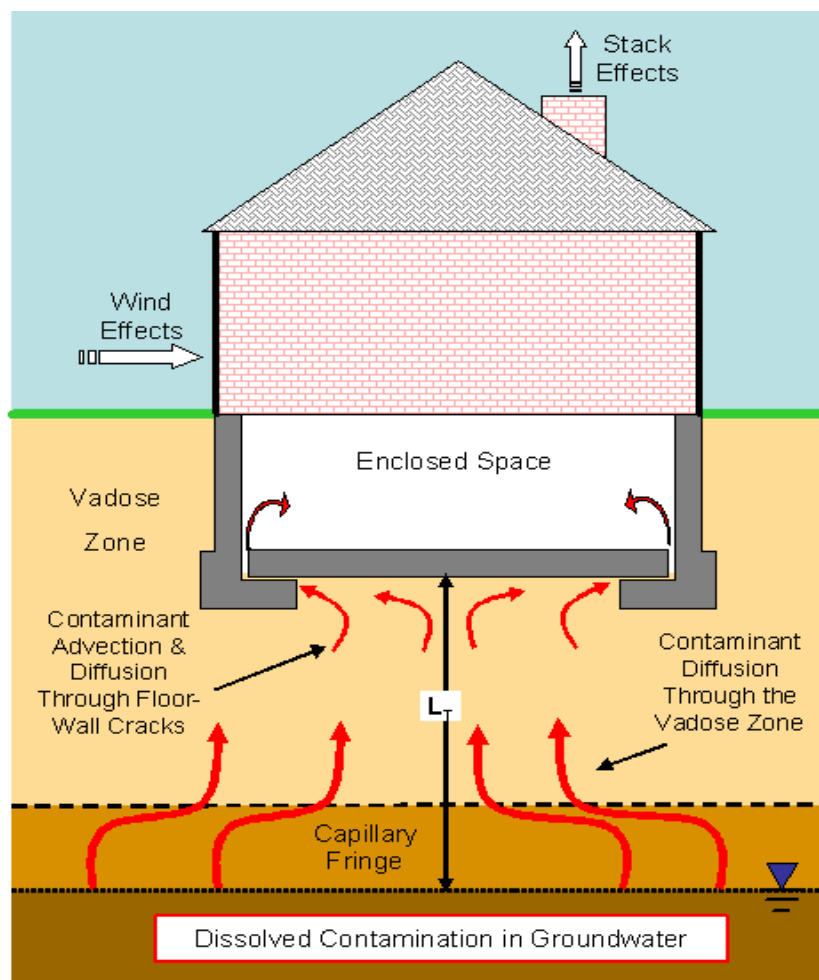


# SUB-SURFACE VAPOR INTRUSION



With raw land in short supply, developers are increasingly becoming redevelopers and are learning to handle the additional risks associated with previous land owners and adjacent properties. One risk rising to the forefront of new property owners is Sub-Surface Vapor Intrusion, where contaminants from soil and groundwater are released above ground, often into new or existing buildings.



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Phase one environmental site assessments are the first step in recognizing the risks of vapor intrusion, and state and federal regulatory agencies have only recently begun to provide testing guidelines for properties with the potential of vapor intrusion of volatile chemicals.

Geotechnical & Environmental Services, Inc. is striving to become the regional expert in this area and has already worked with government agencies and area businesses in identifying underground PCE plumes and their impact on area residents and businesses.

According to the Interstate Technology and Regulatory Institute vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. The term “volatile chemicals” can refer to volatile organic compounds (VOCs), select semi-volatile organic compounds (SVOCs) and some inorganic analytes such as elemental mercury and hydrogen sulfide. In order for a vapor intrusion hazard to exist there must be three components:

- a source
- an inhabited building
- a pathway from the source to the inhabitants

When the three components are identified, harmful vapors may be migrating from the underground source, along a preferential pathway, and into the building. According to the United States Environmental Protection Agency, building depressurization may cause these vapors to enter the building from cracks in the slab or basement floor. Depressurization can be caused by a combination of wind and stack effects, including chimneys, which are the result of heating within the building or ventilation systems. The recognition of vapor intrusion is instrumental in the continuing struggle to protect human health and the environment.

In extreme situations vapors can accumulate in buildings to levels which may warrant explosions. More commonly vapor concentrations are found to be at low levels. Exposure to these toxins even at low levels may produce the risk of long term exposure and the development of chronic health problems.

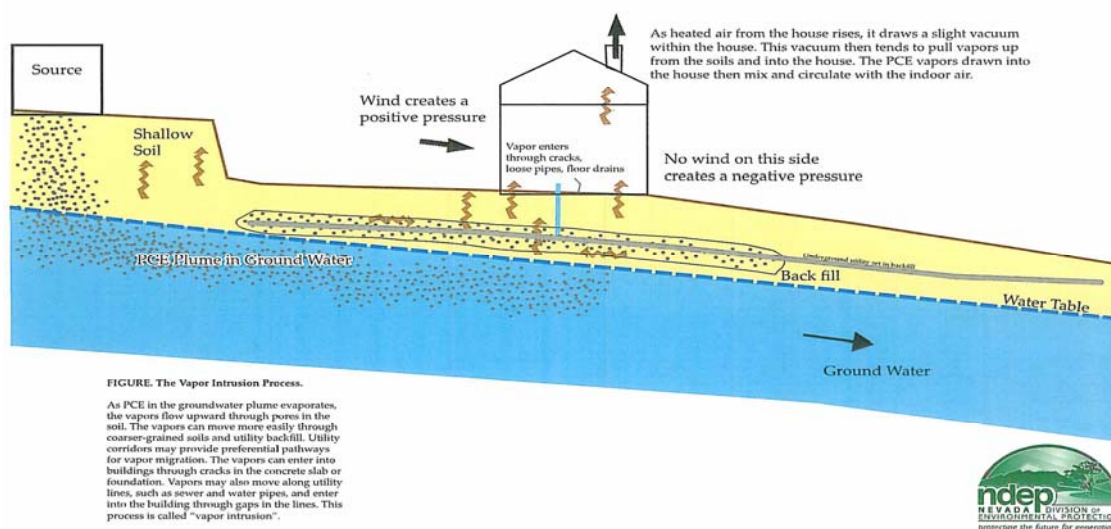
If vapor intrusion is to occur there must first be a source. **So, what is a source?** A source can be soil and/or groundwater contaminated with VOCs, SVOCs or an inorganic analyte. The contaminate(s) must be able to volatilize from the source and migrate toward the ground surface and overlying buildings. Volatilization is generally defined as the conversion of a solid or a liquid to a gas or vapor, by application of heat, by reducing pressure, by chemical reaction or by a combination of these processes.

The second requirement is an inhabited building. This is important in that there can be no threat to human health if there are no humans working or living in a building.

The third component is referred to as a pathway. **What is a pathway?** Vapors, like water, tend to follow the path of least resistance. For contaminated source areas

originating below ground, the path of least resistance for vapors is often toward the surface, if a contaminant is to migrate from the source to the surface the contaminant must be lighter than air.

Vapor must accumulate beneath an inhabited building in order for it to pose a risk to human health and the environment. This requires the vapor to follow a pathway, toward the surface. Vapor prefers to travel through porous materials such as coarse grain sand, and gravel. Historically, vapors have been known to follow utility corridors, such as pipe and cable trenches from the main line to the receptor, providing a **preferential pathway**. The following diagram provides a conceptual picture of the vapor intrusion process as defined by the Nevada Division of Environmental Protection (NDEP).



If a source and pathway have been identified the **risk of exposure** must then be evaluated. This process is complicated and depends on many factors and disciplines. To assist in the evaluation of risk, a Conceptual Site Model (CSM) should be developed.

- Collect existing site data (historical records such as previous surveys and sampling data, site operating records, aerial photographs, maps, Preliminary Assessment and Site Inspection (PA/SI) data, available background information, State soil surveys, etc.)
- Organize and analyze existing site data
- Identify known sources of contamination and potential contaminants
- Identify potentially contaminated areas and affected media
- Identify potential migration routes, exposure pathways, and receptors
  - Construct a preliminary diagram of the CSM
  - Perform site reconnaissance
  - Confirm and/or modify CSM
  - Identify remaining data gaps

Sampling for the presence of vapor in the indoor environment can be confusing, considering the number of parameters able to interfere with the data. This is where the Vapor Intrusion Sampling and Analysis Plan should be developed. Each site should be different; therefore each sampling and analysis plan should be unique.

## **THE APPROACH**

The development of a CSM and a work plan should be in accordance with ASTM E2600-08 Standard Practice for Assessment of Vapor Intrusion into Structures on Property Involved in Real Estate Transactions, the vapor intrusion guidance provided by the United States Environmental Protection Agency (USEPA, 2002a), and the California Department of Environmental Protection, Department of Toxic Substances (2005). A work plan should provide a technically defensible and consistent approach for evaluating vapor intrusion. Vapor Intrusion is a relatively new development, with regulations based on the current understanding of exposure pathways. These guidelines are subject to change with advances in technology and an increased understanding of exposure pathways.

If testing of the potential receptor (business or household) is warranted by the CMS, interior testing alone is considered inadequate by the users due to the multitude of common sources and the possibility of extremely low detection levels that may be found during the screening process. To limit the effects of these sources, multiple samples should be collected in unison. An ambient (outside air) sample should be collected from a location within ten (10) feet of the potential receptor and at least three feet off the ground. This sample is used to identify any possible background contamination from the ambient air that may travel into the home during a vapor intrusion sampling event. A minimum of two (2) indoor air samples should be collected in different locations within the home. Additionally, a minimum of two separate soil vapor samples should be collected from within ten (10) feet of the sub-slab. For example, the first soil vapor sample may be collected from approximately six (6) feet below ground surface (bgs) with the second sample collected approximately eleven (11) feet bgs.

Prior to active sampling, a survey of common products (i.e., cleaners, solvents, air fresheners, perfume, new fabrics, and dry cleaned fabrics) which may interfere with the analysis should be conducted to assist in the interpretation of the results. This inventory of samples should be evaluated further in the event that indoor air results are not consistent with ambient air and soil vapor samples.

## **THE PROCEDURE**

1. **Soil Vapor Sample Boring Location:** Soil vapor sample boring locations should be chosen on opposite sides of the building in locations discussed with the property owner.
2. **USA Locate Mark-Out:** Before ground is broken it is required to contact a Call Before You Dig service. This service determines which public utilities are in the area of the marked boring locations. This service then contacts the utility companies to “mark-out” their utility lines. It is important to note that once a ticket is issued the utility companies have two legal business days to “mark-out” their lines before work can begin.

3. Private Line Locator: A private line locator is necessary to locate lines not owned by the public utility. For example, the Nevada Water Reclamation District does not own the sewer line that runs from the building to the main line. In this instance the utility is not responsible for the sewer line and will not mark out that line.
4. Household Inventory: Many household products such as cleaners, solvents, air fresheners, perfumes, new fabrics, and dry cleaned fabrics may interfere with the accuracy of the analysis. Therefore, prior to the placement of indoor air sampling devices an inventory of everyday products which may interfere with the sampling event should be conducted. The property owner will be asked to refrain from using these products during the twenty four-hour sampling period. The same inventory should be conducted at the end of the twenty four-hour period to ensure that no interfering products were inadvertently introduced in to the sample area.
5. Environmental Drilling: Subsurface exploratory borings, for example, may be advanced to a depth of six (6) feet and eleven (11) feet, and placed within ten (10) feet of the residence if possible. The subsurface exploratory boring is typically advanced with direct push technology. The sampling device should be “pushed” to six (6.0) feet and back pulled to five and a half (5.5) feet and to eleven (11.0) feet and back pulled to ten and a half (10.5) feet to allow for soil vapor extraction sampling. Actual depths may vary by site.
6. Soil Vapor Sampling: Summa Canisters are generally used to collect and contain the soil vapor samples. Soil conditions must allow for soil vapor sampling. Typically two attempts are made at each sample location. If direct push technology is not able to penetrate to the desired depth, other methods may need to advance to the desired depth. If the first attempt fails, the sampling equipment should be withdrawn and re-driven a few feet from the original location. Soil gas sampling is typically, considered to fail when subsurface air flow rates are less than 10 mL/min or when a vacuum of ten (10) inches of mercury or greater is obtained.
7. Indoor Air Sampling: A minimum of two 6-liter “certified clean” stainless steel evacuated Summa Canisters should be pre-set by the analytical laboratory to draw a representative indoor air quality sample over a twenty-four (24) hour period. A household product inventory should be conducted when the canisters are placed and when they are collected, to account for any possible interference in the sample collection. During the twenty-four (24) hour sampling period observations including but not limited to household products and air exchange ratios should be observed and recorded. Indoor air quality samples should be collected in six (6) liter stainless steel evacuated Summa Canisters with flow regulators pre-set by the analytical laboratory to draw over a twenty-four (24) hour period. The Summa Canisters should be packaged and sent to a certified analytical laboratory under the appropriate chain-of-custody protocol and analyzed via EPA Method T0-15.



8. Ambient (Outdoor) Air Samples: When the previously described indoor air samples are collected, ambient air data should also be collected. Since the focus of the indoor air quality assessment is on collecting data specific to the soil or groundwater contamination, the outdoor sample should be evaluated in the same manner.

Ambient air sampling should begin at least one hour, preferably two hours, before indoor air sampling begins. This is recommended since most buildings have an air exchange rate of 0.5-1.0 exchanges per hour and thus, ambient air enters the building before indoor air sampling begins. The ambient air sample should be collected until thirty (30) minutes prior to the end of the indoor sampling period. Specific placement of the Summa Canister is as follows: the canister should be placed on the upwind side of the building, at least three (3) feet off the ground, at the approximate mid-point of the ground story level of the building, in a location approximately five (5) to fifteen (15) feet away from the building.

Outdoor air quality samples should be collected in one 6- liter stainless steel evacuated Summa Canister with a flow regulator pre-set by the analytical laboratory to draw over a twenty-four (24) hour period.

### **QUALITY ASSURANCE/QUALITY CONTROL**

Only “certified clean” Summa Canisters, provided by the analytical laboratory should be used for testing. Certification is performed by the laboratory. As a measure of control, personnel should not fuel vehicles or use permanent markers during this indoor air quality assessment. A trip blank is required and should be included in this investigation to ensure there are no impacts from unforeseen environmental sources that could affect the results of the study. A trip blank is prepared by the analytical laboratory and typically consists of lab grade distilled water which is placed in the same sample containers required to collect samples. The trip blanks travel from and to the lab with and in the same manner as the actual samples. Once the samples and the trip blank arrive at the analytical lab the trip blank is analyzed in the same manner as the actual samples. In theory, the trip blank should not contain any of the chemicals analyzed for, this assists in the assurance of uncontaminated samples. Once the samples are collected they are packed and shipped priority overnight to the analytical laboratory, a hold time of seventy two hours should be upheld by the laboratory. Field duplicates should be collected where deemed appropriate. A field duplicate is a “double” sample taken from a predetermined sample interval. Typically, the number of field duplicates collected is dependant upon the number of samples required. For example, if twenty (20) samples are collected then two (2) field duplicates should be collected, this is approximately ten percent (10%) of the required samples.

### **RESPONSE ACTION AND CONTINGENCY PLANNING**

The data obtained from this indoor air quality sampling investigation should be used to identify activities and/or responses and aid in determining human health impacts and their associated mitigation measures.

## **EVALUATION OF INDOOR AIR SAMPLING RESULTS**

The purpose of sampling indoor air for sub-slab vapor intrusion is primarily to evaluate the risk to human health. The equations for human risk assessment and take into consideration a number of potential pathways, including indoor air pollution from the sub-surface. When calculating human risk or hazard from vapor intrusion, this pathway is added to the risk/hazards posed by all other potentially complete exposure pathways. By combining all potential pathways a cumulative risk assessment at a site can be determined. The determination of cumulative risk will assist in determining the necessity of mitigation.

## **MITIGATION MEASURES**

In the event mitigation is deemed necessary to protect human health, the installation of a sub-slab depressurization system is a viable solution to vapor intrusion in an existing building.

According to the State of California Vapor Intrusion Guidance Document, dated December 15, 2004, this mitigative approach involves the installation of a sub-slab collection system with either a passive or active venting system in existing structures where installation of a membrane system below the foundation is not feasible. These types of systems have been used successfully in the past to mitigate the intrusion of naturally occurring radon gas into buildings.

When designing a sub-slab venting system a number of factors must be considered.

1. Collection Pipe Spacing: A collection pipe system for VOC capture should be installed beneath or adjacent to the foundation slab. The number and spacing of collection points should be based on the soil and engineered fill properties beneath the building.
2. Collection Pipe Layout: The gas collection piping should be installed either horizontally or at an angle beneath the building. Horizontal collection piping is usually installed along the perimeter of the building with horizontal drilling techniques, with the piping physically extending under the building. The installation of the collection system near building footings and/or utility corridors. The collection pipe system should be installed using threads as opposed to glues that may be dissolved by VOCs such as perchloroethylene (PCE) causing possible leakage. The need for drainage and de-watering improvements must be considered and suitable improvements to the system must be contemplated, as necessary, to insure the proper operation of the collection pipe system.
3. Vent Riser Design: The underground gas collection pipes must be connected to solid risers that extend above the building. The vent risers may be equipped with a sampling port and fitted with a non-restricting rain guard to prevent precipitation and debris from entering the piping system. Vent risers

should be properly secured to the building to protect them from damage. Vent risers should be terminated a minimum of two (2) feet above the roof of the structure and be a minimum of ten (10) feet away from any window or air intake into the building. A small fan or blower within the vent riser may be required. It should be noted that access to power may warrant a utility trench.

4. Utility Conduit Seal: Conduit seals must be provided at the termination of all utility conduits to reduce the potential for gas migration along the conduit to the interior of the building. These seals must be constructed of closed cell polyurethane foam, or another inert gas-impermeable material, extending a minimum of six (6) conduit diameters or six (6) inches whichever is greater, into the conduit.

In the event mitigation is warranted a detailed work plan and cost estimate should be provided for the installation of a sub-slab depressurization system including a proposed operations and maintenance plan.

The threat of exposure to volatile organics is developing, as are the processes to detect and mitigate. As new understanding and technologies develop, so will investigative methods. The purpose of these advances is to ultimately protect human health from short and long term exposure to volatile organics. The cost of determining if there is the potential for exposure to volatile organics will vary between sites and should be evaluated on an individual basis.

In the future, homes and businesses may be designed to eliminate harmful chemicals from entering from below the foundation. Until then Geotechnical & Environmental Services, Inc. will continue to stay abreast of the issue and investigate possible intrusions as needed.

#### References:

Department of Toxic Substances Control California Environmental Protection Agency, Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, December 15, 2004 (Revised February 7, 2005)

Interstate Technology Regulatory Council (ITRC), Vapor Intrusion Pathway Guideline (2007). [www.itrcweb.org](http://www.itrcweb.org)

United States Environmental Protection Agency, OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Sub-surface Vapor Intrusion Guidance) November 2002.