

INTRODUCTION INTO VAPOR INTRUSION

2014

Michigan Environmental Compliance Conference

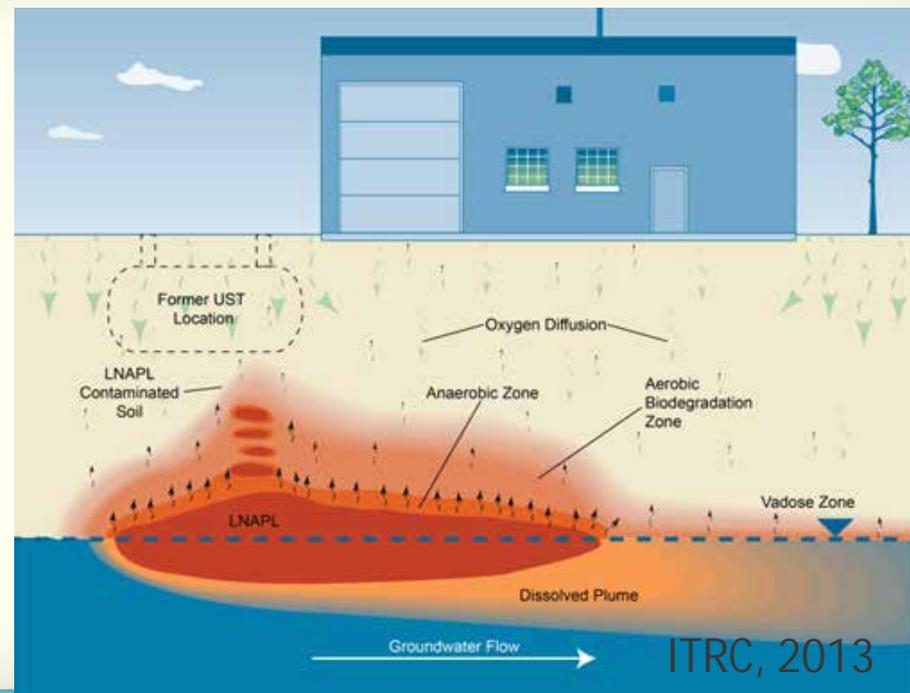
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June 10 - Livonia



Department of
Environmental Quality
PURE MICHIGAN



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Vapor Intrusion?



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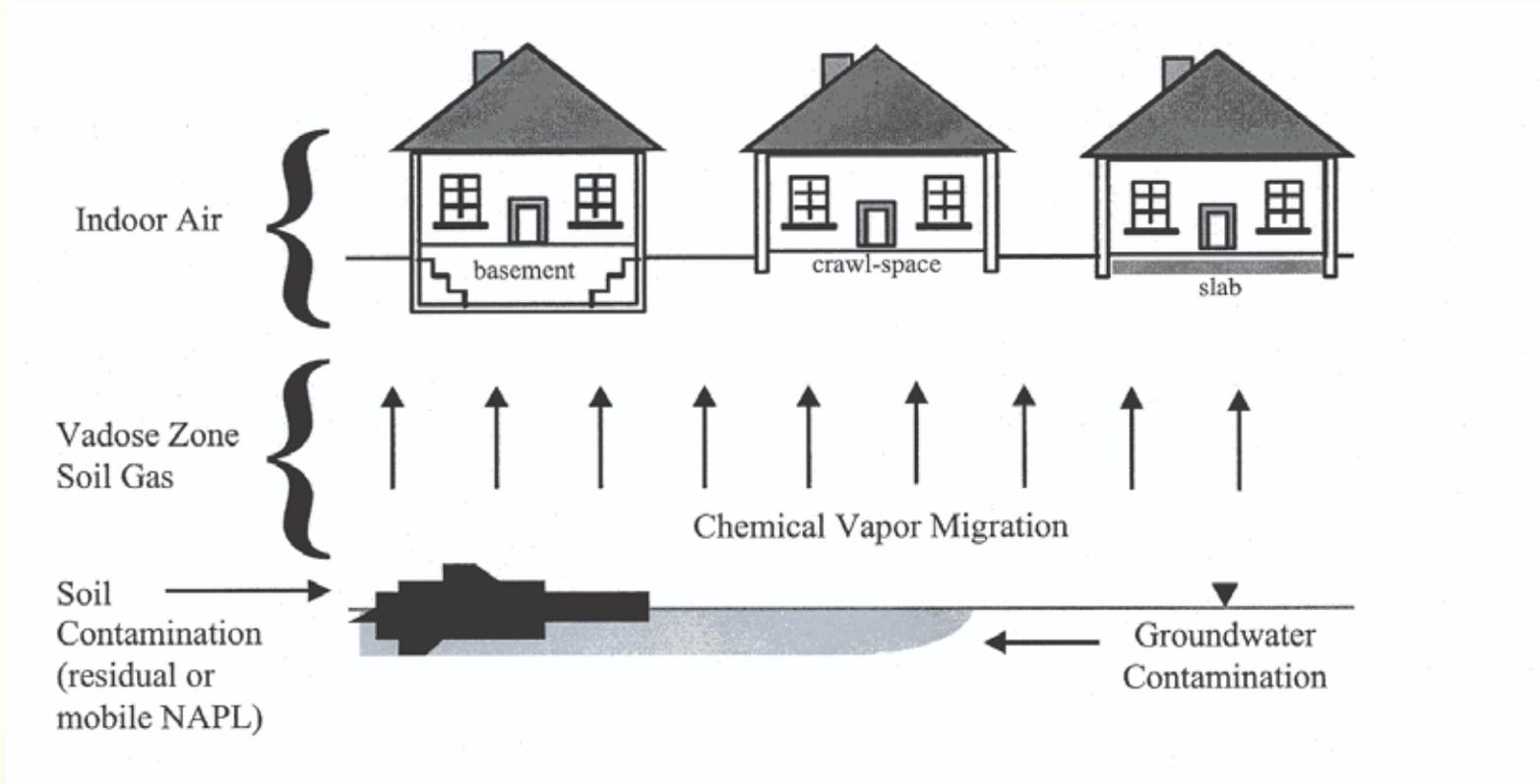
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Today

- What is Vapor Intrusion?
- How do you evaluate for it?
- How does it relate to indoor air?
- What do you compare it to?
- If you have an issue, how do you mitigate it?
- Where can I get further assistance?

What is Vapor Intrusion (VI)?



From: USEPA. November, 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA 530-D-02-004.

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What is the nature of VI?

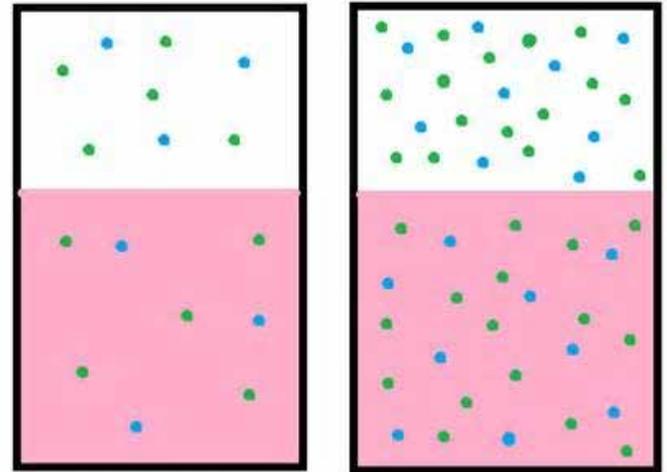
- Typically unavoidable and involuntary (inhalation)
- High “intake” rates lead to low acceptable levels
 - 20,000 L/day of air compared to 2 L/day of water
- Typically below odor thresholds
 - Benzene – 1,000x less
 - TCE – 2,500x less
- Low concentrations in soil and groundwater may pose a risk

What compounds?

- Hydrocarbons
 - Petroleum Hydrocarbons (BTEX, TMBs)
 - Chlorinated HCs (TCE, TCA, PCE, VC)
- Semi-volatiles:
 - Naphthalene and PAHs
- PCBs and some pesticides
- Others. . .

What compounds (cont)?

- Michigan – defined under Part 201
 - Hazardous substances with a Henry's Law Constant equal to or greater than $0.00001 \text{ atm}\cdot\text{m}^3/\text{mol}$ at standard temperature and pressure.
- Henry's Law
 - At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid



What type of facilities?

- Chlorinated Hydrocarbons (VOCs)
 - Chemical Manufacturers
 - Solvent recyclers
 - Vapor Degreasers
 - Foundries
 - Dry Cleaners



What type of facilities (cont)?

- Semi-volatiles (SVOCs)
 - MGP Sites (PAHs)
 - Electrical Power (PCBs)
- Petroleum hydrocarbons
 - Service Stations (LUSTs)
 - Petrochemical facilities
 - Refineries
 - Pipelines

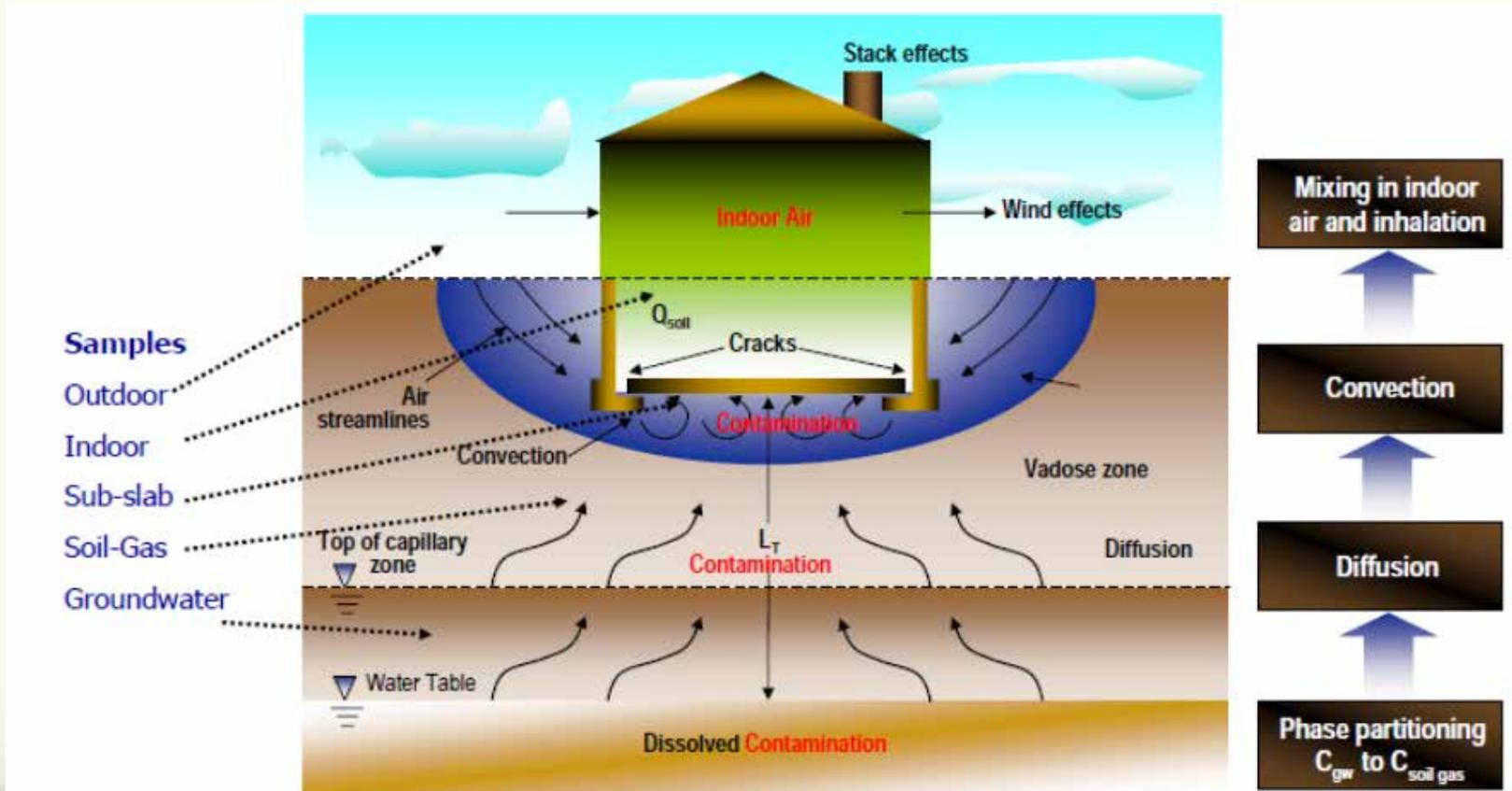


Root of the Problem

- How do you evaluate for it?
 - Sample
 - Attenuation factors
 - Empirical derived
 - Modeled
 - What do you compare it to?

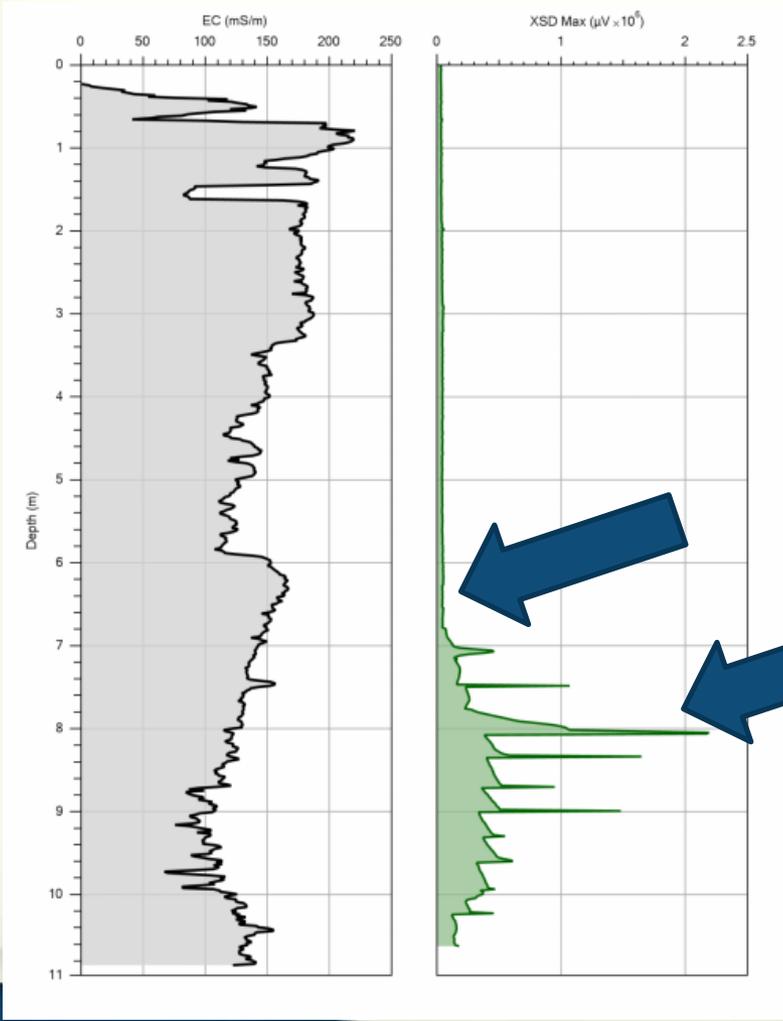


How do you evaluate for it?



Soil

- Not a good predictor
- Where the sample is collected matters



Soil (cont)

- PROs
 - Commonly collected during the course of an investigation
 - Sampling methodology is well accepted



- CONs
 - May not accurately represent vapor concentrations when sources are present adjacent to collected sample
 - VOC loss on sampling may be significant



Groundwater

- PROs
 - Commonly collected during the course of an investigation
 - Can be performed at properties having no existing buildings



- CONs
 - May not accurately represent vapor concentrations when sources are present in the vadose zone
 - Modeled indoor air concentration

Soil Gas

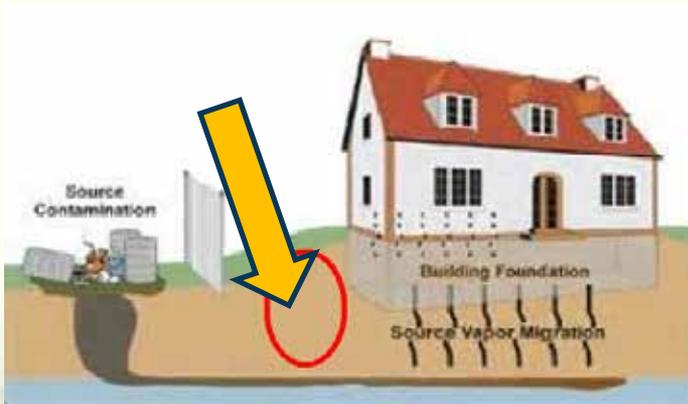
- PROs

- Can provide an estimate of vapor concentrations near the source or near buildings
- Can be performed without entering the structure



- CONS

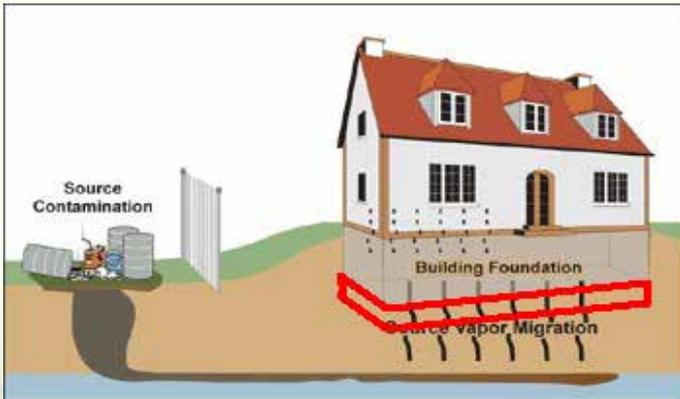
- Results may not be representative of vapor concentrations under a building
- May not reflect how soil gas concentrations will change if a building is subsequently built on a currently vacant property



Subslab Soil Gas

- PROs

- Can provide measure of vapor concentration directly below indoor air space
- Closest subsurface sample to receptors



- CONs

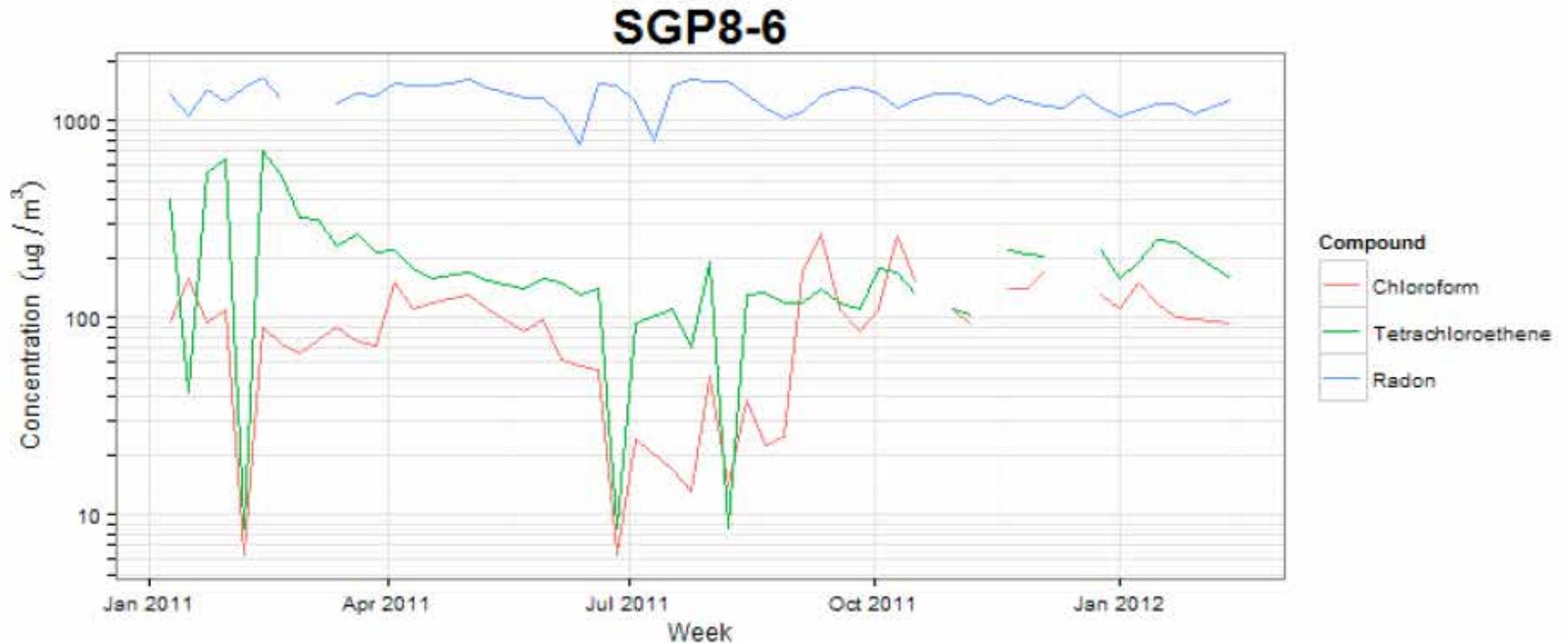
- Method is intrusive
- Cannot be performed at properties having no existing buildings

Why not indoor air?

- Highly variable
 - Seasonal
- TWA vs. grab
- Expensive
 - Relocation
 - Prep/post
- Expect indoor air concentrations



Variability of Indoor Air



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EPA 2011 Indoor Air



VOCs in Background Indoor Air
(Reporting Limits in $\mu\text{g}/\text{m}^3$)

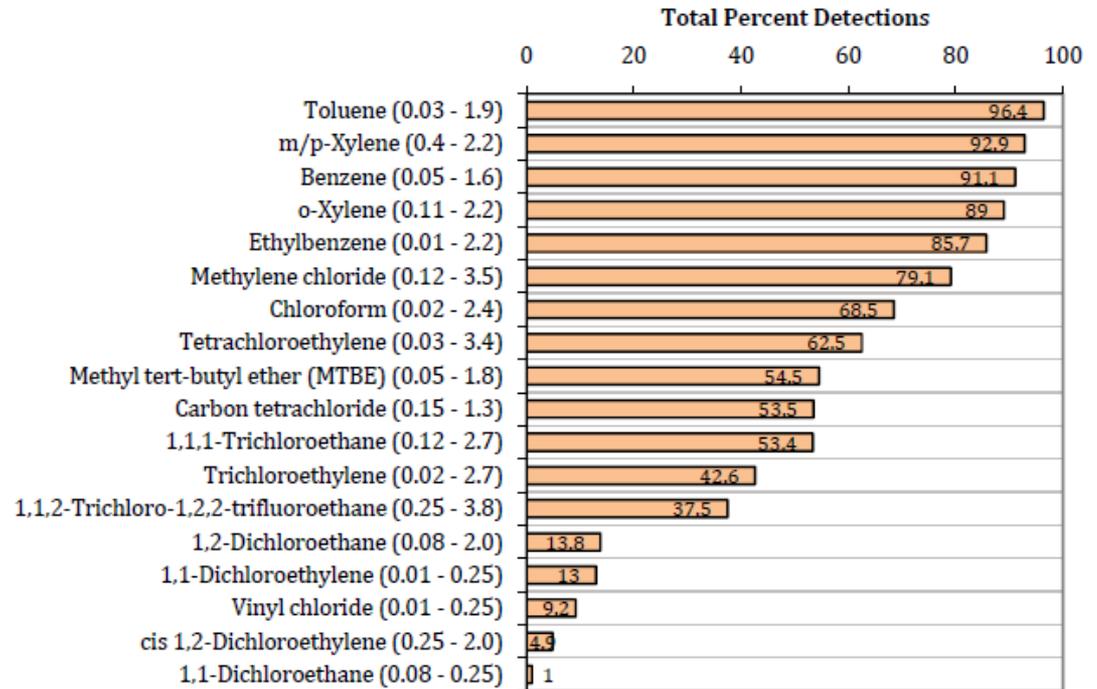


Figure 4. Total percent detections of common VOCs in background indoor air compiled from 15 studies conducted between 1990 and 2005. Range of reporting limits is shown in parentheses.

Some are easy to figure out. . .



PCE > 95% by weight

Can also include:

- TCE
- Toluene
- Acetone
- More. . .



Can include:

- TCE
- Toluene
- Acetone
- More. . .



- PCE

Some aren't



Contains:

- Naphthalene (31 mg/m^3)
- 1,4 Dioxane (2,100 mg/m^3)
- Toluene (120 mg/m^3)
- Ethanol (600,000 mg/m^3)
- And a bunch of others . . .



Contains:

- TCE
- PCE (up to 95% by weight)



Contains:

- Ethylbenzene (3,400 mg/m^3)
- Toluene (660 mg/m^3)
- TPH (390,000 mg/m^3)
- And more . . .



1,2 DCA

Grilling with flavor. . .



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Indoor Air

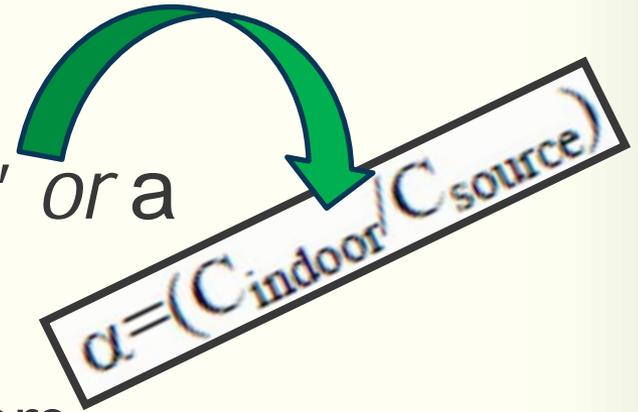
- PROs
 - Can provide direct measurement of indoor air concentrations



- CONs
 - Method is intrusive
 - Indoor contaminants and lifestyle sources may bias the data
 - Varies significantly over time
 - Cannot be performed at properties having no existing buildings

Estimating indoor air concentrations

- Commonly referred to as the:
 “attenuation factor” or a
- Can be difficult to predict
 - influenced by a number of factors
 - soil properties and contaminant characteristics
 - building design and condition
 - seasonal effects
 - biodegradation
 - more . . .


$$\alpha = (C_{\text{indoor}} / C_{\text{source}})$$

Modeling

- Johnson and Ettinger (1991)

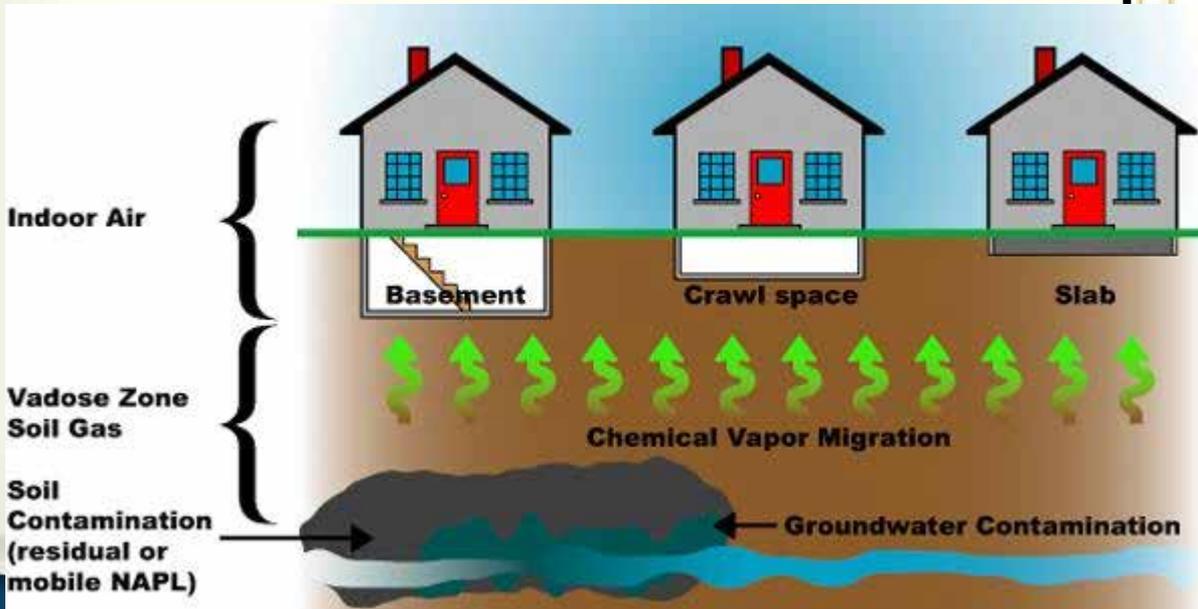
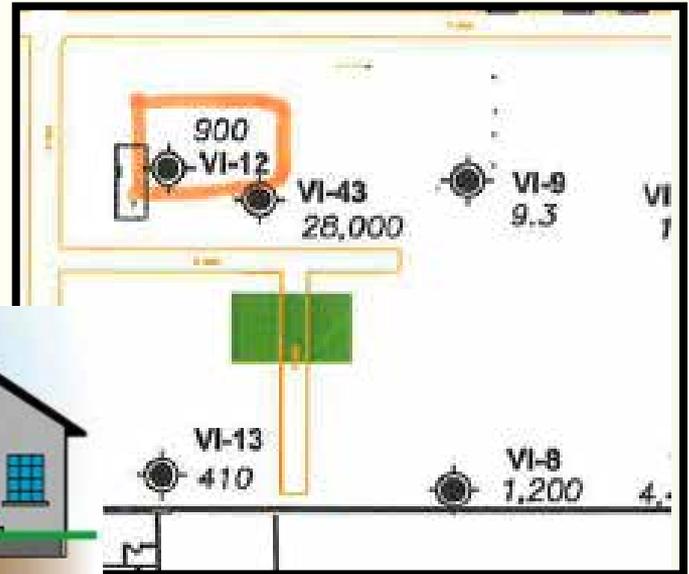
$$\alpha = (C_{\text{indoor}} / C_{\text{source}})$$


$$\alpha = \frac{\left[\left(\frac{D_T^{\text{eff}} A_B}{Q_{\text{building}} L_T} \right) \times \exp \left(\frac{Q_{\text{soil}} L_{\text{crack}}}{D^{\text{crack}} A_{\text{crack}}} \right) \right]}{\left[\exp \left(\frac{Q_{\text{soil}} L_{\text{crack}}}{D^{\text{crack}} A_{\text{crack}}} \right) + \left(\frac{D_T^{\text{eff}} A_B}{Q_{\text{building}} L_T} \right) + \left(\frac{D_T^{\text{eff}} A_B}{Q_{\text{soil}} L_T} \right) \left[\exp \left(\frac{Q_{\text{soil}} L_{\text{crack}}}{D^{\text{crack}} A_{\text{crack}}} \right) - 1 \right] \right]}$$

*Johnson, P. C, and R. A. Ettinger. 1991. Heuristic model for predicting the intrusion rate of contaminant vapors in buildings. Environ. Sci. Technol. 25: 1445-1452

Location, Location, Location

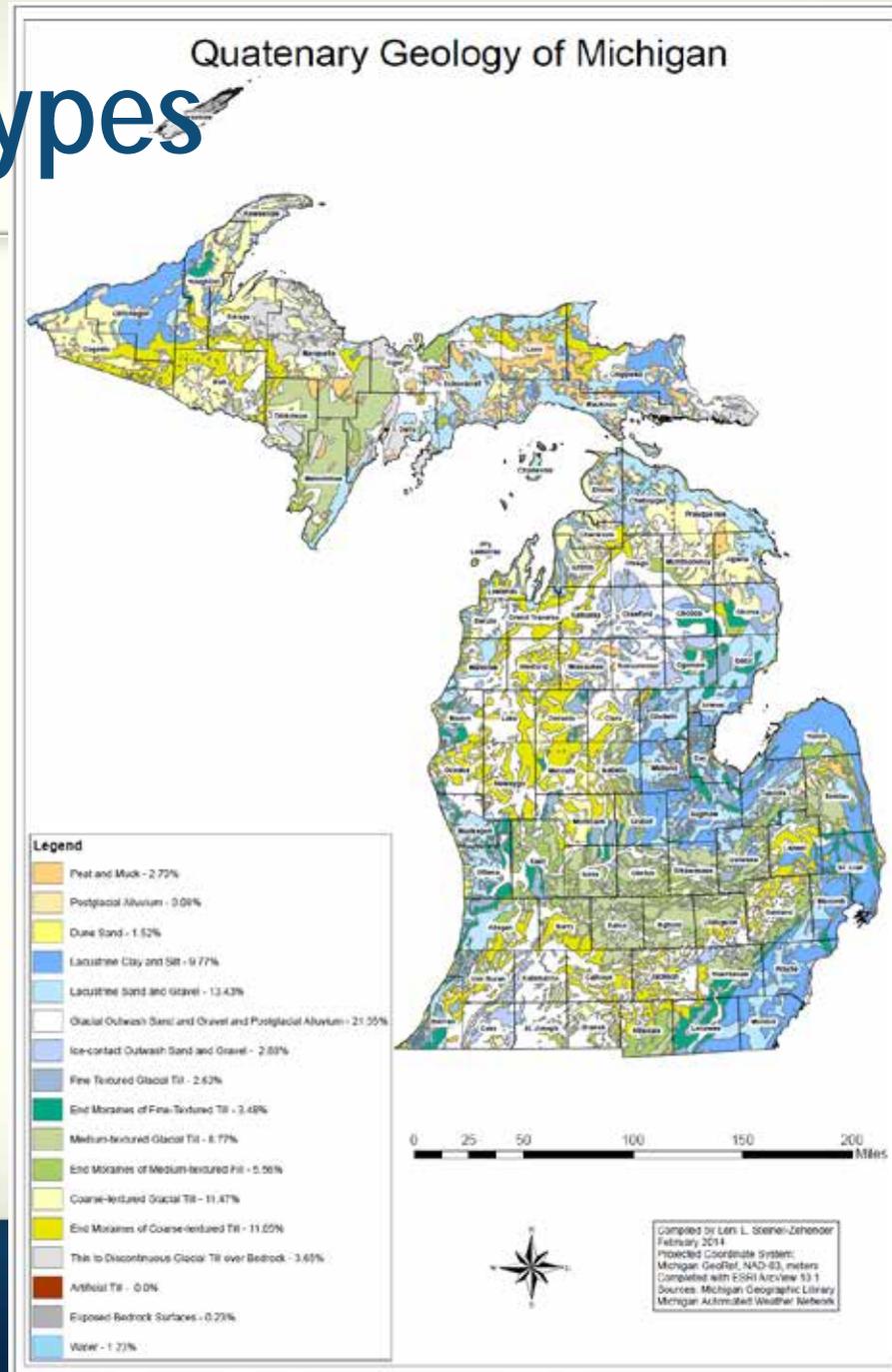
- Distance from source
- Accuracy of RECs/CSM



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Soil Types

- Sand – 39.4%
- Loam – 36.7%
- Clay – 15.9%
- Other – 8.0%



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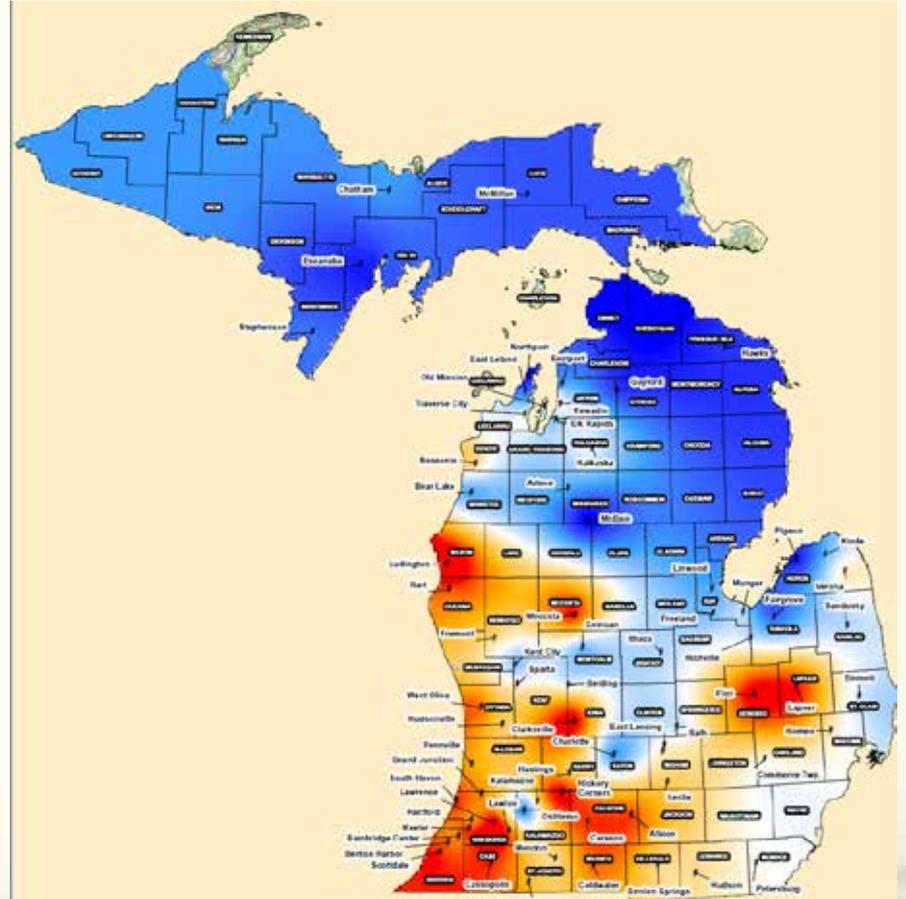
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System Temperature

- Assign temp based on identified county average
 - Data based on 72 Stations
 - Daily average
 - Up to 15 years of data



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Other inputs. . . possible

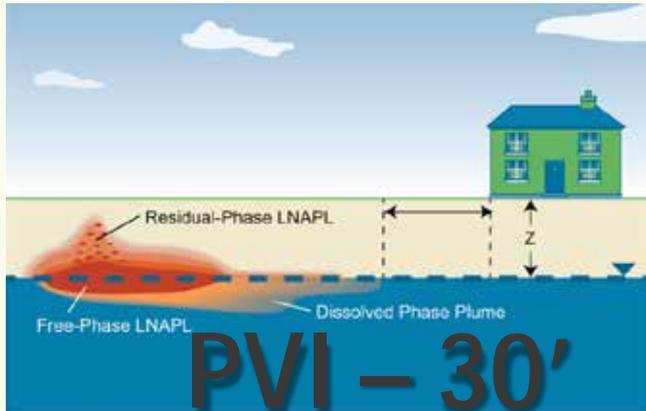
- Actual soil properties
 - bulk density
 - total porosity
 - water filled porosity
 - soil water content
 - grain size
 - fraction of organic carbon
- Building parameters
 - air exchange rate
 - building construction
- More. . .



When to Worry About VI?

- Structures with odors, wet basements
- Sites with contaminants
- Complaining occupants
- Property transactions. . .

When to worry about VI (cont)



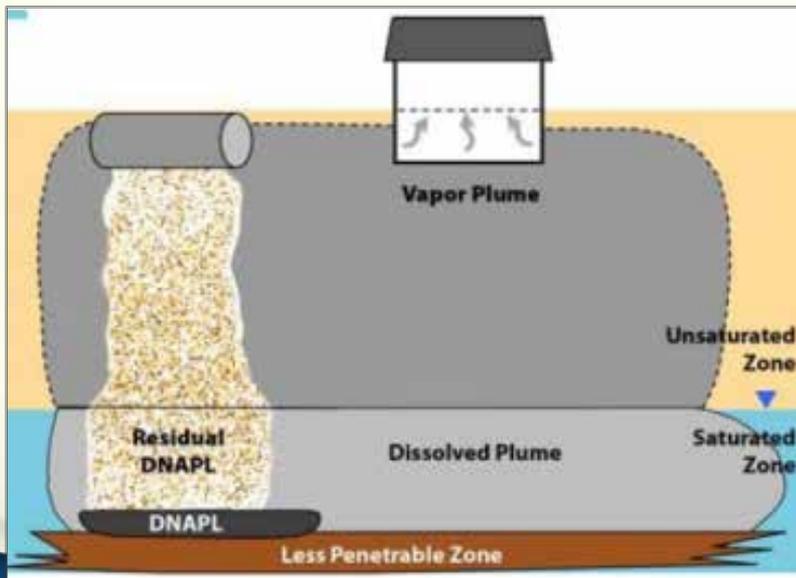
- Preliminary Screening Distances



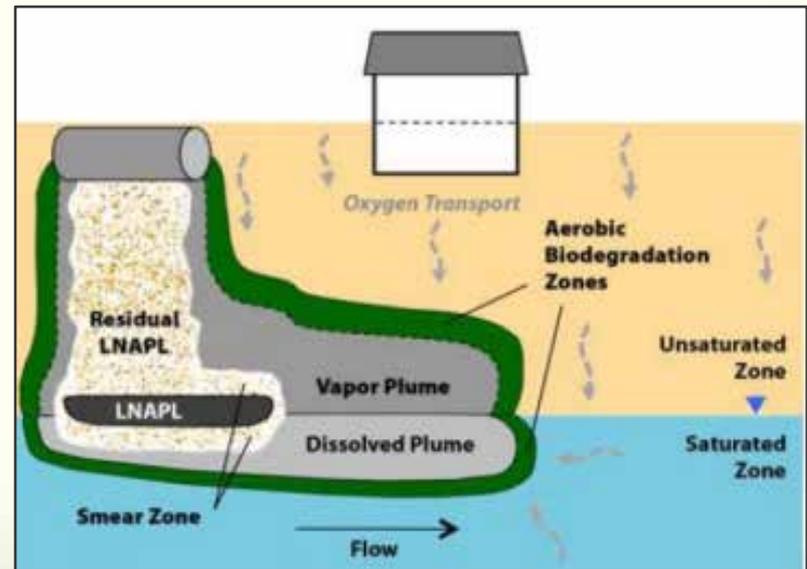
Biodegradation of PHCs

There are differences between PHCs and CHCs that influence whether and how vapors migrate into buildings.

CHC



PHC



What do you compare it to?

- Things to consider:
 - Residential or nonresidential
 - Duration
 - Sensitive population
- MIOSHA

MIOSHA



- Part 201 allows the use MIOSHA if:
 - Facility is covered by the classifications provided by NAICS Sector 31-33 - Manufacturing;
 - Person complies with the specified provisions of MIOSHA; and
 - Air monitoring and hazard communication program account for all hazardous substances of concern



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Why not MIOSHA?



- Not designed for the “non-worker”
- Often requires awareness training, PPE, and/or medical monitoring
 - *“Simply complying with OSHA’s antiquated PELs will not guarantee that workers will be safe.”* - David Michaels - Assistant Secretary of Labor for Occupational Safety and Health



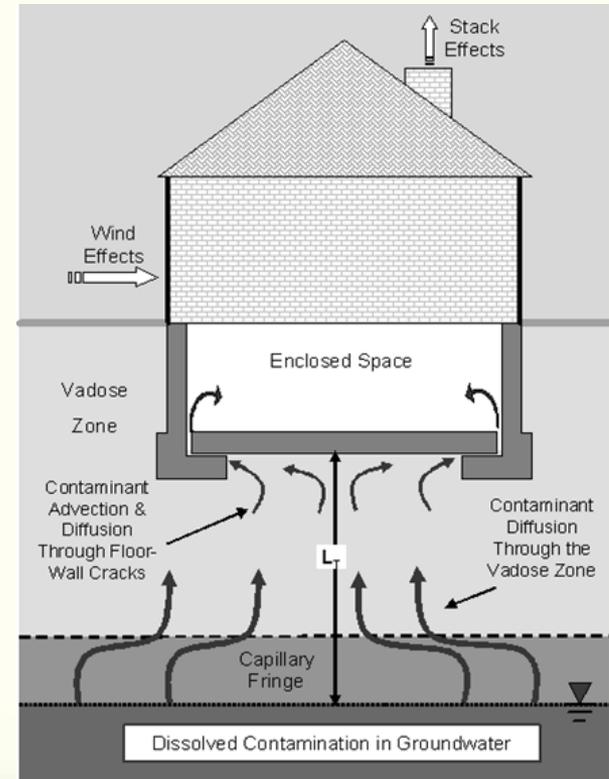
Response Actions

- Remediation
 - Source Area
 - Mitigation
- Building Controls
- Institutional Controls



Before you rush. . .

- Multiple Lines of Evidence
 - Soil gas spatial concentrations
 - Groundwater spatial data
 - Building construction
 - Sub-slab soil gas data
 - Indoor air data
 - Soil stratigraphy
 - Temporal patterns



Response Actions

Source Removal



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Response Actions

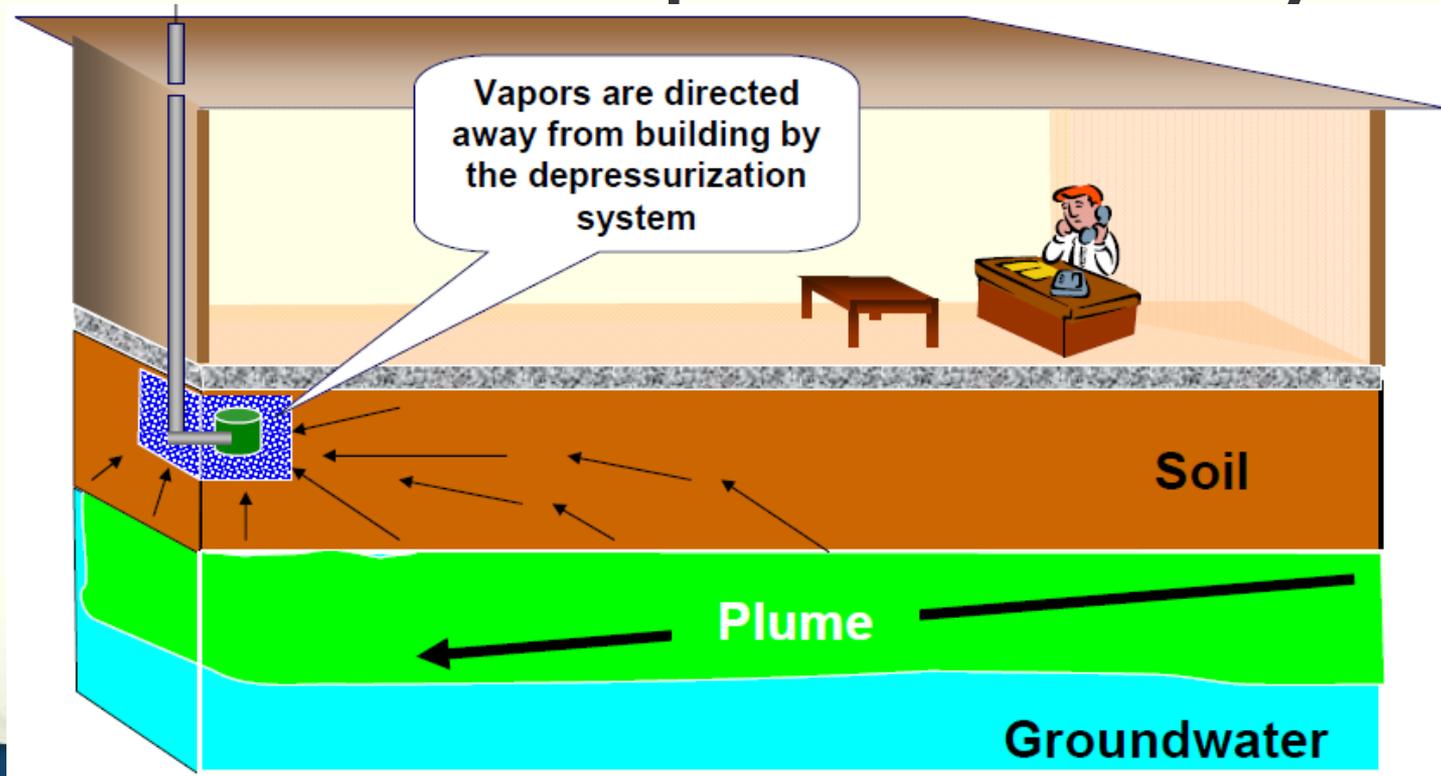
Mitigation

- Sub-Slab Depressurization System
- Sub-Membrane Depressurization System
- Passive Barrier System

Response Actions

Mitigation

Active/Sub Slab Depressurization System



Response Actions

Mitigation

Active/Sub Slab Depressurization System



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Response Actions

Mitigation

Sub Membrane Depressurization System



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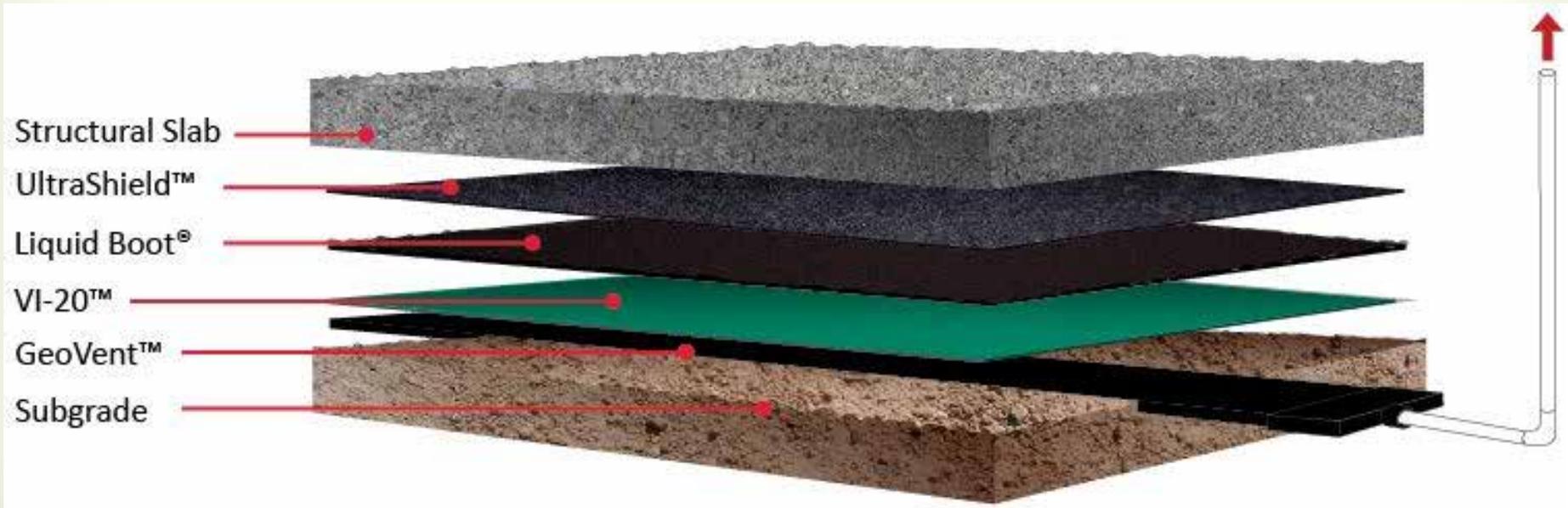
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Response Actions Mitigation

Passive Liner and Venting System



Response Actions

Mitigation



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Response Actions

Mitigation



Liner

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Response Actions Mitigation



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Response Actions Mitigation



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Response Actions

Building Controls



- Sealing leaks
- Building pressurization using HVAC
- Indoor air cleaners



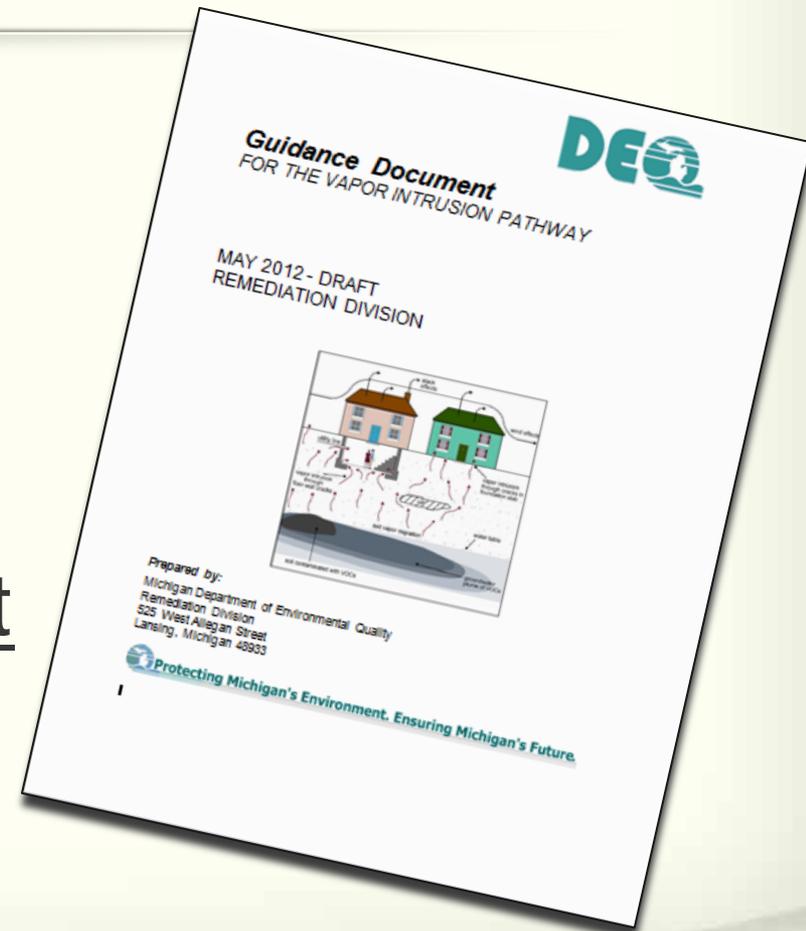
Response Actions

Institutional Controls

- Requiring building controls
 - Now and/or in the future
- Controlling the type of property use
- Controlling what can be built and where

DEQ Vapor Intrusion Guidance

- Released in May 2012
- Includes recommended approaches, SOPs, checklists, & more
- Guidance document is not a statutory requirement



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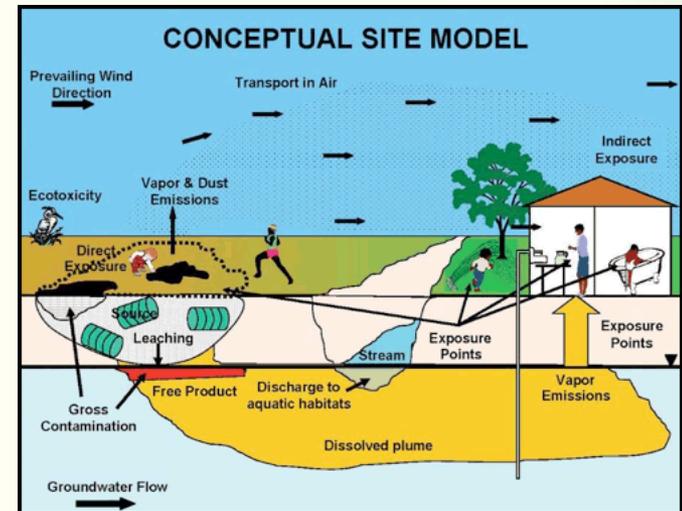
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Other. . . US EPA

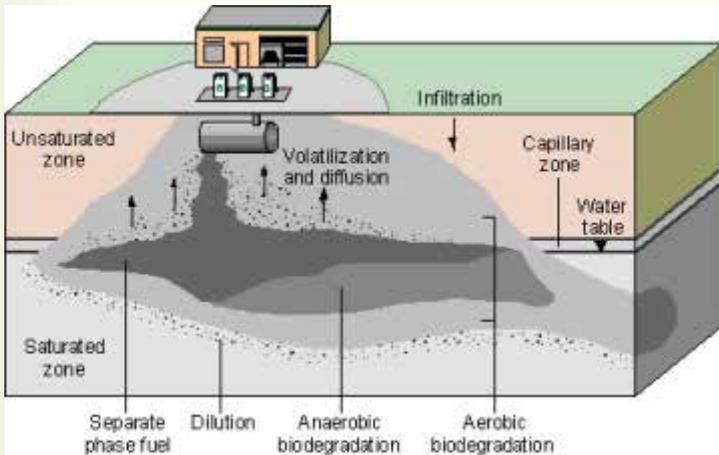
- Chlorinated Volatile Organic Compounds
 - Attenuation factors
 - Conceptual model scenarios
 - Superfund VI FAQs
 - Fact sheet on mitigation



<http://www.epa.gov/oswer/vaporintrusion/guidance.html>

Other. . . US EPA (cont)

- Petroleum Hydrocarbons



- Petroleum Hydrocarbons And Chlorinated Hydrocarbons Differences
- Evaluation Of Empirical Data To Support Soil VI Screening Criteria

<http://www.epa.gov/oust/cat/pvi/>

Other . . . ITRC

- Vapor Intrusion Pathway: A Practical Guideline
 - Reviewing soil gas data
 - Toolbox of investigative methods
 - Quality assurance considerations
 - Indoor air surveys including a form
 - More
- Vapor Intrusion Issues at Brownfield Sites
- PVI – Coming soon!

<http://www.itrcweb.org>

DEQ Assistance for VI is available!

- Redevelopment

- Grants and loans

Carrie L. Geyer, P.E.

Chief, Brownfield Redevelopment Unit

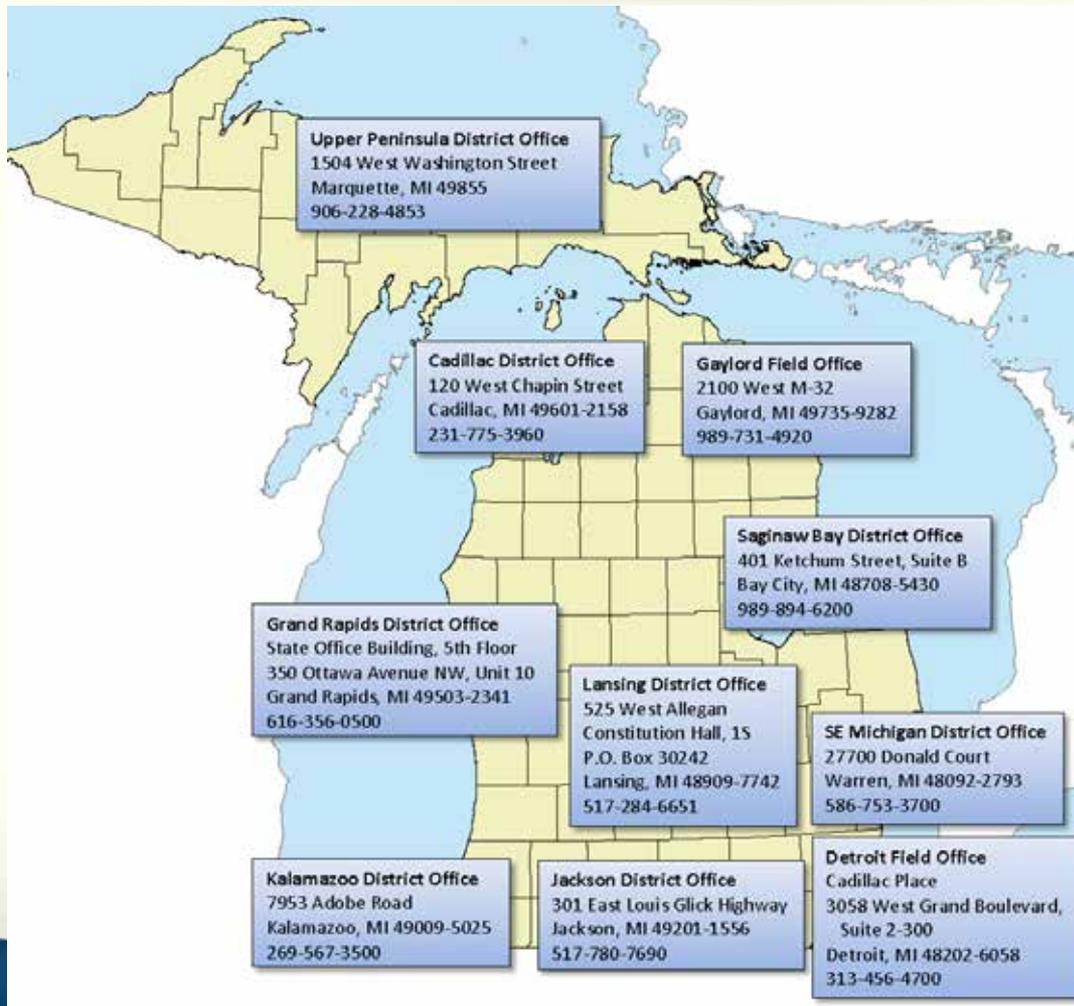
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RRD Points of Contact



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THANKS FOR LISTENING!

Questions?



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