# Vapor Intrusion:
# Key Concepts for Radon Professionals

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1 —What is Vapor Intrusion (VI)?

2 —Why isn't this just radon with chemicals?

3 —What are all these chemicals everyone keeps talking about?

4 —How is vapor intrusion investigated?

5 —How is VI mitigated?

6 —Building on your radon expertise

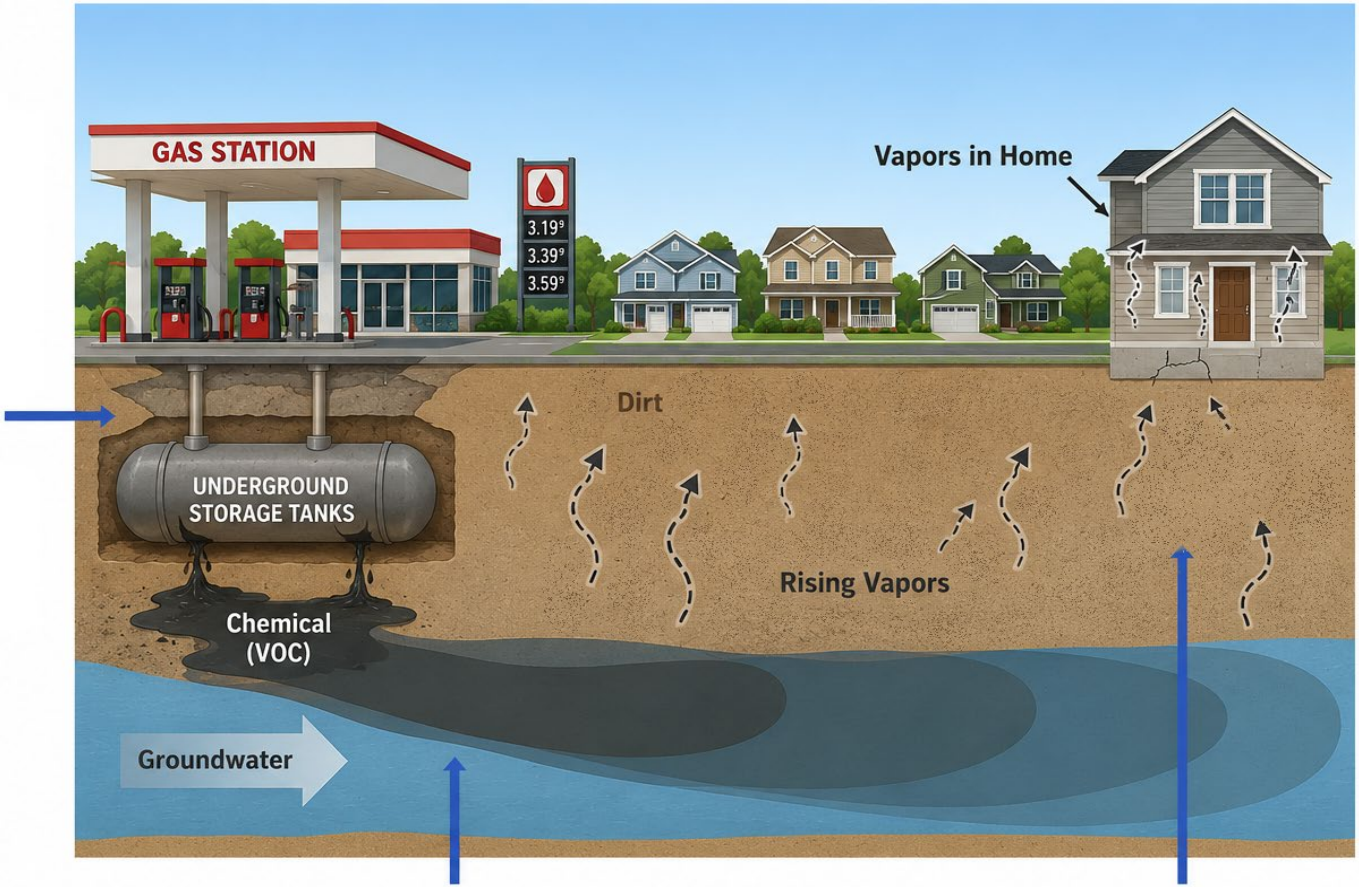
# What exactly IS Vapor Intrusion?

NOT the contamination itself

NOT the chemical spill

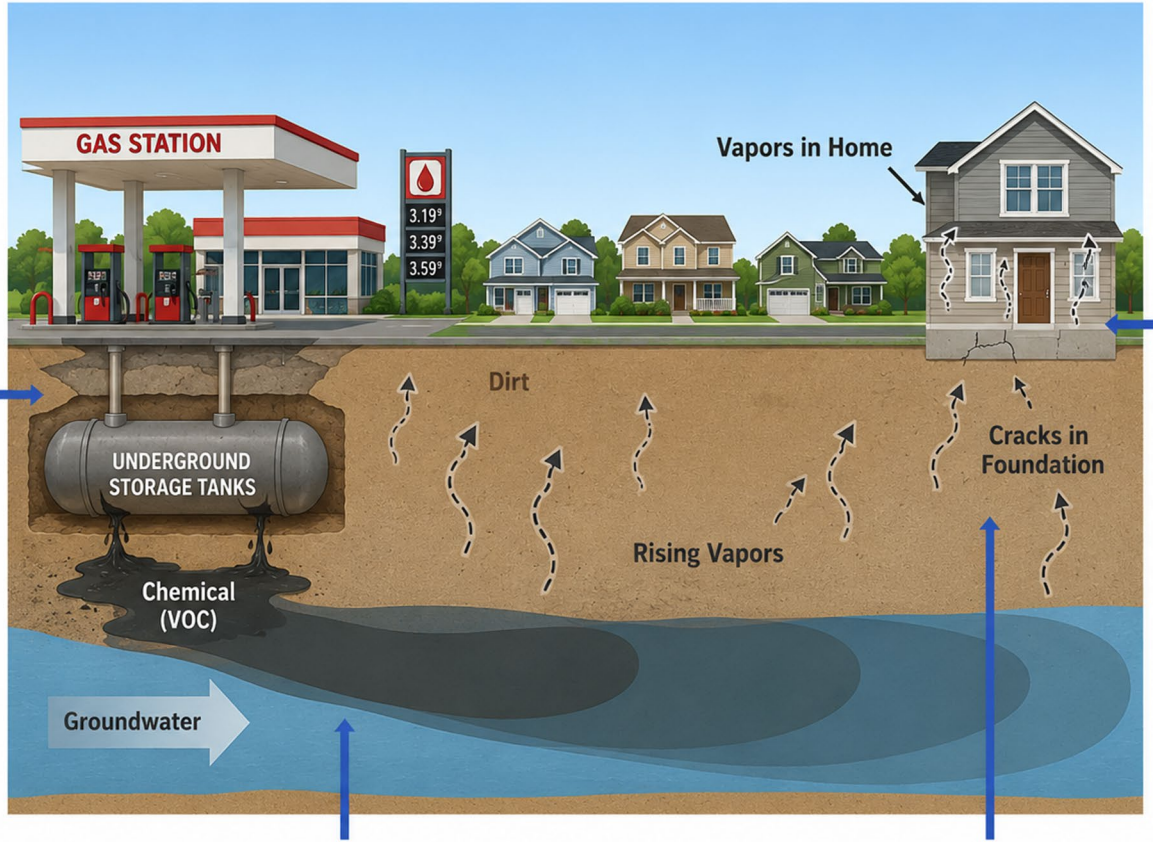
NOT the leaking underground storage tank

VI is what happens AFTER contamination gets into the environment


GAS STATION
3.19⁹
3.39⁹
3.59⁹
Vapors in Home
Dirt
UNDERGROUND STORAGE TANKS
Chemical (VOC)
Rising Vapors
Groundwater

**1**

**Source of Contamination -** A leak from an underground storage tank allows petroleum chemicals to seep into the surrounding soil and groundwater beneath the gas station.




**4**

**Indoor Exposure -** Once inside, these vapors may accumulate in indoor air, potentially exposing occupants.

Because many vapor-forming chemicals are colorless and odorless, they often go unnoticed without testing.

**2**

**Contamination Migration -** As groundwater moves through the subsurface, dissolved contaminants spread beneath nearby properties. Some of these chemicals evaporate into the soil, creating contaminated soil gas.

**3**

**Vapor Intrusion -** Chemical vapors can migrate upward through the soil and enter buildings through foundation cracks, utility penetrations, sump pits, and other openings.

# Why isn’t this just radon with chemicals?

# Vapor Intrusion



## Definition

Vapor intrusion = movement of **chemical vapors** from contaminated soil/groundwater into **buildings.**

## How It Happens

**Driven by:**

- **Pressure differences**
- **Temperature gradients**
- **Diffusion** (high → low concentration)



## Three-Part Pathway Model



# Risk of Adverse Health Effects Depend On...

nature, frequency,
and duration of exposure



## Health Effects

- Eye, nose, and throat irritation
- Nosebleed
- Headaches
- Nausea
- Vomiting
- Dizziness
- Visual disorders
- Loss of coordination
- Shortness of breath
- Allergic skin reaction
- Fatigue
- Damage to liver, kidney, and central nervous system
- Memory impairment
- Cancer

# Radon vs Vapor Intrusion

*How is this different than radon?*

| | Radon | Vapor Intrusion |
|---|---|---|
| SOURCE | Naturally occurring uranium in soil (widespread)  | Contaminated soil or groundwater  |
| PATHWAY | Very predictable (cracks, slab, sump)  | May or may not exist  |
| RECEPTOR | Building occupants  | Building occupants  |

**Radon:** Assume path = Test result

**VI:** Prove path = Further investigation

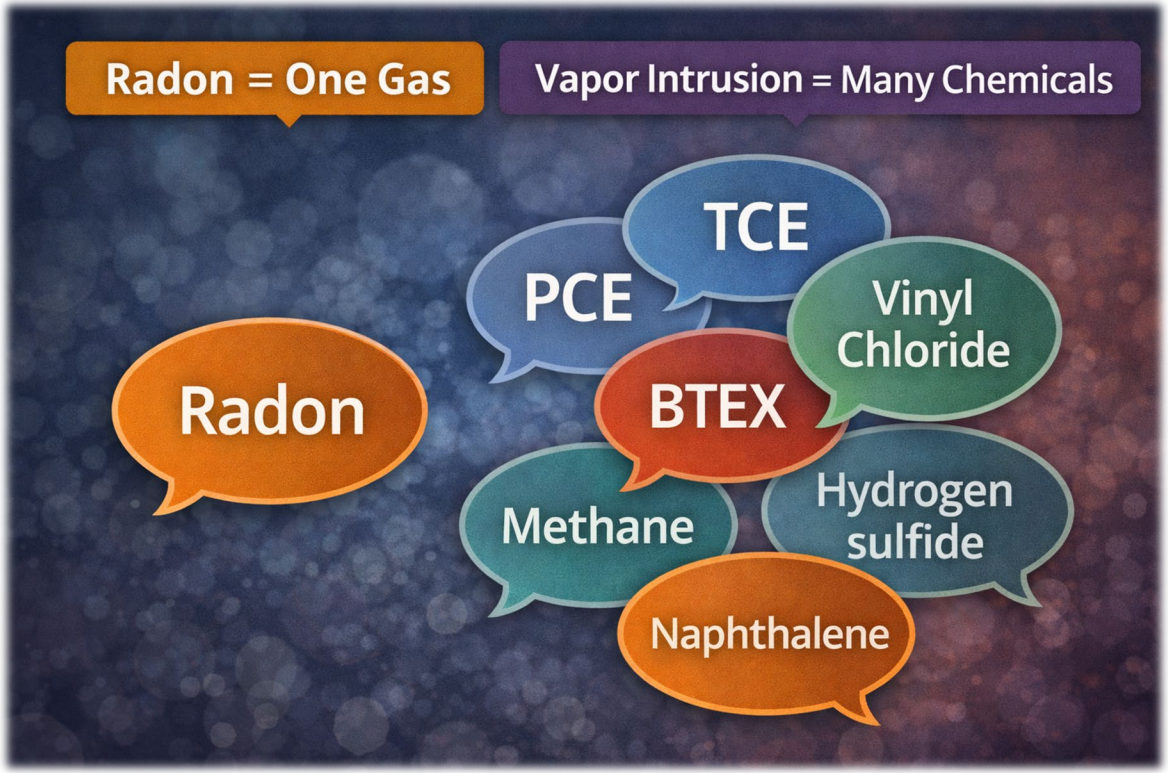
# Similar—yet Different

# The Mindset Shift



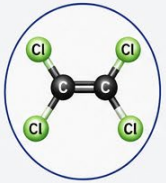
# What are all these chemicals everyone keeps talking about?

# One Gas vs Many Chemicals



# VAPOR INTRUSION (VI): CHEMICALS AND SOURCES

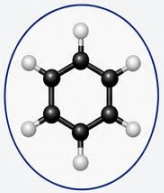
## COMMON VI CHEMICALS




### CHLORINATED SOLVENTS (PCE, TCE, VINYL CHLORIDE)

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- Vinyl chloride

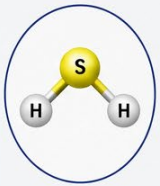




### PETROLEUM COMPOUNDS (BTEX)

- Benzene
- Toluene
- Ethylbenzene
- Xylene






### OTHER VOCs (EXAMPLES)

- Methane
- Hydrogen sulfide
- Naphthalene



## WHERE VI COMES FROM



### INDUSTRIAL / CLEANING SOURCES

- Dry cleaning operations
- Metal degreasing
- Manufacturing facilities
- Printing and electronics



### FUEL / PETROLEUM SOURCES

- Underground storage tanks
- Gas stations
- Fuel spills and leaks
- Pipelines



### WASTE / DECOMPOSITION SOURCES

- Landfills
- Septic systems
- Sewer lines
- Organic waste decomposition

# Galen Myers EPA Superfund Site 1970's to Present

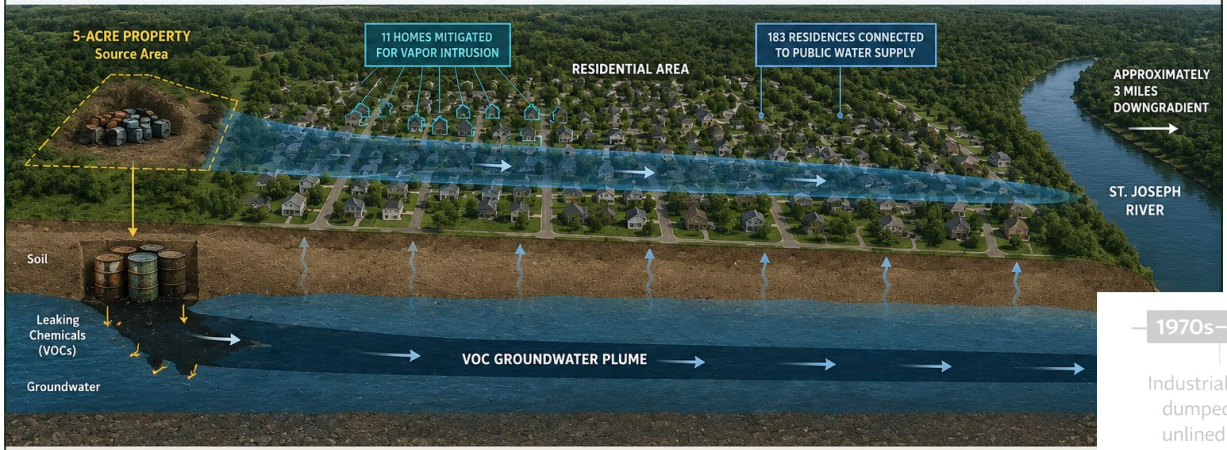
**1970's**
Industrial drums were dumped and buried on the 5-acre property.

**Leaks & Releases**
Chemicals from the drums leaked into the soil and reached the groundwater.

**Groundwater Flow**
A long, narrow VOC plume formed in the groundwater and flows slowly downstream.

**Community Impact**
183 residences connected to public water supply. 11 homes mitigated for vapor intrusion.

**Downstream**
The plume travels approximately 3 miles to the St. Joseph River.




1970s– 1988 — Industrial waste dumped in unlined pit

1988 — Contamination spreads to residents' wells

1989 — EPA designates site a Superfund (NPL) site

Present Day — Long-term management & monitoring

VOC Groundwater Plume
Groundwater Flow Direction
Vapor Migration

## SITE IMPACT SUMMARY

**183 Residences**
Connected to the public water supply to ensure safe drinking water.

**11 Homes**
Mitigated for vapor intrusion between the source area and the river.

**3 Miles**
Long, narrow VOC plume moving slowly with the groundwater to the St. Joseph River.

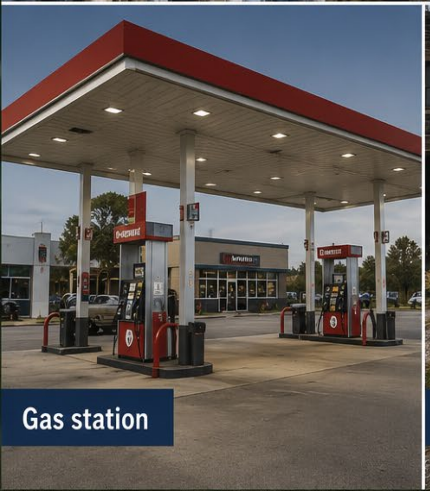
The Galen Myers Site was proposed to the EPA Superfund Program in 1983 and remains under investigation and remediation to protect human health and the environment.

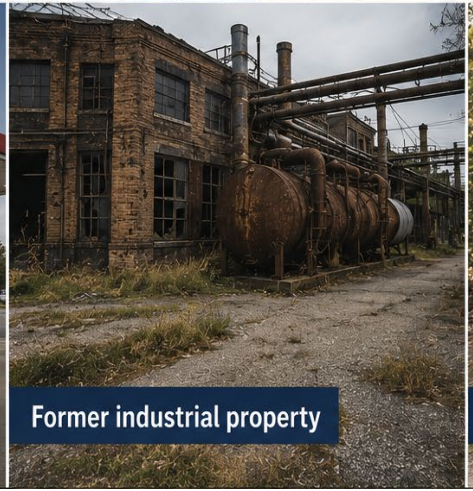
# Where Do VOCs Come From?













If you were testing a house next to one of these sites...

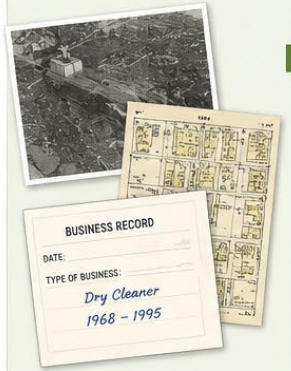
would it change the questions you'd ask ?

# How is vapor intrusion investigated?

# HOW ENVIRONMENTAL PROFESSIONALS
# INVESTIGATE VAPOR INTRUSION

## 1 HISTORICAL RECORDS

Investigate the past uses of the property to identify potential sources of contamination.

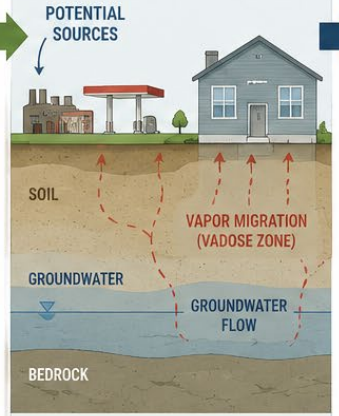



**Examples:**

- Aerial photographs
- Sanborn maps
- City directories
- Environmental reports
- Regulatory databases

## 2 CONCEPTUAL SITE MODEL (CSM)

Develop a working hypothesis of how contamination could move from the source to people inside buildings.




The CSM evolves as new information is collected.

## 3 TESTING – COLLECT MULTIPLE LINES OF EVIDENCE

Samples are collected from multiple media to evaluate vapor migration and potential exposure.

**GROUNDWATER**
Is contamination present in the groundwater?

**SOIL**
Is contaminated soil contributing vapors?

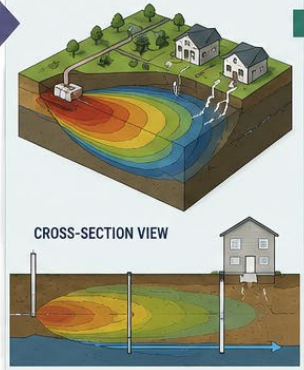
**SOIL GAS**
Are vapors present in the subsurface and moving?

**SUB-SLAB**
Are vapors present beneath the building?

**INDOOR AIR**
Are vapors entering the building and impacting indoor air?

## 4 PREDICTIVE MODELING

Computer models are used to estimate how contaminants may move through the subsurface and into buildings over time.




Models consider:
geology, groundwater flow, soil properties, vapor transport, building characteristics, and more.

## 5 MULTIPLE LINES OF EVIDENCE

Vapor intrusion is confirmed (or ruled out) by evaluating and integrating all available evidence.




**No single test proves vapor intrusion. The investigation is about assembling the complete picture.**

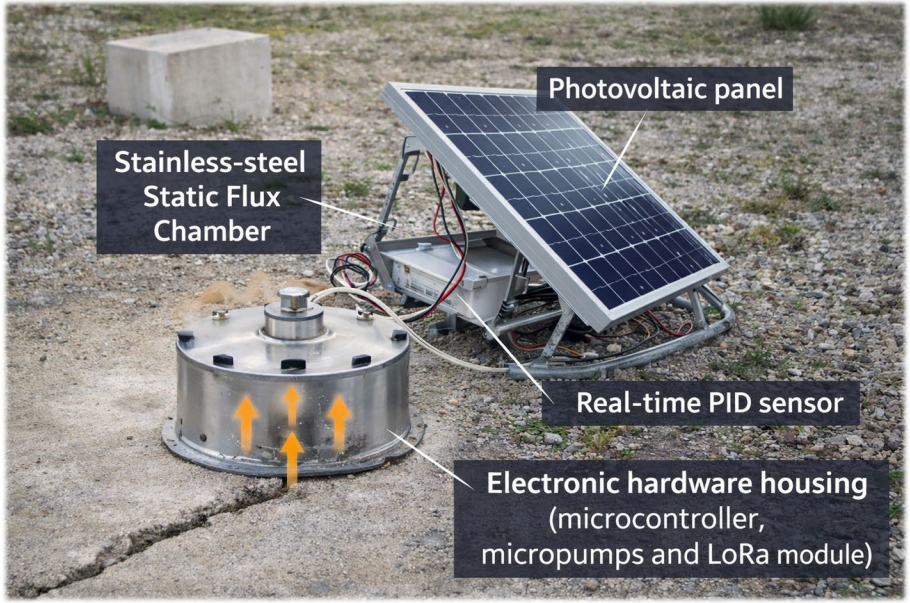
# Soil Testing







# Measuring Flux

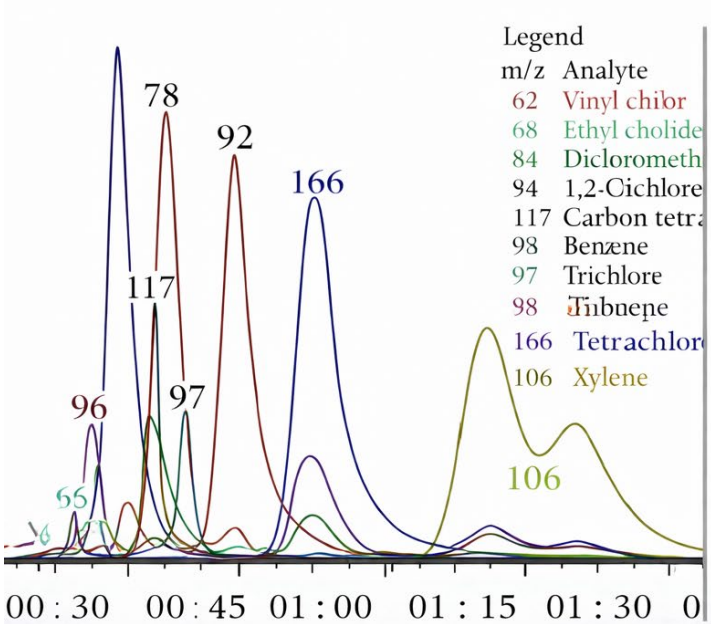



- Measures how much vapor is moving into a building
- Often done with a flux chamber placed on the ground or slab
- More direct than just measuring concentration
- Used in advanced investigations and research

# Testing Equipment



# Hapsite


Legend
m/z Analyte
62 Vinyl chlor
68 Ethyl cholide
84 Diclorometh
94 1,2-Cichlore
117 Carbon tetr
98 Benzene
97 Trichlore
98 Tribuene
166 Tetrachlor
106 Xylene
78
92
166
117
96
97
106
65
00 : 30
00 : 45
01 : 00
01 : 15
01 : 30



# Predictive Modeling

- Uses data to estimate future vapor intrusion risk

  Combines:
  - Groundwater data
  - Soil gas data
  - Building conditions
- Helps predict whether indoor air could be impacted
- Often used before testing inside a building

# Why Multiple Methods Matter

No Single Test Gives the Whole Answer

- Groundwater tells you the source
- Soil phase tells you contamination in the soil
- Soil gas tells you what vapors are present
- Indoor air tells you what people are breathing
- Flux and modeling help confirm the pathway



## Chemical sufficiently toxic if...

- Vapor concentration of the pure component in a soil source exceeds **10 times** the indoor air target risk level

***or***

- If in groundwater, saturated vapor concentration exceeds **1,000 times** the target indoor air risk level




## EPA recommends:

**Vapor Intrusion Screening Level Calculator (VISL)**

- Provides screening-level concentrations for groundwater, soil vapor, and indoor air for multiple risk levels

**It's Complicated**

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# How is VI mitigated?

# VI Mitigation is Similar to Radon

- Both often use sub-slab depressurization
- Both reduce entry of soil gas
- Most systems are active
- Fans, piping, and sealing may look familiar

# How VI Mitigation is Different

- Different chemicals
- Explosion concerns with methane
- Corrosion concerns
- Different exhaust placement requirements
- Possible need for treatment systems

# Commissioning Goals

VI Mitigation may have multiple goals:

- Reduce vapor entry
- Capture and remove contaminants
- Prevent explosion hazards (methane)
- Meet regulatory action levels
- Protect occupants based on building use

Design depends on:

- Chemicals of concern
- Toxicity and health risk
- Regulatory requirements
- Need for long-term monitoring or treatment

# Overview of Active and Passive Mitigation Strategies



- **Active mitigation strategies** involve the use of mechanical systems, such as sub-slab depressurization systems, to actively remove vapors from beneath buildings.



- **Passive mitigation strategies** include the installation of vapor barriers, ventilation systems, and passive soil venting systems to prevent vapors from entering buildings

## Design Principles of Vapor Barriers



- **Vapor barriers** are impermeable membranes installed beneath buildings to prevent the migration of vapors from the subsurface into indoor spaces.



- **Design considerations** include the selection of appropriate barrier materials, installation methods, and sealing techniques.

# Membranes and Vapor Barriers

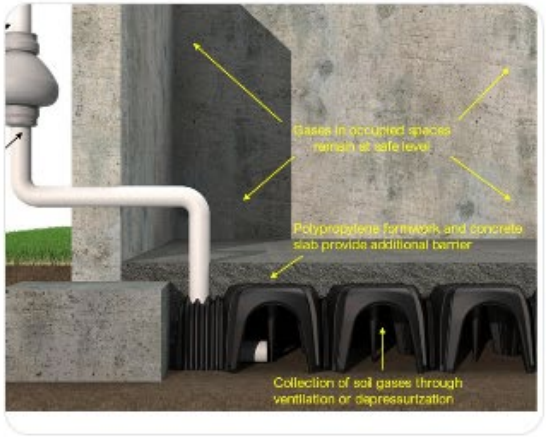






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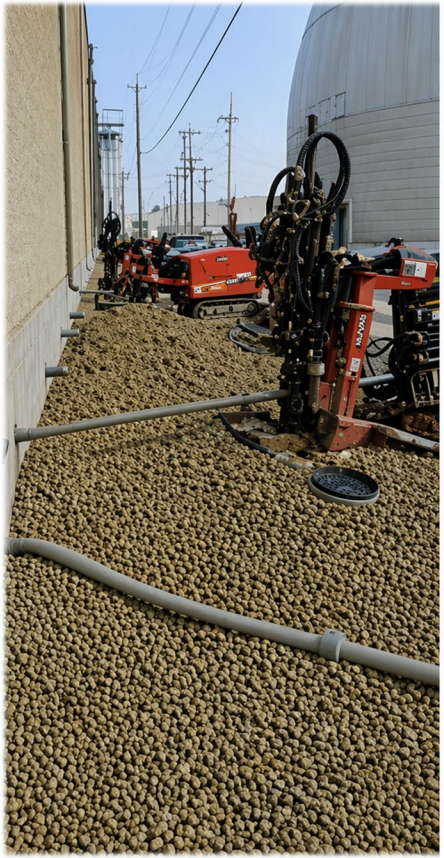
# Raised Floors/ Engineered Voids

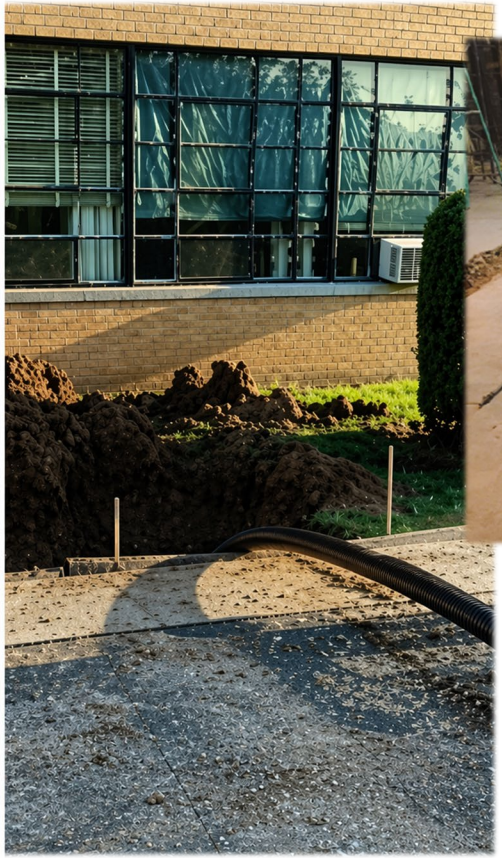












# Trenching and Horiztonal Boring




# Multiple Fans and Blowers

# Flammable or Explosive Gases or Vapors

- This consideration is specific to flammable or explosive gasses or vapors



More Dangerous

# Monitoring and Maintenance




- Common issues with mitigation systems may include fan failures, leaks in vapor barriers, and blockages in soil gas collection systems.
- Troubleshooting procedures involve identifying the root cause of the issue and implementing corrective actions to restore system functionality.

- Regulatory agencies may require periodic reporting of system performance data, maintenance activities, and any corrective actions taken.
- Documentation of mitigation system design, installation, and maintenance activities is essential for demonstrating compliance with regulatory requirements and ensuring accountability.

# SYSTEM MONITORING









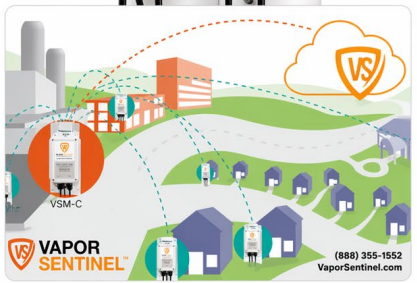



## Remote Monitors

- Vapor Sentinel is a sensor-equipped field device that remotely monitors Vapor Intrusion Mitigation (VIM) systems and triggers a notification when a system failure is detected.
- Transmits airflow, pressure (vacuum), power, and device temperature measurements continuously via cellular or WiFi communication networks.

- Remote Monitoring
- 24/7/365 Real-time Monitoring
- Secure Cloud-based Data Storage
- Customized reporting
- Efficient Installation
- Proprietary Patented Technology






## OM&M Manuals must include the essentials

- Date of installation
- Maintenance and monitoring instructions
- Contact information for service inquiries
- System description
- Operating instructions
- Stewardship instructions
- Historical information
- Checklists

# Contaminated Vapor

This consideration is specific to contaminated vapor exhausted from active soil depressurization (ASD) systems and evaluations after installation for compliance with federal, state or local requirements or guidance.



# Building on your radon expertise

# Why Additional Qualifications Matter



ESA companies



Environmental consultants



Industrial hygienists



Environmental engineers

## Skills that Transfer:

### Building science
Apply your understanding of building construction, air movement, and enclosure performance.

### Pressure field understanding
Use your knowledge of pressure differences and how they influence air and gas movement.

### SSD systems
Leverage your experience with sub-slab depressurization system principles and components.

### Communication with clients
Continue using your strong client communication and education skills to explain findings and solutions.

## Skills You Need to *Add:*

### VOC chemistry
Understand common VOCs, their sources, behavior, and potential health effects.

### Environmental regulations
Learn relevant environmental regulations, guidelines, and compliance requirements.

### Sampling methods
Learn soil gas, sub-slab, groundwater, and indoor air sampling techniques and protocols.

### Report interpretation
Develop skills to interpret laboratory results, compare to screening levels, and communicate findings.

+



# Takeaways

Radon and vapor intrusion share similar physics—
*but not the same investigation.*

Recognizing potential *VI sites* is valuable for every radon professional.

The future will reward professionals who understand *both.*




Your radon knowledge is the foundation.
*Keep building the future.*

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