methylnaphthalene |
| Trichloroethene | Biphenyl |
| 1,4-Dioxane | Acenaphthylene |
| 1,1,2-Trichloroethane Toluene | Acenaphthene |
| 1,2-Dibromoethane (EDB) | Dibenzofuran |
| Tetrachloroethene | Fluorene |
| 1,1,1,2-Tetrachloroethane | |
| Chlorobenzene | |

**Note:** Additional compounds may be targeted to meet project specific requirements. The standard reporting quantitation level (RQL) for each compound is 10 or 25 nanograms (ng); however, the demonstrated limit of quantitation (LOQ) for each compound is 10 ng. Concentration data can additionally be reported in units of ug/m3 with reporting limits based on the sampling period and uptake rates.

The primary purpose of this document is to describe the methods and procedures used to perform a passive soil gas investigation. This document is broken into two separate parts:

1. General Overview of Passive Soil Gas Investigation for Site Characterization
2. Step-by-Step Passive Soil Gas Sampler Installation and Retrieval

For complete site characterization, Beacon Environmental recommends a passive soil gas survey be performed followed by a limited and focused soil and/or groundwater sampling program to measure the concentrations of identified compounds.

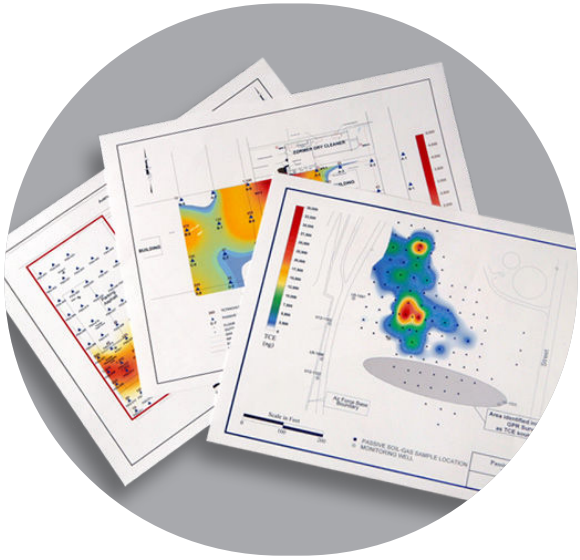
## Part 1: General Overview of Passive Soil Gas Investigation for Site Characterization

### 1.0 Survey Design

The survey design varies depending on the amount of 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. Generally, a grid with 25-foot spacing between sample locations is used to identify source areas, but the actual spacing will be dependent on the size of the area of investigation and the project budget. Wider grids and transects are used to track groundwater contamination. 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 field technician. 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 8260C. 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 – 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 (e.g., one to three feet). The PSG Sampler (which contains two sets of ***hydrophobic adsorbent*** cartridges) is installed in the hole and covered with an aluminum foil plug and soil to seal the sampler in the ground. The adsorbent cartridges used by Beacon Environmental 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.

For locations covered by asphalt or concrete surfacing, an approximately 1 1/2-inch diameter hole is drilled through the surfacing to the underlying soils. A 1/5" to 1" diameter drill bit can then be used to advance the hole to a three-foot depth to increase the sensitivity of the method. The upper 12 inches of 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.

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 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 established 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™.

A two-person team can install approximately 50 to 100 samplers per day depending on the number of sample locations 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. Figure 3 shows installation through asphalt and grass surfaces, respectively.

Figure 2 – Beacon PSG Sampler

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.

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 that can create background contamination problems as experienced by wet labs. This ensures that a clean laboratory environment is maintained for trace analyses.

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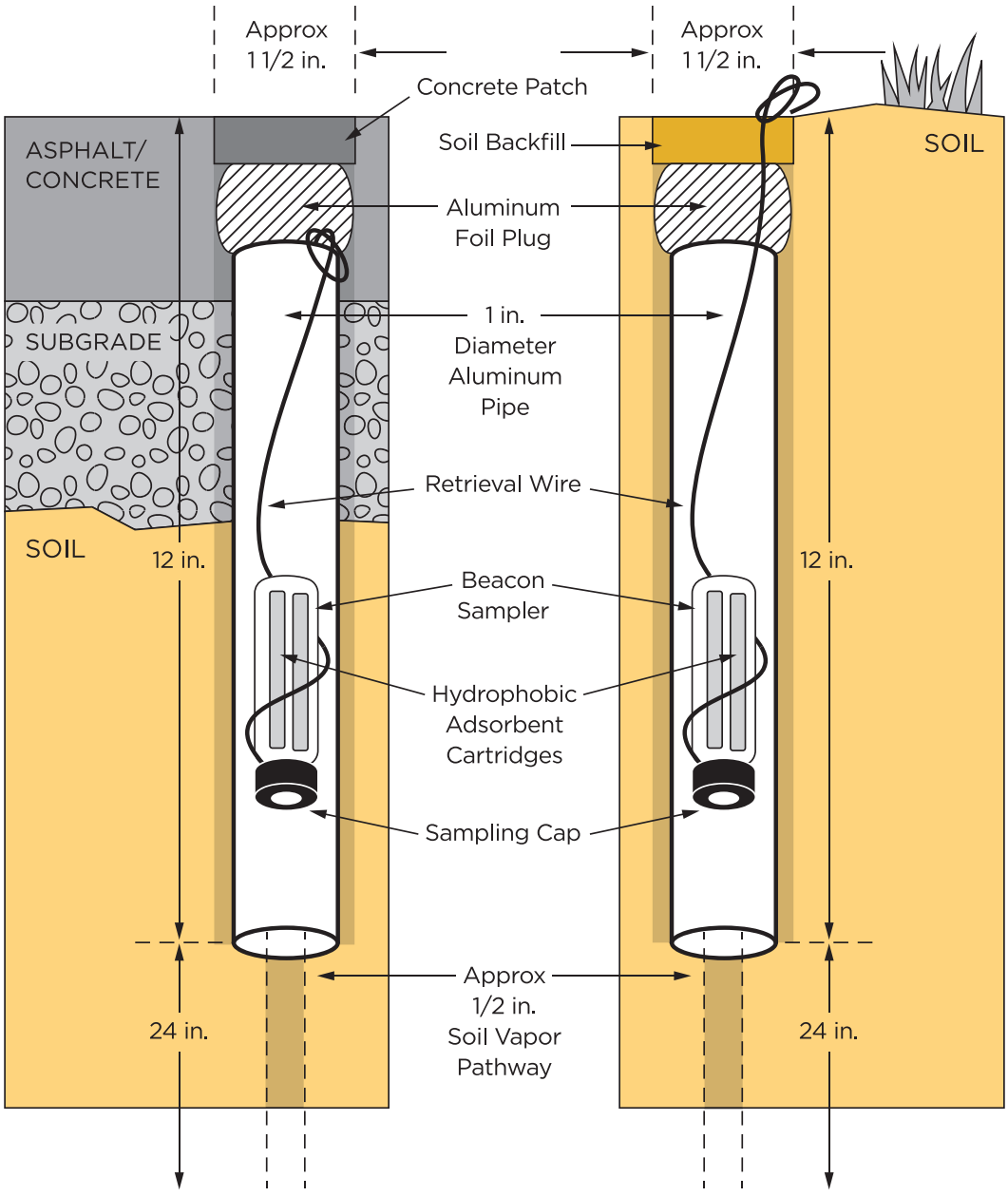
## Figure 3 – Beacon PSG Sampler Installation



Soil gas samples are analyzed by Beacon Environmental using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation, following EPA Method 8260C procedures. Samples are routinely analyzed for a list of approximately 40 compounds, which can additionally include total petroleum hydrocarbons (TPH). Results are based on an ***initial five-point calibration***. In addition, a BFB tune is performed daily and a method blank is run following the daily calibration verifications. ***Internal standards and surrogates*** are included with each sample analysis. The laboratory's reported quantitation level (RQL) for each of the targeted compounds is 10 or 25 nanograms (ng); however, the limit of quantitation (LOQ) is 10 ng and the limit of detection (LOD) is 5 ng. MDL studies are performed, as well. As an option, tentatively identified compounds (TICs) can be reported for each sample, with the results based on the closest internal standard to the TIC.

**Figure 4 – BeSure Sample Collection Kit™**


Beacon Environmental is known for providing 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.

## Summary of Analytical Procedures

| Description | Included |
|---|---|
| Analysis by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) following EPA Method 8260C - Accredited | √ |
| Analytical results based on multi-point initial calibration | √ |
| MDLs based on a seven replicate study | √ |
| Limit of Detection (LOD) and Limit of Quantitation (LOQ) studies are performed quarterly | √ |
| Internal standards and surrogates included with each run | √ |
| BFB tunes (5 to 50 nanograms through GC, per method) | √ |
| Continuing calibration checks and method blanks | √ |

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

- Markes TD100xr with auto recollection
- Markes Mass Flow Controller Module
- Agilent 7890 Gas Chromatograph / 5977B Mass Spectrometer

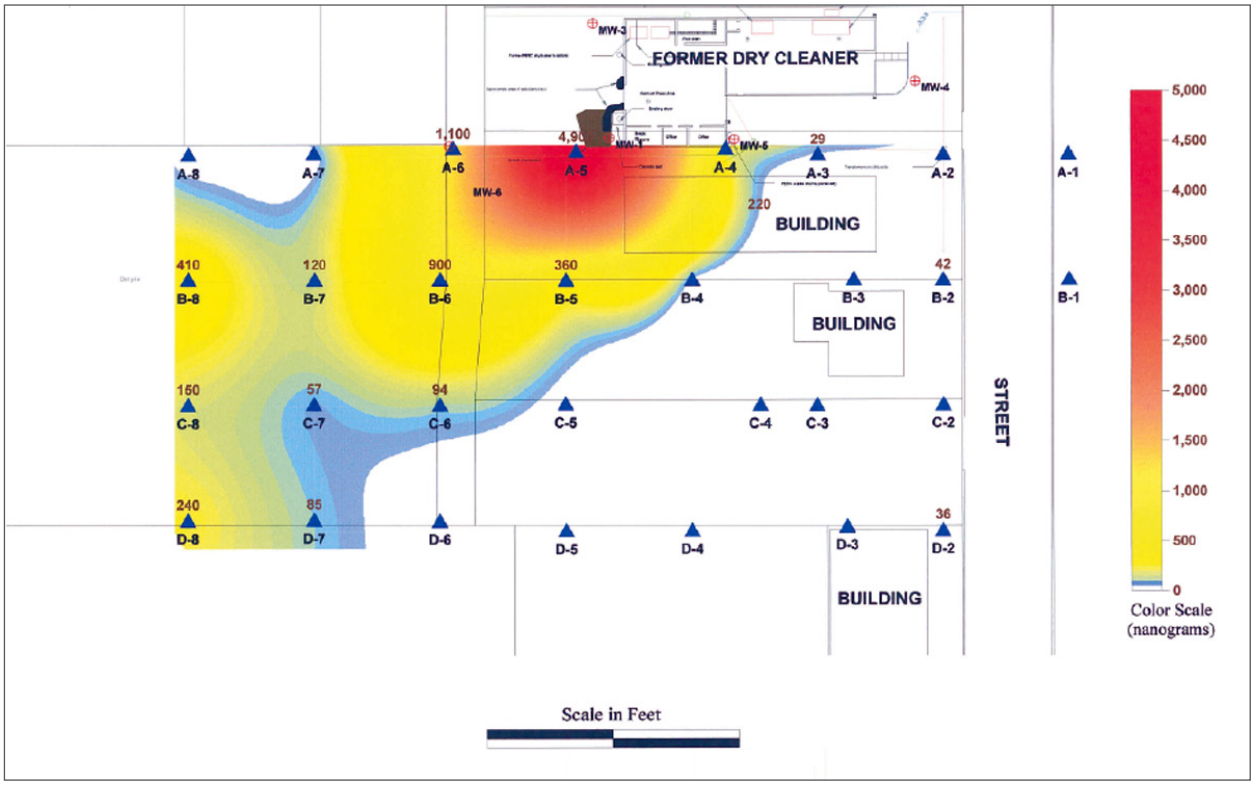
## 4.0 Reporting

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

- Project objectives
- Investigation plan
- QA/QC program and findings
- Laboratory data
- Color Isopleth Maps showing the distribution of detected compounds
- Field procedures
- Laboratory procedures
- Field Deployment Reports
- Chain-of-Custody documentation

Beacon Environmental requests a CAD drawing of the site is provided with coordinate data for each location to facilitate creation of color isopleth maps. BEACON can provide the color isopleth maps as layers for use with CAD software or provide data files of the contours for use with GIS software. Beacon Environmental provides post survey support to assist in interpreting the data, when requested.

### Color Isopleth Map Example



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## Biography of Author

Harry O'Neill is the President of Beacon Environmental and has managed soil gas and vapor intrusion investigations for more than 25 years, working on federal, state, and commercial projects throughout the United States, as well as internationally across six continents. Under his direction since 1999, Beacon Environmental has achieved DoD ELAP, NELAP, and ISO/IEC 17025 accreditation for the analysis of soil gas and air samples to target trace concentrations of organics using sorbent samplers. In addition, Mr. O'Neill oversaw the implementation of the quality program that enabled Beacon to become the first National Environmental Field Activities Program (NEFAP) and accredited field sampling and measurement organization (FSMO) in the United States.

The company's accreditation is for the collection of soil gas and air samples. Mr. O'Neill has been on the forefront of the acceptance of passive sampling technologies at the national and international level and has managed the implementation of thousands of soil gas and air sampling surveys. He is a member of AWMA, ITRC, and ASTM, and is the lead author of ASTM Standard D7758: Standard Practice for Passive Soil Gas Sampling in the Vadose Zone, and has published and presented findings throughout the United States, as well as internationally across four continents as an invited speaker. Mr. O'Neill can be contacted at Harry.ONeill@Beaconusa.com or by phone at 1-410-838-8780.

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