Vapor Intrusion Pathway: A Practical Guideline

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New Jersey Dept. of Environmental Protection

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WWW.ITRCWEB.ORG

ITRC – Shaping the Future of Regulatory Acceptance

- Host organization
- Network
  - State regulators
    - All 50 states and DC
  - Federal partners

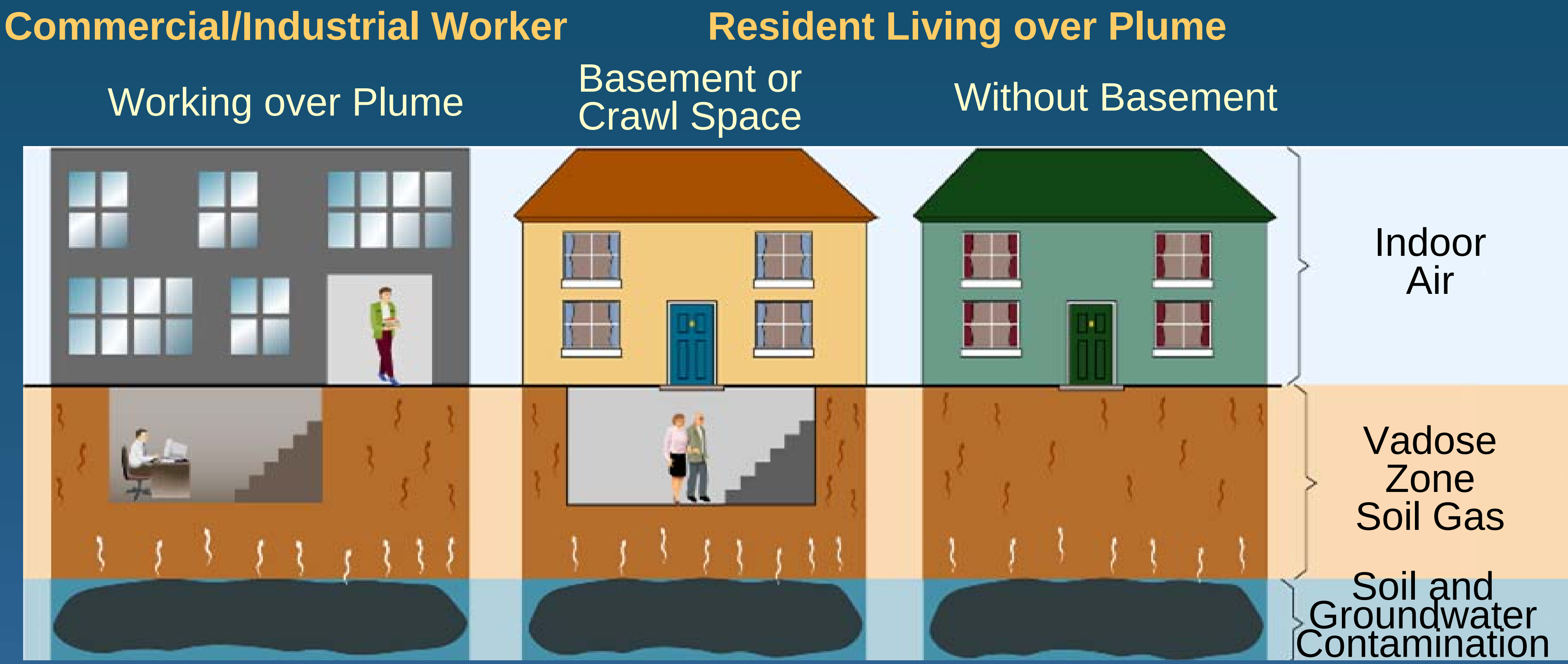
DOE DOD EPA

  - ITRC Industry Affiliates Program
  - Academia
  - Community stakeholders

- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Documents
    - Technical and regulatory guidance documents
    - Technology overviews
    - Case studies
  - Training
    - Internet-based
    - Classroom

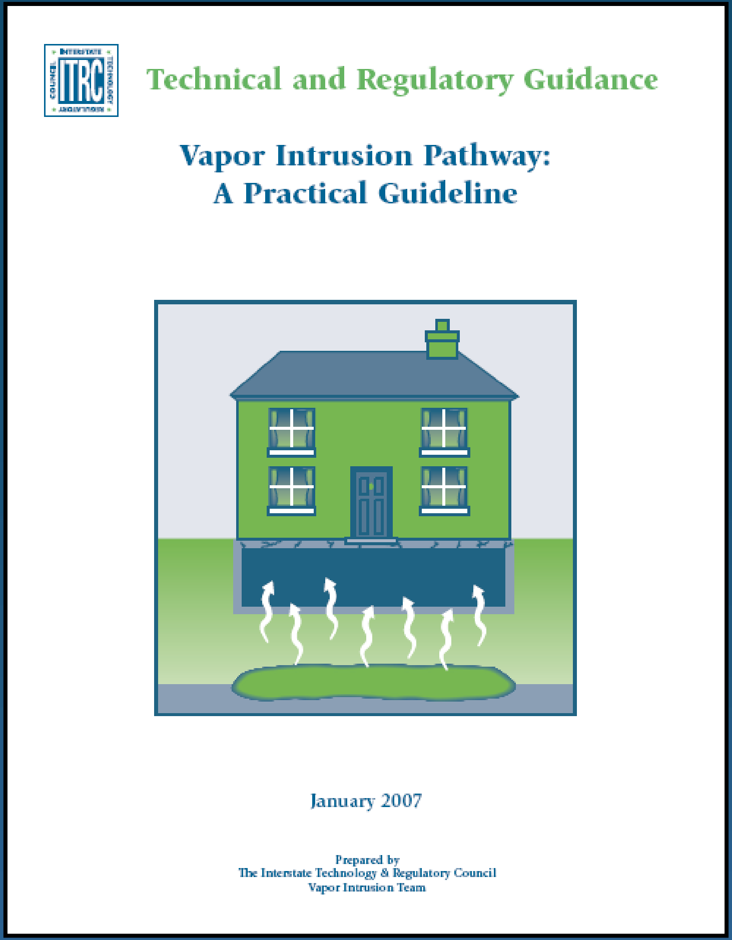
Vapor Intrusion

The migration of volatile chemicals from the subsurface into overlying buildings (USEPA 2002a)



ITRC Vapor Intrusion Pathway: A Practical Guideline

- Key vapor intrusion issues
  - Investigative strategies
  - Phased, iterative process
  - Background contamination
  - The "toolbox"
  - Conceptual site model
  - Future land use
  - Remediation technologies
  - Closure strategies
  - Qualified consultants



Technical and Regulatory Guidance

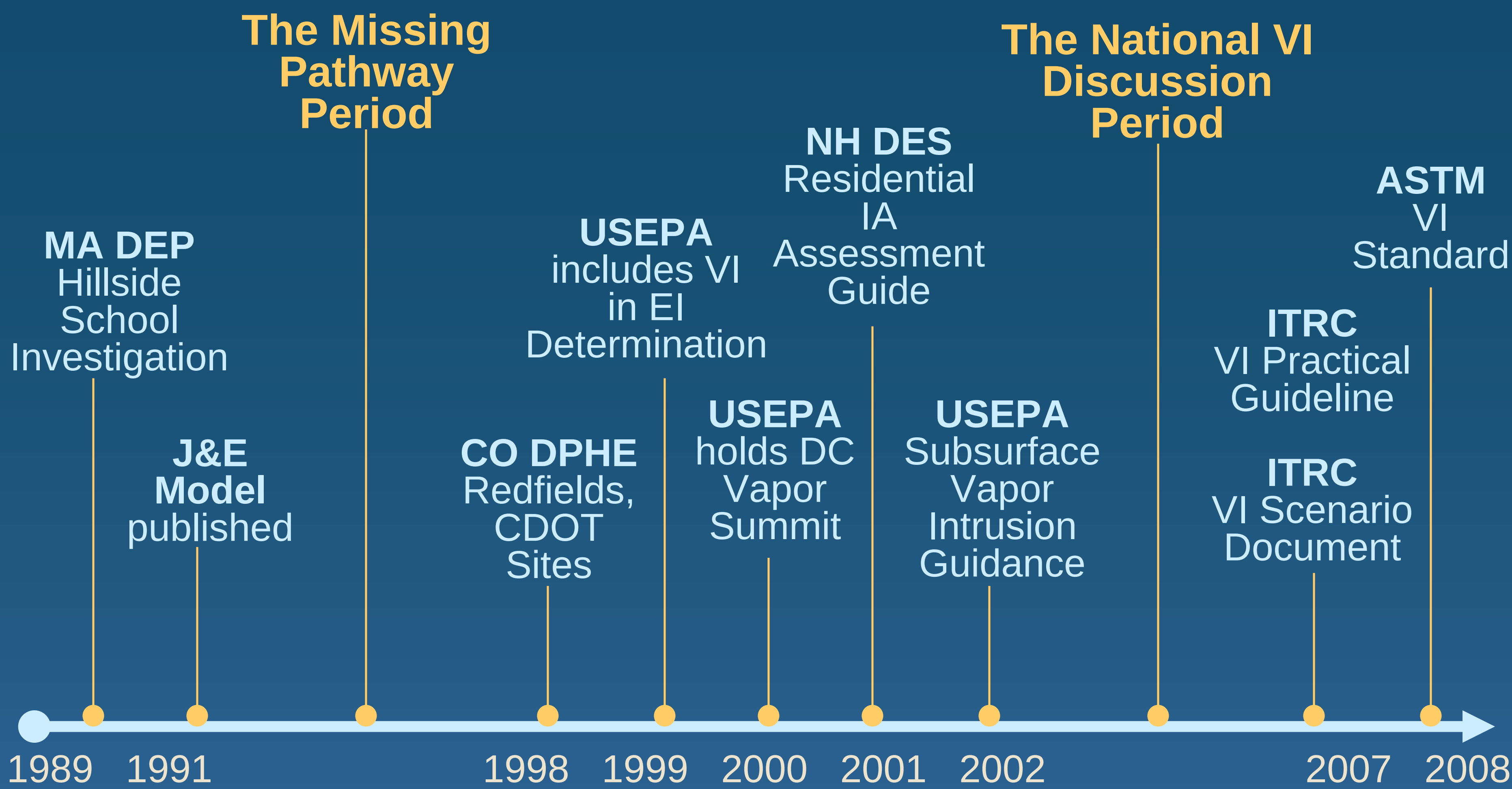
Vapor Intrusion Pathway:
A Practical Guideline

January 2007

Prepared by
The Interstate Technology & Regulatory Council
Vapor Intrusion Team

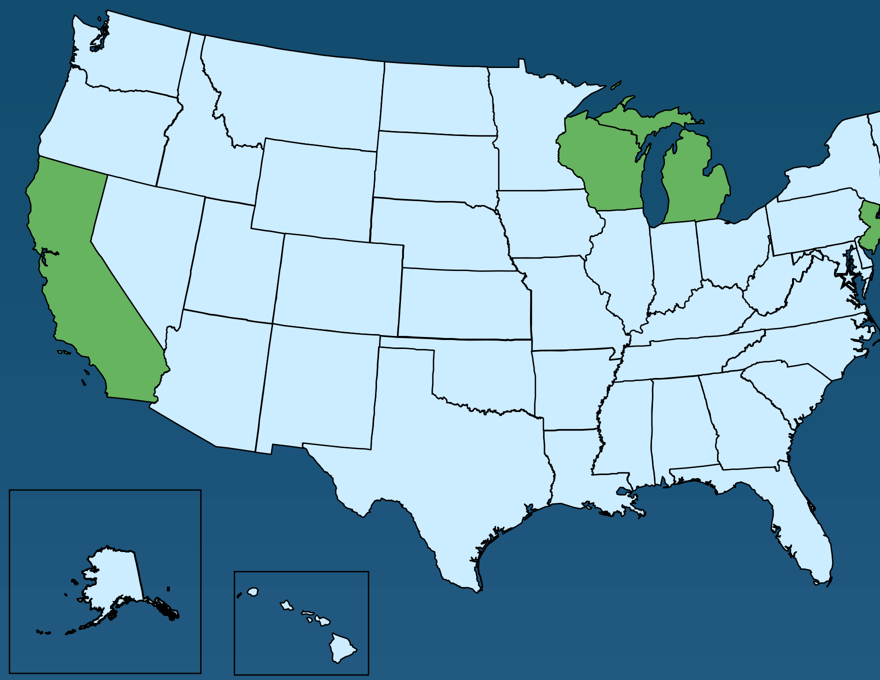
http://www.itrcweb.org/VaporIntrusion

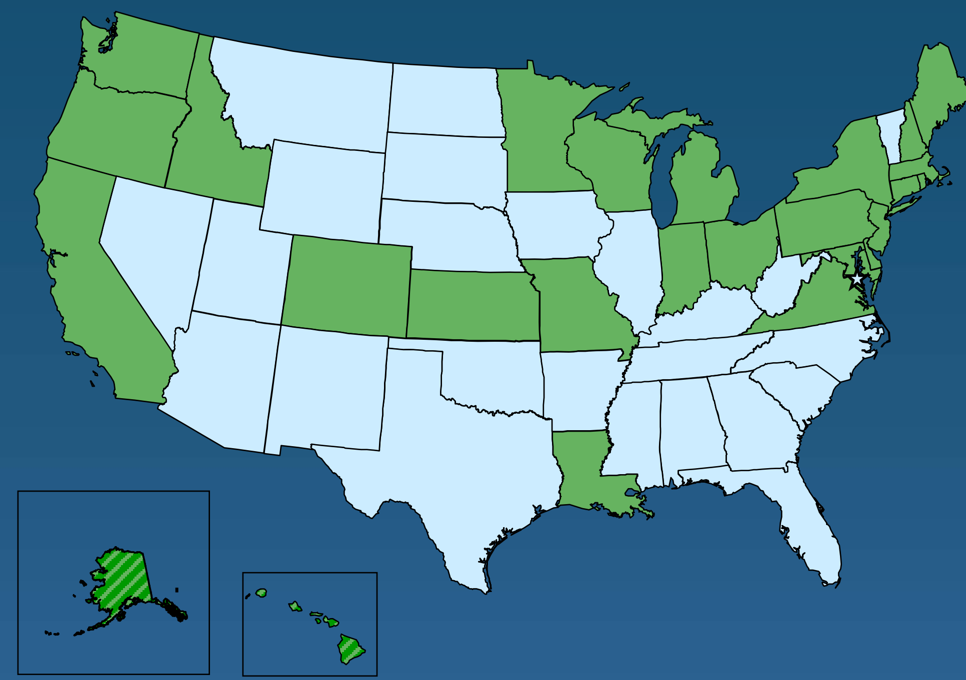
Historical Perspective



VI Regulatory State Guidance

States with Regulatory VI Guidance in 2004





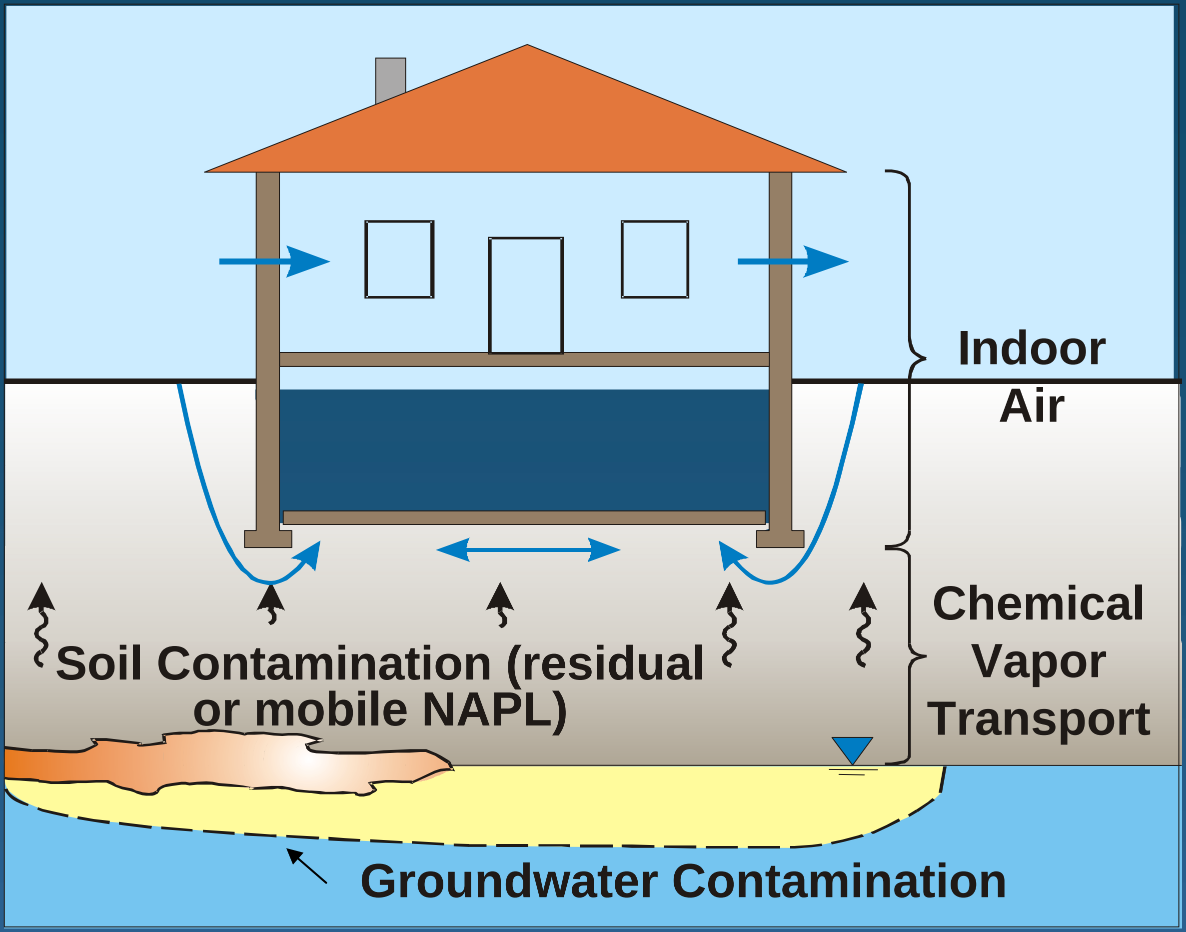
States with Regulatory Guidance in 2009

Interdisciplinary Challenge

- Risk assessor
- Mechanical engineer
- Community relations coordinator
- Industrial hygienist
- Environmental scientist
- Soil scientist
- Hydrogeologist
- Analytical chemist
- Legal professional
- Real estate agents
- Banks
- Insurance agents

Sources of Vapor Intrusion

- Soil contamination
- NAPL (nonaqueous phase liquid)
- Groundwater plumes
- Vapor Cloud

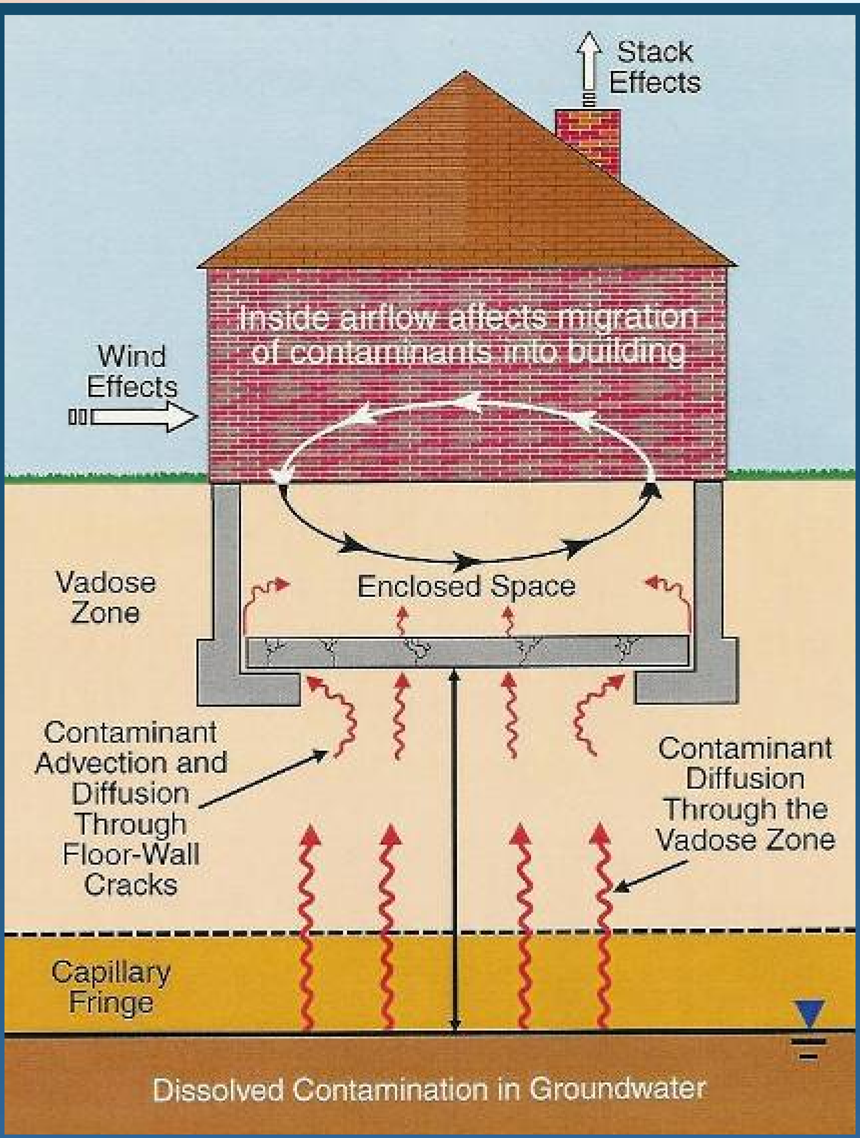


Courtesy: Ian Hers, Golder Associates

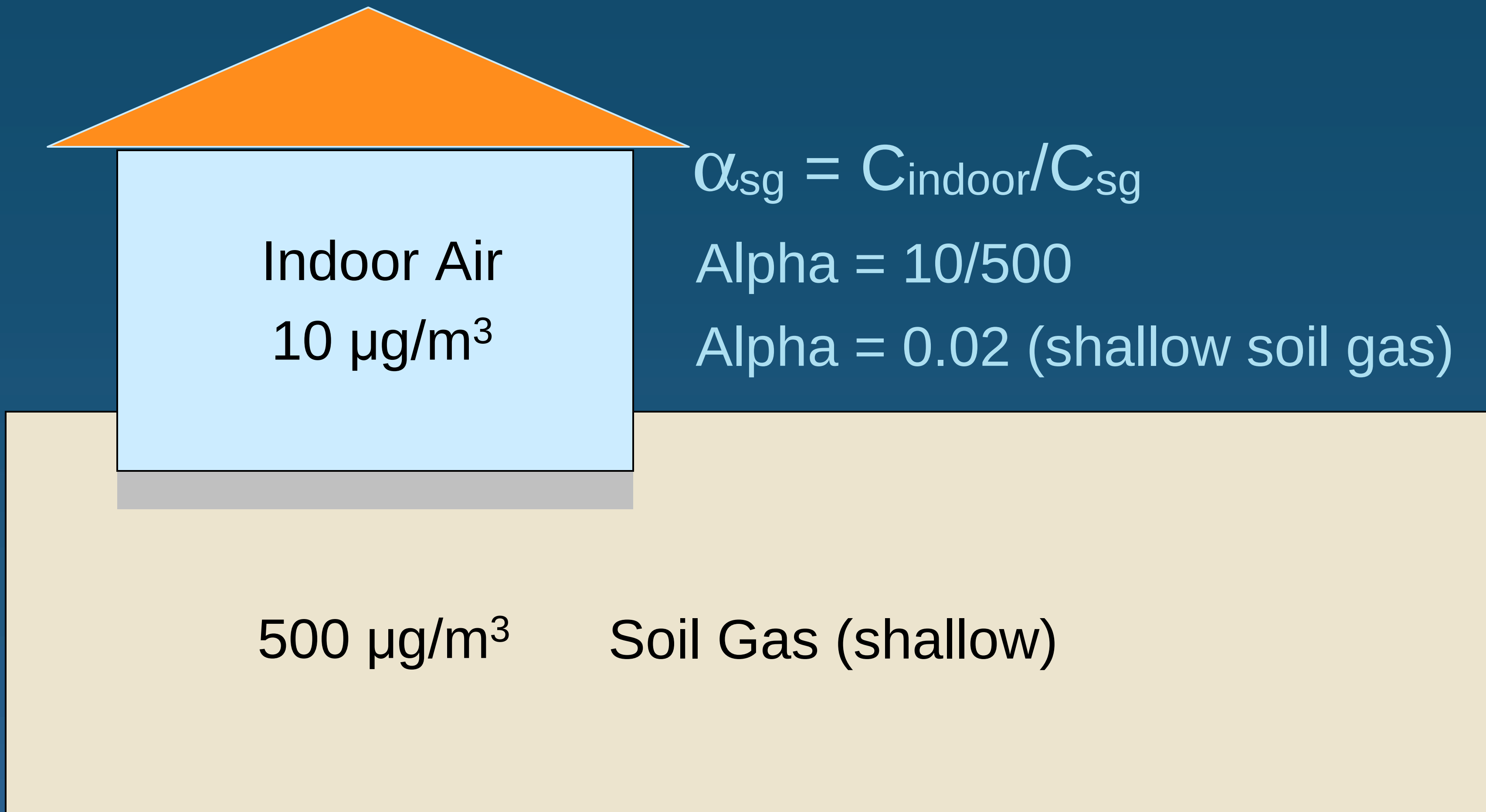
Vapor Pathway into Structures

Pathway

- Partitioning to vapor phase
- Diffusion in vadose zone
- Advection near building
- Dilution in building



Attenuation Factor Concept



$\alpha_{sg} = C_{indoor}/C_{sg}$

Alpha = 10/500

Alpha = 0.02 (shallow soil gas)

Understanding Units

Soil Gas Unit Comparison		
Units	Convert to	Multiply by
µG/L	mg/m^3	1
$\mu g/m^3$	mg/m^3	0.001
ppbv	$\mu g/m^3$	MW/24
$\mu g/m^3$	ppbv	24/MW
ppmv	mg/m^3	MW/24
ppbv	mg/m^3	MW/24,000
µg/L	$\mu g/m^3$	1000
$\mu g/m^3$	µg/L	0.001
µg/L	ppbv	24,000/MW
µg/L	ppmv	24/MW
ppbv	ppmv	0.001
ppmv	ppbv	1000

MW - molecular weight
mg/m^3 - milligrams per cubic meter
$\mu g/m^3$ - micrograms per cubic meter
µg/L - micrograms per liter
ppbv - parts per billion by volume
ppmv - parts per million by volume

Converting Analytical Results

$$\text{ppbv} = (\mu g/m^3 \times 24.45) / \text{MW}$$

$$\mu g/m^3 = (\text{ppbv} \times \text{MW}) / 24.45$$

MW - Molecular weight of the compound
Formulas are chemical-specific

Preferential Pathway

- What are preferential pathways, and when are they significant?
  - Site conditions that result in significant lateral transport, enhanced convective flow, or a source within a building
    - Large subsurface utilities (e.g. storm drains)
    - Basement sumps
    - Elevator shafts
  - Models typically assume soil gas convection
    - CoCs entry into building through cracks is considered common
    - Utility connections should not be considered preferential pathways

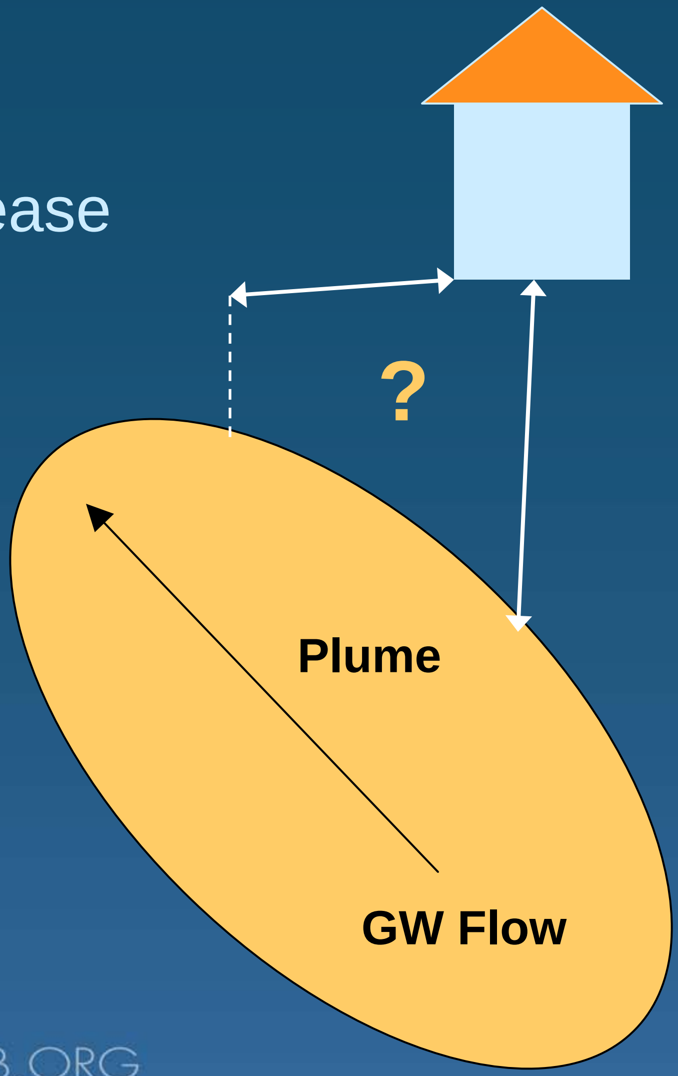
Community Outreach

- Sensitive topic in community
- Strong community outreach helps inform and prepare
- Working with community groups
- Communication strategies

Refer to Appendix A, "Community Stakeholder Concerns" in the ITRC VI-1 2007

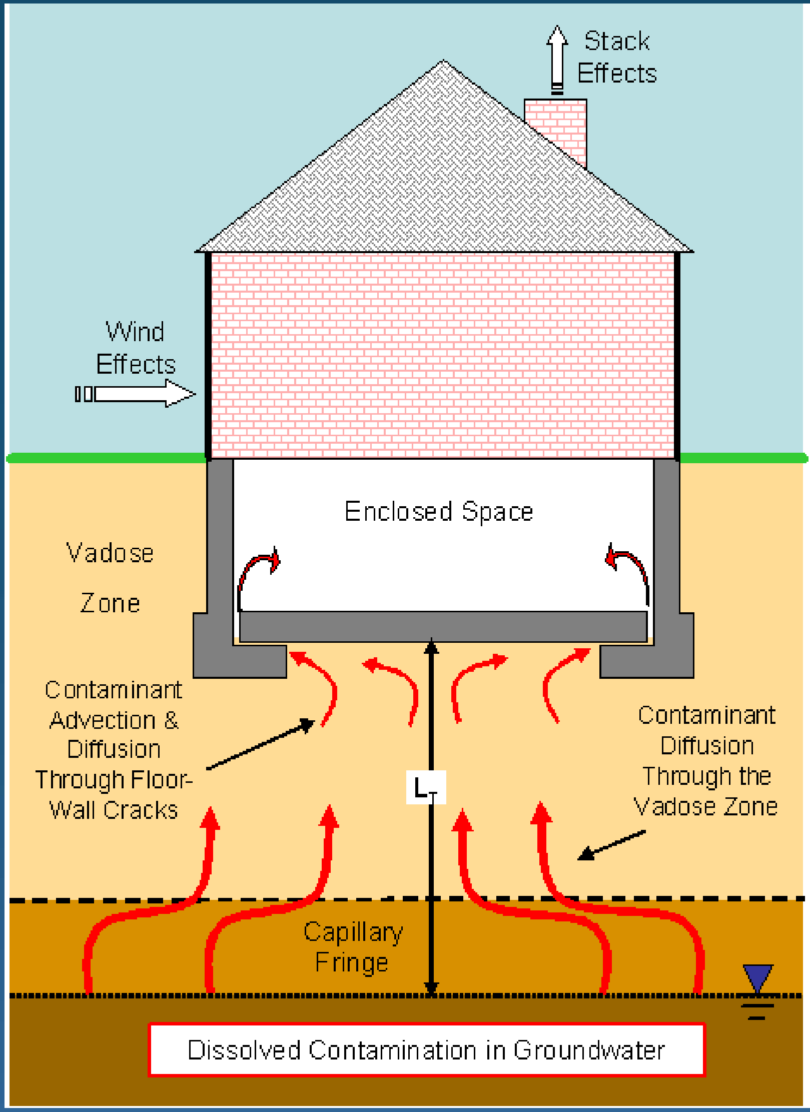
Distance Criteria

- Lateral
- Vertical
- Preferential pathways may increase distance (relatively rare)
- Petroleum hydrocarbons vs. chlorinated solvents
- Many states don't use distance criteria



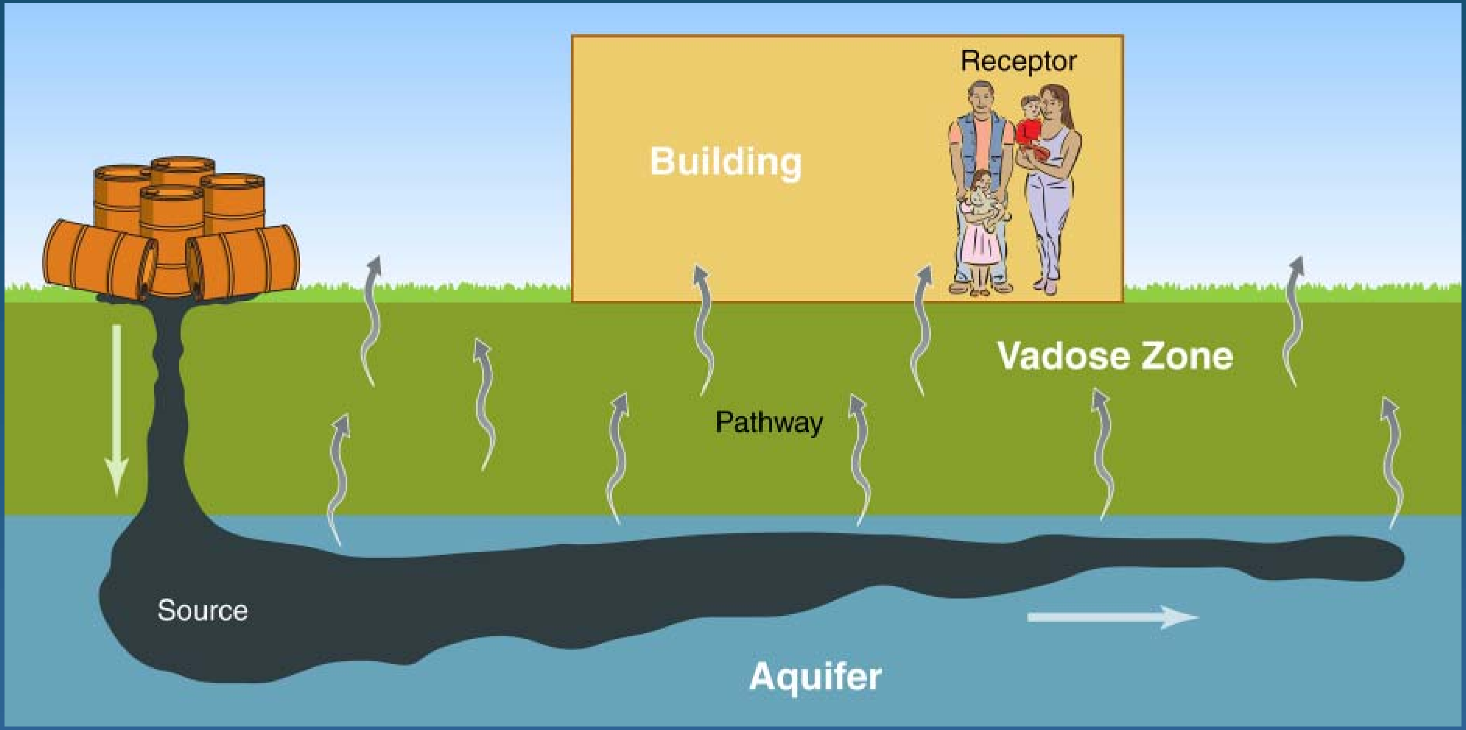
Multiple Lines of Evidence (MLE)

- Soil gas spatial concentrations
- Groundwater spatial data
- Background (internal and external / ambient) sources
- Building construction and current condition
- Sub-slab soil gas data
- Soil gas data
- Indoor air data
- Constituent ratios
- Soil stratigraphy
- Temporal patterns



Conceptual Site Model (CSM)

Simplified version (pictures and/or descriptions) of a complex real-world system that approximates its relationships



Complicating Factors for VI Assessments

- Ultra low screening levels
  - Increases chances for false positives
- Inconsistent screening levels
- Allowed assessment methods
  - Vary among agencies
- Chlorinated vs. petroleum hydrocarbons
  - Treat same way?
  - Allow for bioattenuation – how?

“Exterior” Investigations

- “Map” the contamination
- Identify buildings with potential VI risks
- Identify target compounds
- Collect site-specific geologic/pneumatic data
- Minimize inconvenience to occupants/ owners

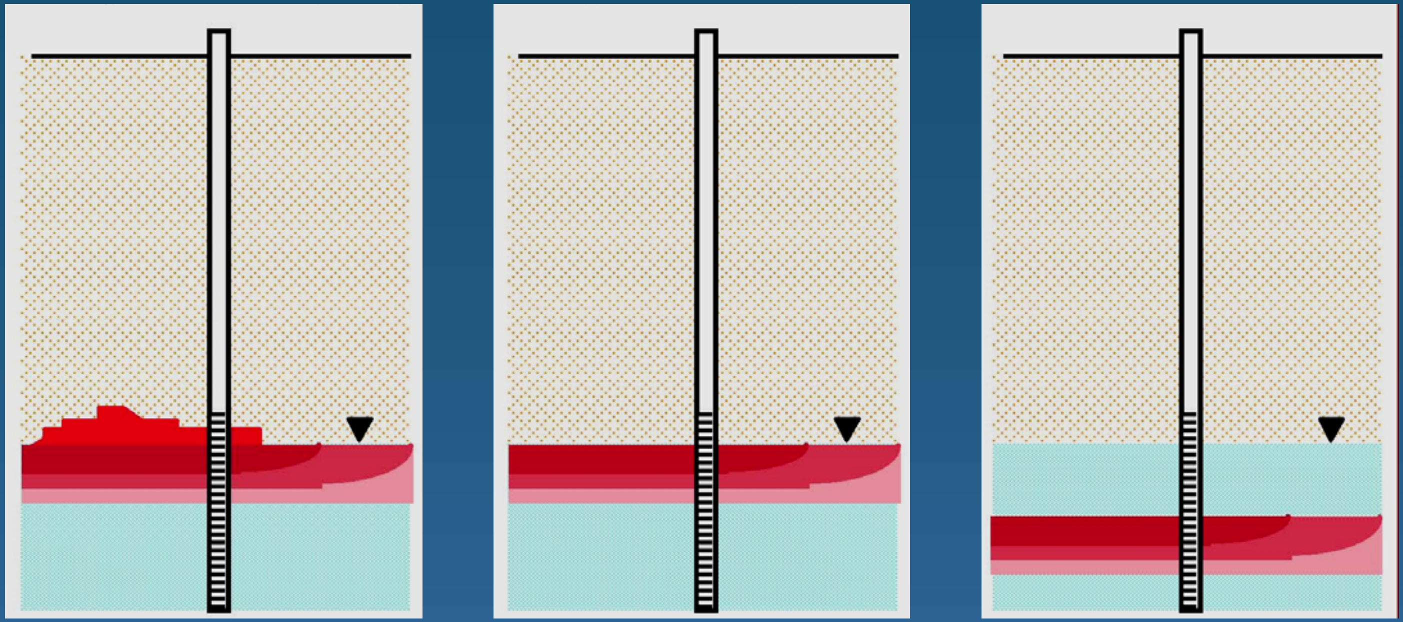
“Bound the scope of the problem”

“Interior” Investigations

- Public relations
  - Access agreements, fact sheets, meetings
- Removal of interior sources (if practical)
- Samples and “controls”
  - Outdoor, sub-slab, etc.
- Analytical methods, analytes, reporting limits
- Risk communication
- Potential litigation

Groundwater Sampling

- Issue: Proper sampling and interpretation of vertical profile of chemicals in groundwater concentration is critical
  - Each scenario below could give the same groundwater concentration, but vastly different soil vapor concentrations



Paul C. Johnson – Arizona State University 2002

Soil Gas Sampling

METHOD

- Active
- Passive
- Flux Chambers (supplemental tool)

Active method most often employed for VI

LOCATION

- Exterior
- Near Slab
- Sub-Slab

Sub-slab soil gas sampling most often employed for VI

Sub-slab Soil Gas Sampling

- Soil gas most likely to enter structure
  - May detect chemicals originating within building
- May collect indoor air concurrently for comparison
- Sample at slab base and/or at depth
- Permanent or temporary sample points
- Active and passive approaches

Active sampling

Passive sampler insertion

Indoor Air Sampling

SUMMA Canister

Evacuation Chamber

Air Sampling Pump with Sorbent Tubes

Tedlar Gas Sampling Bag

Glass Sampling Bulb

What could go wrong?

Indoor Air Measurement

- Pros
  - Actual indoor concentration, no modeling required
  - Relatively quick, no drilling or heavy equipment
  - Less spatial variability than soil vapor
    - One sample often adequate for typical basements
- Cons
  - Potential for background sources, typically addressed by:
    - Ambient air and sub-slab vapor samples
    - Survey of building materials and activities
  - No control (sample left unattended for up to 24 hours)
  - Typically more temporal variability than soil vapor
    - Up to one order of magnitude common for indoor air
  - Requires entering home

Supplemental Tools/Data

- Site specific alpha using radon
  - Factor of 10 to 100 - $100/sample
- Indoor air ventilation rate
  - Factor of 2 to 10 - <$1,000 per determination
- Real-time, continuous analyzers
  - Can sort out noise/scatter
- Pressure measurements
  - Can help interpret indoor air results

Biodegradation

Biodegradable Petroleum Hydrocarbon Volatile Chemicals of Concern (PH-VCoC) are

"petroleum hydrocarbons such as benzene, xylenes, toluene and ethylbenzene (or a mixture of such chemicals) that are a subset of volatile chemicals of concern and that are distinguished because they are known to readily biodegrade to carbon dioxide in the presence of oxygen by ubiquitous soil microbes."

ASTM (American Society of Testing and Materials)

Background Sources

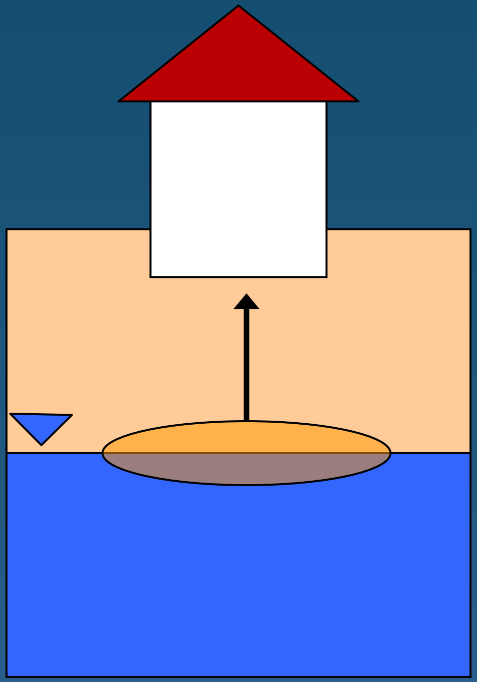
- Background refers to concentrations not attributable to releases from a site, and is usually described as naturally occurring or anthropogenic (USEPA 2002)
  - Background concentrations may exceed risk-based levels in indoor air for some common VOCs
  - Background sources may be inside the building or present in ambient outdoor air
  - The final remedy may or may not eliminate a source of risks caused by background sources
  - Some states incorporate typical background concentrations into their screening values, but most do not

Consideration of Variability

- Indoor air samples of 24-hours typically show up to an order of magnitude temporal variability
  - Radon industry addressed this by requiring samples to be collected over a longer period
- Deeper soil gas samples tend to have less temporal variability, but tend to overestimate risks for degradable compounds
- Season climate changes (hot/cold, wet/dry) are minimal in some areas, significant in others

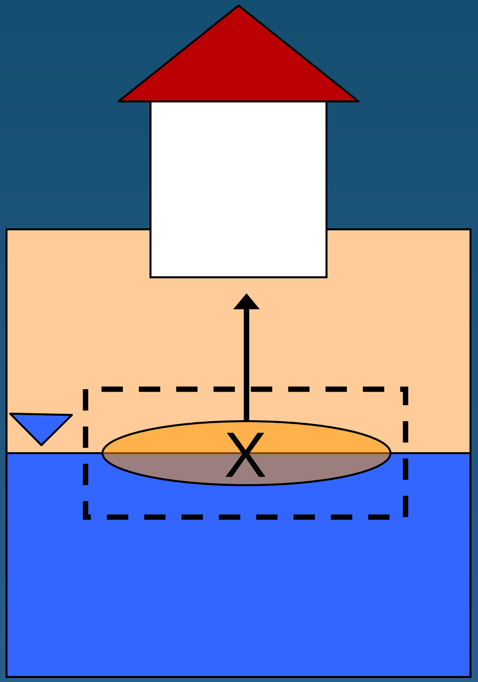
Vapor Intrusion Mitigation

- 3 general approaches



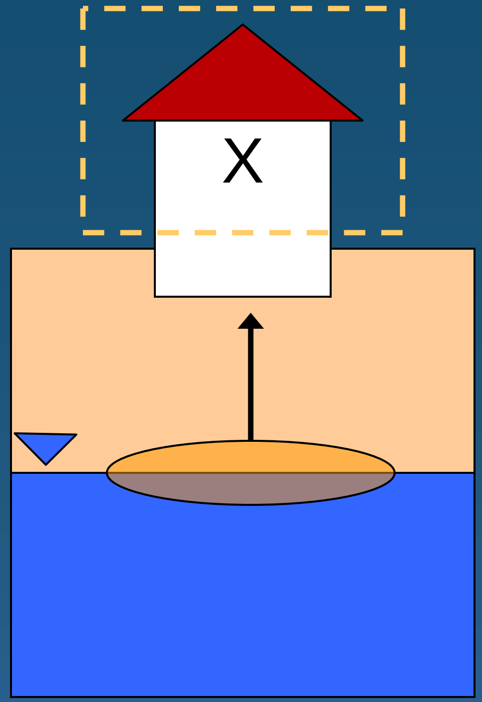
Site Remediation

- Eliminate source of vapors



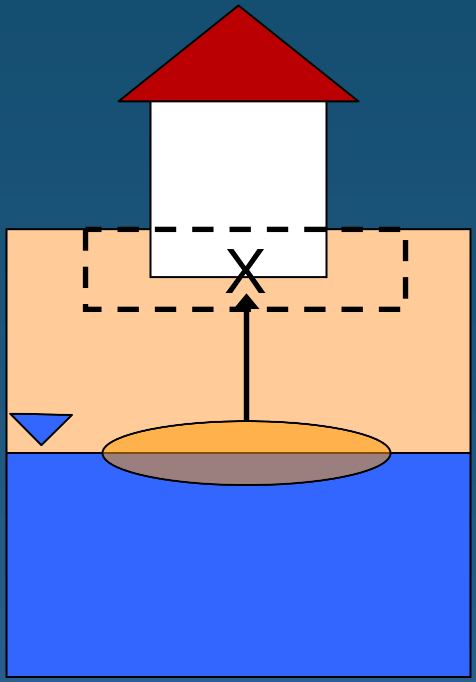
Institutional Controls

- Prevent exposure to vapors

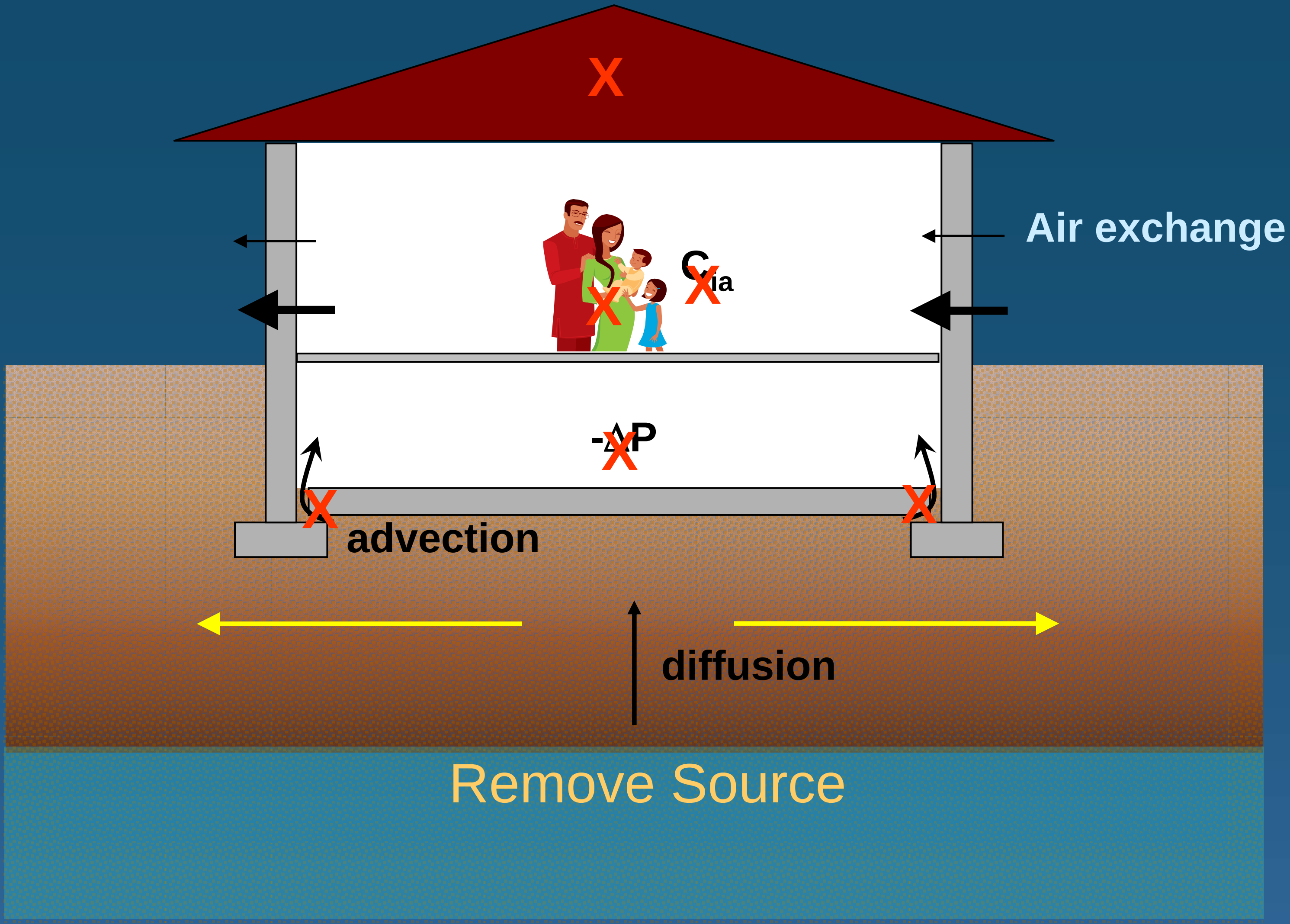


Building Controls

- Prevent entry of vapors into building

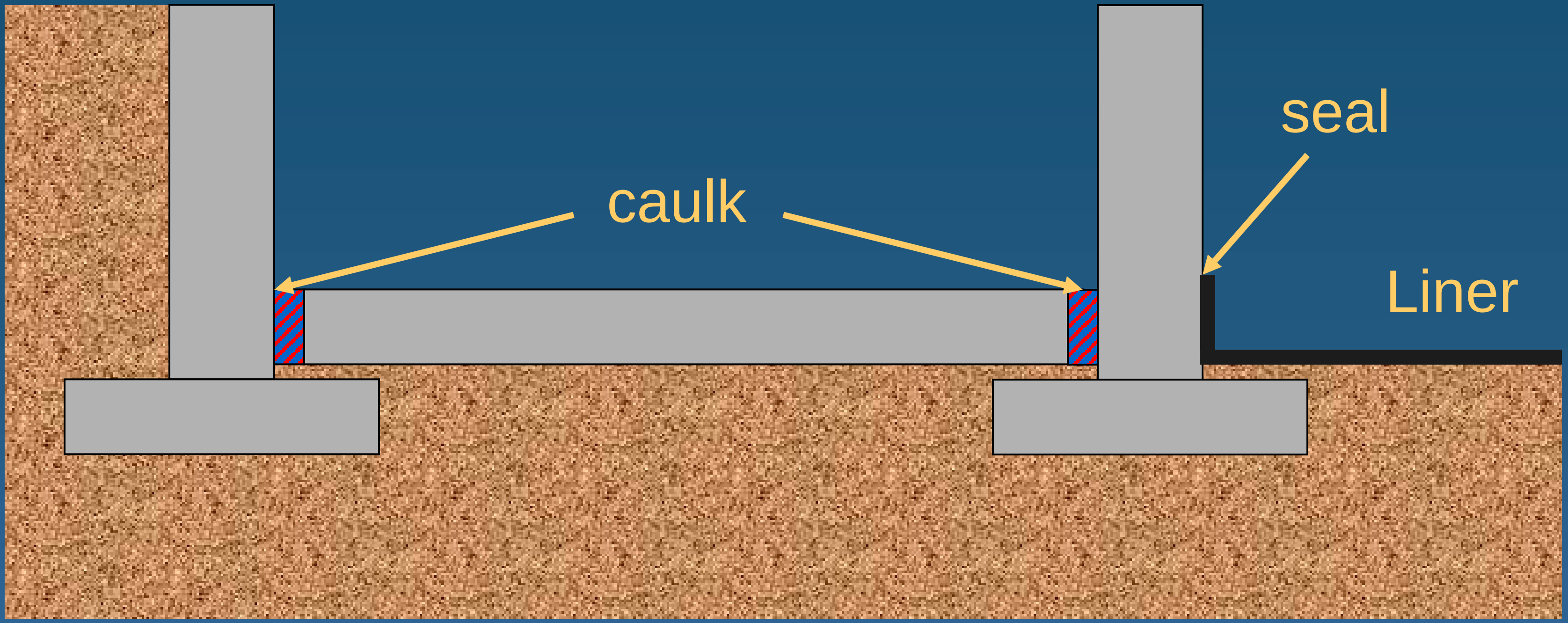


Mitigation Concepts



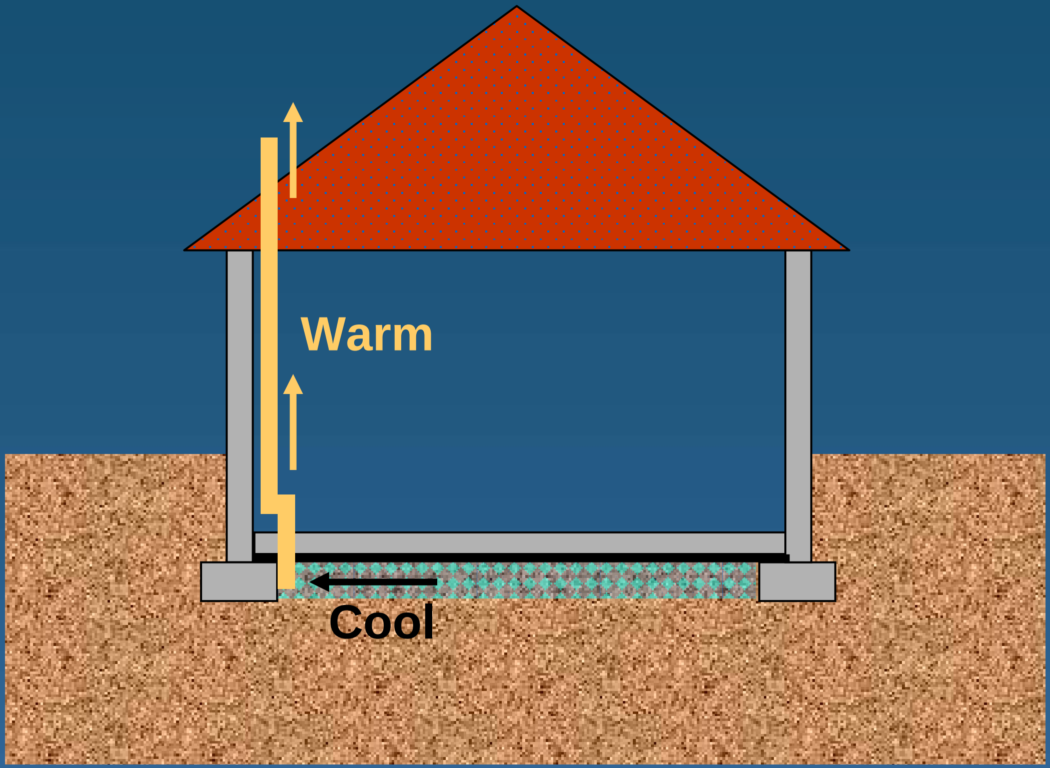
Barriers – Existing Buildings

- Seal cracks and penetrations
- Crawl space liners (e.g. LDPE)



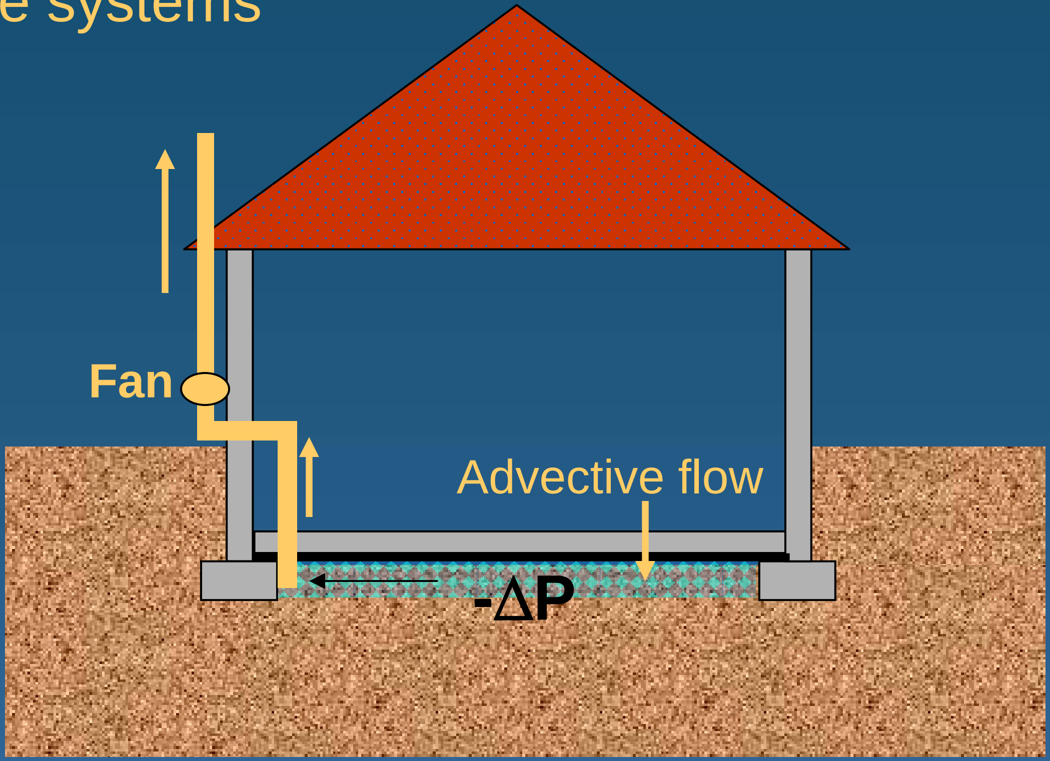
Passive Venting Mechanisms

- Passive venting layers rely on diffusion and natural pressure gradients
  - Thermal-induced pressure gradient



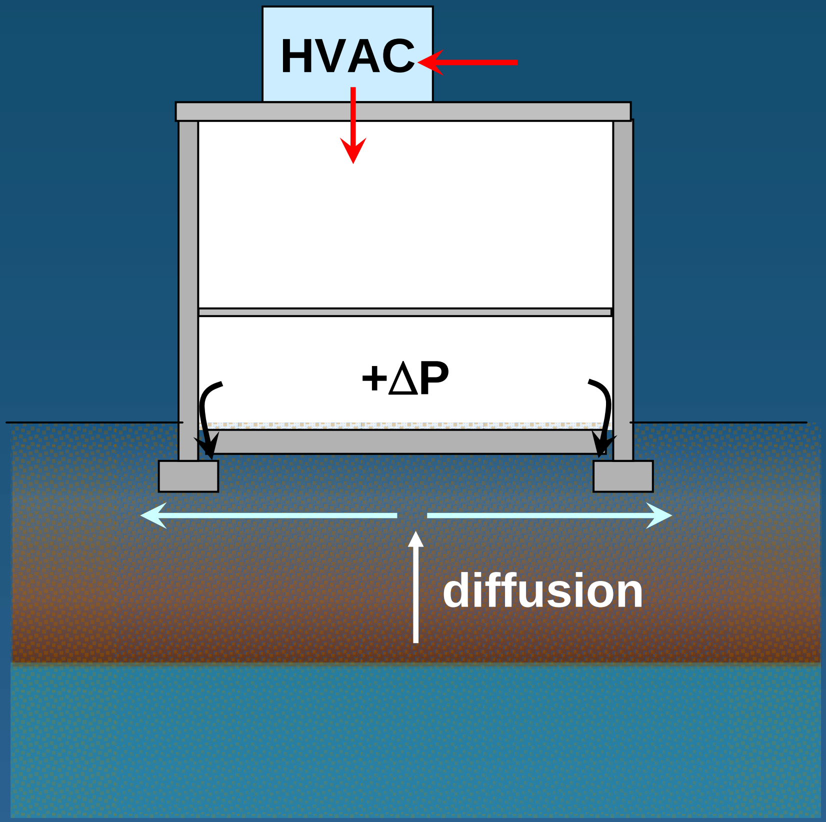
Active Venting

- Active venting layers rely on fans to create suction (i.e., depressurize venting layer)
  - Passive vents are only 10 to 50% as effective as active systems



Building Pressurization

- Positive building pressures
  - Requires increase intake air flow
  - Creates downward pressure gradient through slab
  - Increases energy costs



Intrinsically Safe Design

Operation, Maintenance and Monitoring

- Operation
  - Electrical costs
  - Emission controls
- Maintenance
  - Fan replacement
- Monitoring
  - Testing
  - Inspections

Low Pressure Monitoring Panel
Courtesy Tom Hatton, Clean Vapor, Inc.

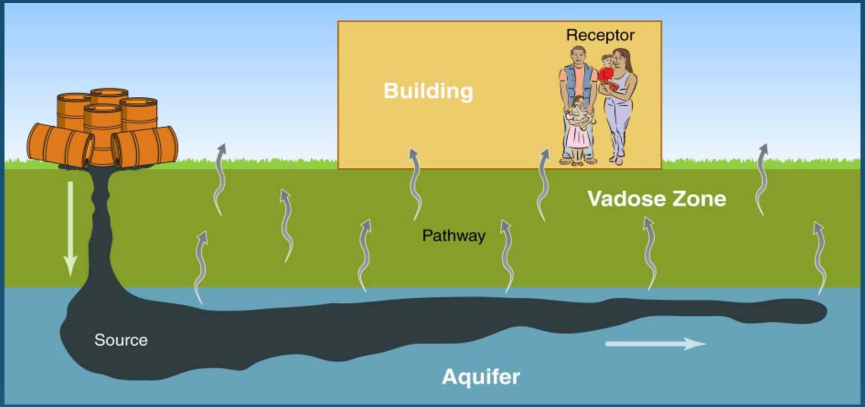
Lessons Learned

- Vapor intrusion is a complex pathway
- Multiple lines of evidence approach is critical
- The investigative “tool box” is large and growing
- Background sources & physical processes complicate data interpretation
- There are more mitigation options than just SSD
- A community outreach program is essential
- Science of vapor intrusion is advancing and changing

ITRC VI Classroom Training

ITRC is offering 2-Day classroom training on the VI pathway that will include:

- Interactive Presentations
- Hands-on Exhibits
- Informative Handouts
- Problem Sets



2010 Sessions:

Norfolk, VA - March 22-23, 2010
TBD – July 12-13, 2010
Atlanta, GA – October 4-5, 2010