# Sampling Protocol for Determining the Upward Migration Risk by Soil Vapor Measurement

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*Which Soil Vapor Method to Use?*

There are three methods commonly employed to measure soil vapor contamination: active, passive, and surface flux chambers. A full discussion of the various measurement techniques is beyond the scope of this document, however some summary thoughts will be presented here. Excellent overviews of soil vapor survey collection methods can be found in the San Diego County Site Assessment Manual (http://www.co.san-diego.ca.us/deh/lwq/sam) and in the Standard Encyclopedia of Environmental Science, Health, & Technology, Chapters 11.8 & 11.9 (ISBN# 0-07-038309-X).

Active soil vapor methods (withdrawal of the soil vapor from the subsurface and subsequent analysis of the vapor) give concentration data, which are required for calculating the contaminant flux using Fick's first law or with various versions of the Johnson-Ettinger model. Further, vertical profiles of the soil vapor concentrations can be obtained to aid in determining the direction and magnitude of the flux. Finally, active soil vapor data can be collected and measured in real-time, enabling decisions to be made in the field.

The problem most often raised with active soil vapor data is whether the concentrations measured at any given time and day are representative of normal conditions (i.e., how "stable" are active soil vapor data?). Variations caused by barometric changes, building pressures, etc. are known to exist; however they are difficult to quantify. These effects are known to lessen with increased depth below the surface (or away from the building) and generally it is considered that data collected from three to five foot depths are fairly stable. If variation is a concern, especially for depths less than 5' bgs, a semi-permanent vapor monitoring probe/implant can be left in the ground allowing repeated measurements at any desired frequency (for a guide of vapor monitoring probes go to www.hplabsonsite.com/).

Passive soil vapor methods (burial of an adsorbent in the ground with subsequent retrieval and measurement of the adsorbent) give a time-integrated measurement, and therefore reduce the uncertainty due to temporal variations as described above. Passive methods also are generally easier to implement. However, passive soil vapor methods only yield soil vapor data in terms of mass, not concentration, and therefore passive soil vapor data can not be used for upward vapor migration assessment. A "conversion" of the data from mass units to concentration units is sometimes attempted in order to use the data for determination of the health risk. The assumption required in making the conversion from mass to concentration is the volume of vapor that passed by the buried adsorbent during the burial time period. There is no practical way to estimate this volume, and thus the resulting values have a high degree of uncertainty. Further, because passive collectors are buried so close to the surface (generally 2 feet of less); the measured values are highly influenced by any near-surface effects. For these two reasons, the passive soil vapor technique is not applicable for upward vapor migration assessment.

Surface flux chambers are enclosures that are placed directly on the surface (ground, floor, etc.) for a period of time (generally a few hours to a few days), and the resulting contaminant concentration in the enclosure is measured. By dividing the measured concentration by the incubation time, a direct value for the flux is determined. This method offer advantages over the other two methods because it yields the actual flux of the contaminant out of the ground, which eliminates some of the assumptions required when calculating the flux with a model (e.g., effective diffusivity, influence of a cement slab, etc.). However, this technique is not as fast or easy to implement, also is subject to near surface effects (are the measured fluxes "stable"), and gives no idea of what may be "hiding below".

Which method to use on a given site depends upon the site-specific goals and the logistical limitations. The active soil vapor method offers less uncertainty and more versatility than the surface flux chamber method for most situations. If the flux chamber method is used, deploy multiple chambers and collect for at least 8 hours (24 hours preferred) to ensure representativeness, and collect at least one soil vapor sample under the footprint to see if anything lies below, especially at chlorinated solvent sites

*Recommended Sampling Protocol for Active Soil Vapor Surveys*

The following procedure is recommended for collecting near surface soil vapor data with the intent of determining the upward vapor flux into an existing or future room/building:

1. Collect active soil vapor data at 5 feet bgs at enough sampling points under or near the building to give a reasonable estimate of the average subsurface soil gas concentration under the building footprint. At a minimum, samples should be collected at the corners of the existing or future building and the location of highest contaminant concentration under the building (if determined previously). If the location of the future building is unknown, collect soil vapor data at 5 feet bgs spatially across the site to identify the location of highest concentration.

2. Calculate the health risk from the average soil vapor value. If the risk calculation indicates that upward vapors poses no threat to human health, then submit a formal request for closure to the governing agency.

3. If the risk calculation indicates that upward vapor may pose a threat to human health, then repeat steps 1 and 2 at three (3) feet bgs.

4. If the risk calculation still indicates that upward vapor may pose a threat to human health, then the soil vapor concentration at a shallower depth (<3 feet bgs) needs to be determined. It is recommended that data be collected at 1-foot intervals from 1 foot

to 3 feet bgs to ensure that vertical variations are adequately characterized. Measured concentrations this close to the surface can be greatly influenced by soil vapor collection technique and atmospheric air infiltration due to barometric pumping. Thus, "time-average" data may be appropriate to ensure that the measured soil vapor values are representative.

Time averaged data are most easily obtained by installing a semi-permanent vapor monitoring probe/implant in the ground (for a guide of vapor monitoring probes go to www.hplabsonsite.com/). The soil vapor should be analyzed multiple times (2 or more) over time to demonstrate consistency in concentrations. If determination of bioattenuation is desired, measurements of oxygen and carbon dioxide should be taken.

For subsurface enclosures, such as basements or utility trenches, the same protocol can be used, however soil vapor samples should be collected from 3 to 5 feet below the floor (rather than bgs). Additionally, it may be necessary to also consider the potential flux through the walls in addition to the floor. Assuming a contaminant source deeper than the enclosure, the most conservative assumption is to assume the flux through the walls is equal to the flux through the floor. In this case, the total flux into the room would be equal to the flux through the floor times the combined surface area of the floor and the walls. Alternatively, a soil vapor measurement may be made on each side of the wall (3 to 5 feet away) and the flux through the wall computed separately. The total flux into the room would then be computed by summing the individual fluxes through the floor and walls.

*Recommended Sampling Protocol for Surface Flux Chamber Surveys*

While operational logistics often limit the number of chambers deployed, it is advised that more than one chamber be deployed to enable some reproducibility to be demonstrated. Longer exposure times are advantageous (8 to 24 hours) since they give a time-integrated result that is more representative of the actual flux into a surface enclosure. Collection and analysis of multiple samples from a chamber at regular intervals over the deployment period (e.g., every 4 hours) is advised since it allows estimates of precision, enables spurious measurements to be eliminated, and any variability in the measured fluxes to be detected.

1. Deploy surface flux chambers at enough sampling points under or near the building to give a reasonable estimate of the average flux into the building. At a minimum, samples should be collected at the ends of the existing or future building and the location of highest contaminant concentration under the building (if determined previously). If the location of highest contaminant concentration is unknown, deploy a chamber at the center of the room.

2. Calculate the health risk from the average flux value. If the risk calculation indicates that upward vapors poses no threat to human health, then submit a formal request for closure to the governing agency.

3. If a flux is measured, collect an active soil gas sample at 3 to 5 feet bgs below the chambers showing a measurable flux in order to verify that the measured contaminant is in the soil gas below the chamber.

Soil vapor samples (active or flux chamber data) should be collected and analyzed following EPA SW-846 protocols modified for vapor or any specific protocols by the local oversight agency. An excellent set of analytical protocols for soil vapor samples exists in the San Diego County Site Assessment Manual (http://www.co.san-diego.ca.us/deh/lwq/sam/pdf_files/SoilGas.PDF). Required detection levels are contaminant specific and depend upon acceptable room air concentrations.