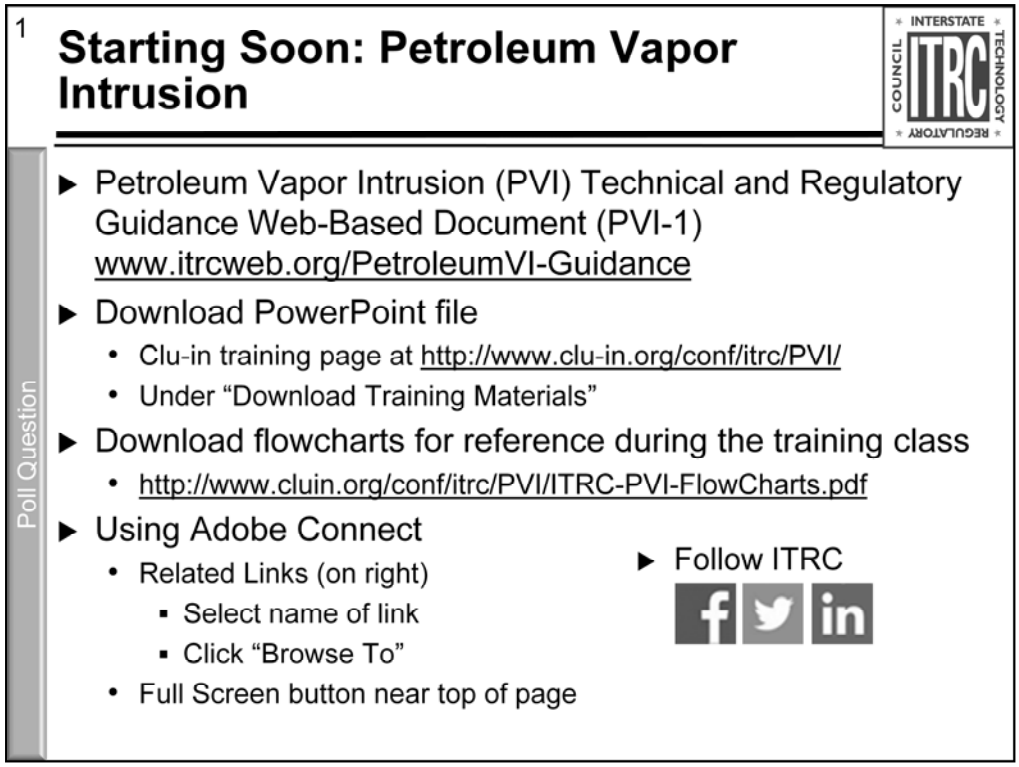

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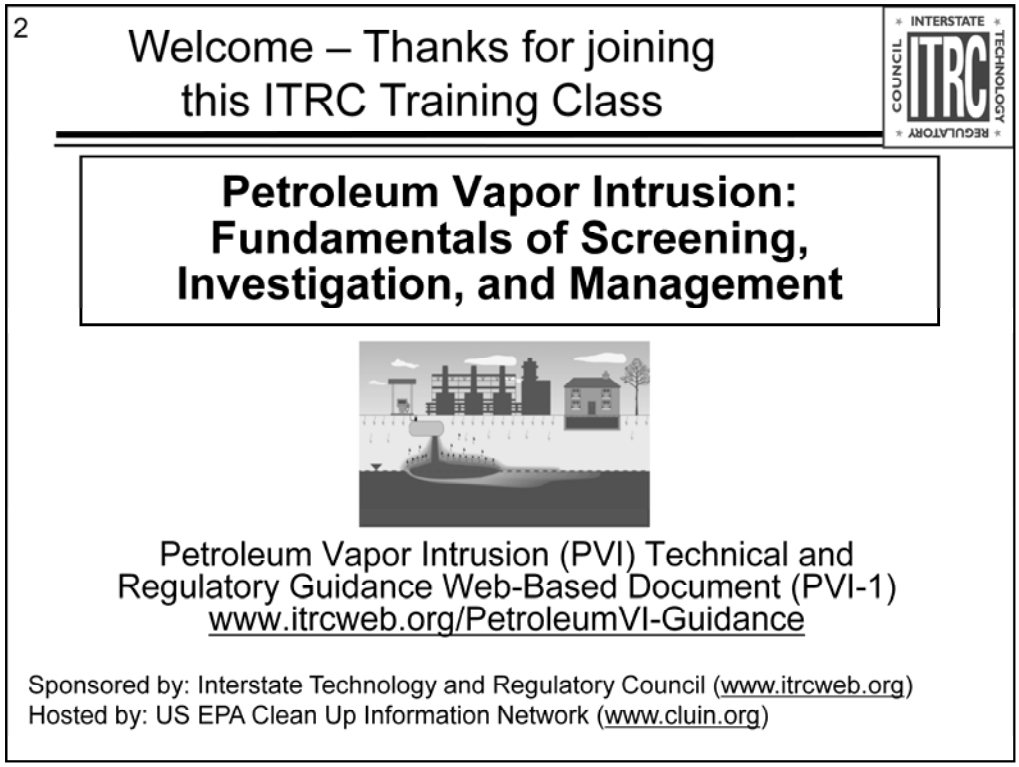


Chemical contaminants in soil and groundwater can volatilize into soil gas and migrate through unsaturated soils of the vadose zone. Vapor intrusion (VI) occurs when these vapors migrate upward into overlying buildings through cracks and gaps in the building floors, foundations, and utility conduits, and contaminate indoor air. If present at sufficiently high concentrations, these vapors may present a threat to the health and safety of building occupants. Petroleum vapor intrusion (PVI) is a subset of VI and is the process by which volatile petroleum hydrocarbons (PHCs) released as vapors from light nonaqueous phase liquids (LNAPL), petroleum-contaminated soils, or petroleum-contaminated groundwater migrate through the vadose zone and into overlying buildings. Fortunately, in the case of PHC vapors, this migration is often limited by microorganisms that are normally present in soil. The organisms consume these chemicals, reducing them to nontoxic end products through the process of biodegradation. The extent and rate to which this natural biodegradation process occurs is strongly influenced by the concentration of the vapor source, the distance the vapors must travel through soil from the source to potential receptors, and the presence of oxygen (O_2) in the subsurface environment between the source and potential receptors.

The ITRC Technical and Regulatory Guidance Web-Based Document, Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management (PVI-1, 2014) and this associated Internet-based training provides regulators and practitioners with consensus information based on empirical data and recent research to support PVI decision making under different regulatory frameworks. The PVI assessment strategy described in this guidance document enables confident decision making that protects human health for various types of petroleum sites and multiple PHC compounds. This guidance provides a comprehensive methodology for screening, investigating, and managing potential PVI sites and is intended to promote the efficient use of resources and increase confidence in decision making when evaluating the potential for vapor intrusion at petroleum-contaminated sites. By using the ITRC guidance document, the vapor intrusion pathway can be eliminated from further investigation at many sites where soil or groundwater is contaminated with petroleum hydrocarbons or where LNAPL is present.

After attending this ITRC Internet-based training, participants should be able to:

Determine when and how to use the ITRC PVI document at their sites

Describe the important role of biodegradation impacts on the PVI pathway (in contrast to chlorinated solvent contaminated sites)

Value a PVI conceptual site model (CSM) and list its key components

Apply the ITRC PVI 8 step decision process to screen sites for the PVI pathway and determine actions to take if a site does not initially screen out (e.g., site investigation, modeling, and vapor control and site management)

Access fact sheets to support community engagement activities at each step in the process

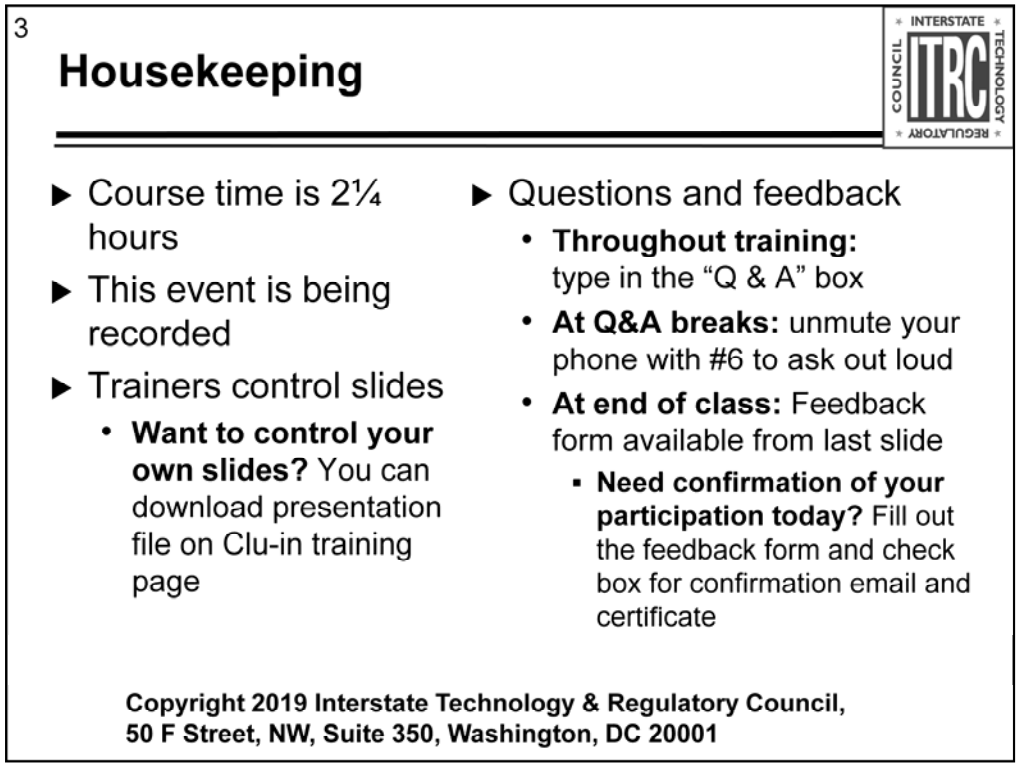
For reference during the training class, participants should have a copy of the flowcharts, Figures 1-2, 3-2, and 4-1 from the ITRC Technical and Regulatory Guidance Web-Based Document , Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management (PVI-1, 2014) and are available as a 3-page PDF at http://www.cluin.org/conf/itrc/PVI/ITRC-PVI-FlowCharts.pdf

Starting in late 2015, ITRC will offer a 2-day PVI focused classroom training at locations across the US. The classroom training will provide participants the opportunity to learn more in-depth information about the PVI pathway and practice applying the ITRC PVI guidance document with a diverse group of environmental professionals. Email training@itrcweb.org if you would like us to email you when additional information is available.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: US EPA Technology Innovation and Field Services Division (TIFSD) (www.clu-in.org)

ITRC Training Program: training@itrcweb.org; Phone: 402-201-2419

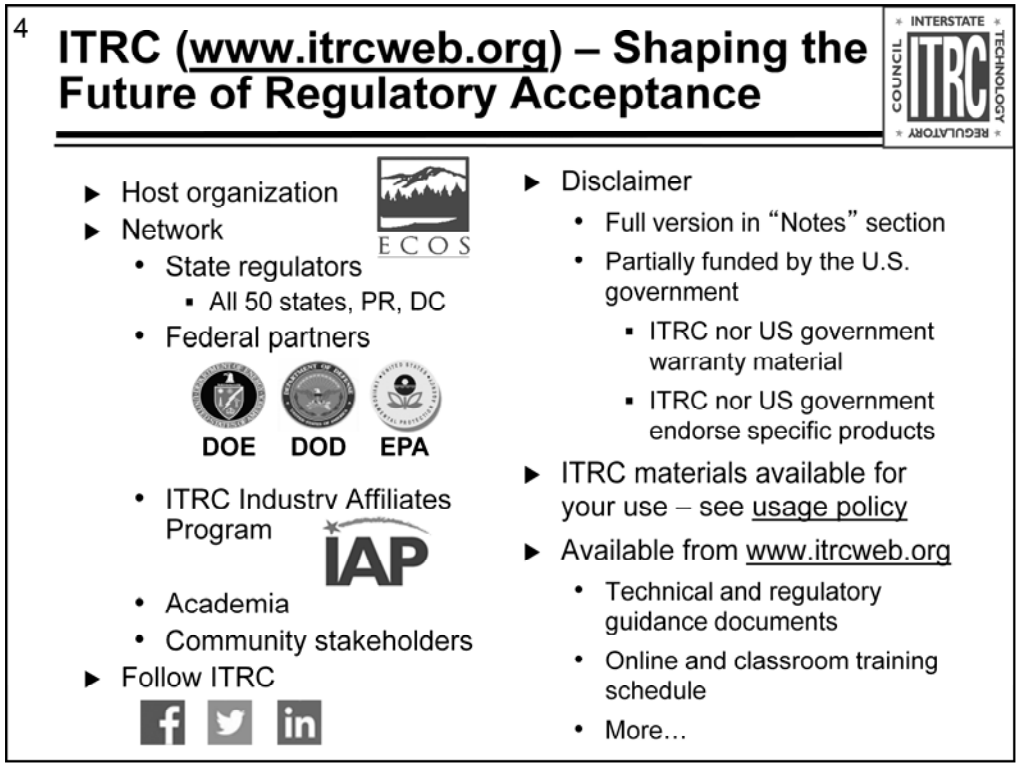


Although I'm sure that some of you are familiar with these rules from previous CLU-IN events, let's run through them quickly for our new participants.

We have started the seminar with all phone lines muted to prevent background noise. Please keep your phone lines muted during the seminar to minimize disruption and background noise. During the question and answer break, press #6 to unmute your lines to ask a question (note: *6 to mute again). Also, please do NOT put this call on hold as this may bring unwanted background music over the lines and interrupt the seminar.

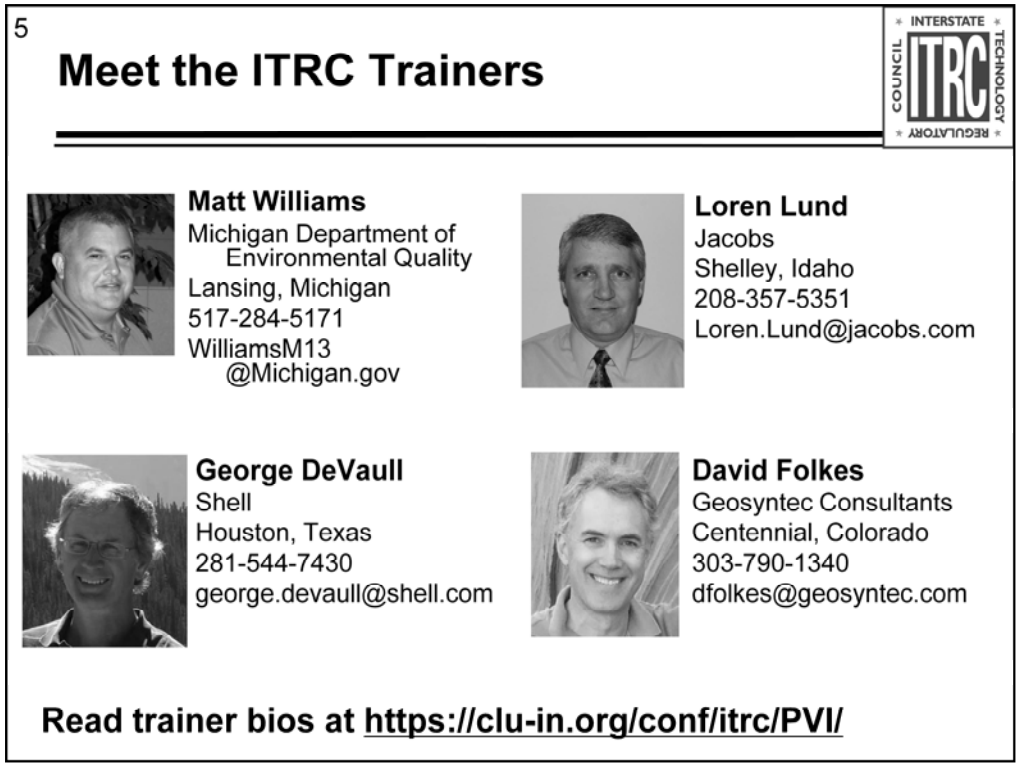
Use the "Q&A" box to ask questions, make comments, or report technical problems any time. For questions and comments provided out loud, please hold until the designated Q&A breaks.

Everyone – please complete the feedback form before you leave the training website. Link to feedback form is available on last slide.



The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

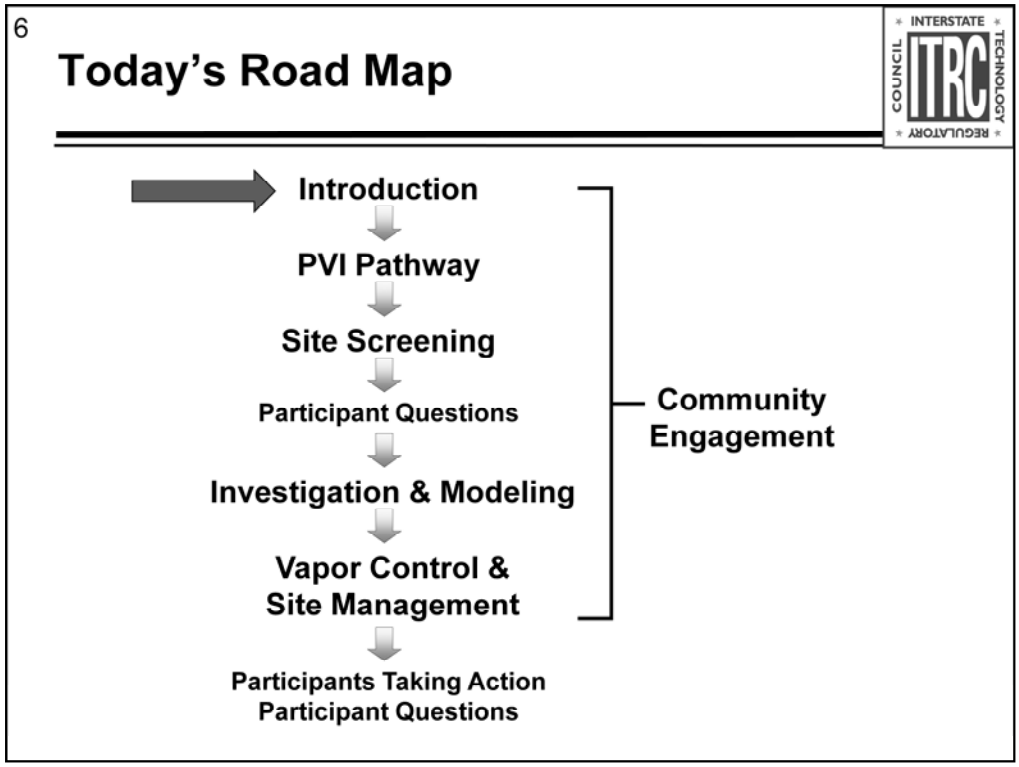


Matt Williams is the Vapor Intrusion Specialist for the development and implementation of methods used to investigate and assess vapor intrusion issues for the Remediation and Redevelopment Division of the Michigan Department of Environmental Quality. He is a Geologist that has 18 years of experience in both the public and private sectors working on a wide variety of projects across the United States. He has drafted several guidance documents and standard operating procedures for the MDEQ and has conducted numerous training and talks on soil gas methods and vapor intrusion for stakeholder groups and consultants. He co-leads ITRC 2-day classroom training on Petroleum Vapor Intrusion and is a trainer in both the 2-day classroom and Internet-based training. Matt earned a Bachelor of Science degree in Geology from Central Michigan University in Mt Pleasant, Michigan in 1993.

George DeVaull is a Principal Technical Expert in Environmental, Soil and Groundwater with Shell Global Solutions US Inc. in Houston, Texas. He has worked at Shell since 1990 on many hundreds of soil and groundwater projects across the oil and gas industry including downstream (refineries to retail), exploration and production, chemicals, and multi-party sites across many countries and six continents. His current work includes research & development on chemical fate and transport (biodegradation in the environment, soil vapor migration and intrusion into enclosures, environmental evaluation of novel and new chemical products); risk assessment frameworks and applications (human and ecological evaluations), and guidance and standards development and technical consultation (US, States, other countries, joint industry/government consortia, ASTM, API). George is a principal author of the BioVapor vapor intrusion model. For ITRC, George has contributed as a member of the petroleum vapor intrusion team since 2012. George earned a Bachelor of Science,1984, and Master of Science, 1985, in mechanical engineering, and a PhD, 1990, all from University of Illinois Champaign-Urbana.

Loren Lund is the vapor intrusion practice leader for Jacobs and resides in Shelley, Idaho. He has worked at Jacobs since 2017 and CH2M since 2008, which was acquired by Jacobs. He has worked in environmental risk analysis and vapor intrusion since 1990. Loren is responsible for overseeing/training staff and insuring vapor intrusion best practices are applied. He is responsible for the company's compendium of best practices, standard operating procedures, quality assurance procedures, and VI website. Loren is an organizing committee member, classroom instructor, session chair, and presenter for the Air and Waste Management Association (AWMA) VI specialty conferences. He is a member of the Interstate Technology Regulatory Council (ITRC) Petroleum VI team, where he was the co-team leader responsible for authoring one of the chapters. Loren co-chairs the Navy VI Focus Group, was a co-author of the Navy 2011 Background Indoor Air Guidance for VI, and the senior technical leader for the Web-based Navy VI Tool and the current Navy Environmental Sustainability Development to Integration (NESDI) VI Decision Framework database project. He has reviewed multiple national VI guidance documents, authored over a dozen papers, and has been a session chair or featured speaker at more than a dozen VI conferences or sessions since 2004. Loren has presented over a dozen webinar training sessions on VI assessment and mitigation in the last five years. He earned a bachelor's degree in chemistry and a Ph.D. in biochemistry at Utah State University. He was a post-doctorate and adjunct professor in toxicology at the University of Texas in Austin.

David Folkes is a Principal with Geosyntec Consultants, Inc. in Denver, Colorado. Dave has worked on over 100 vapor intrusion (VI) projects across North America and overseas since 1998, including sites in Europe, South America, Australia, and Southeast Asia. He is Project Director of the Redfield Site, one of the largest VI sites in the US, and has served as an expert witness on several major VI cases, including class action lawsuits. Dave has been extensively involved with development of VI practice and guidance in the US, including training of regulators and consultants on use of the 2002 draft EPA VI guidance; and assistance with VI guidance development and training in many states over the past decade. As a member of the Interstate Technology and Regulatory Council (ITRC) VI Team, Dave helped develop its 2007 guidance and served as an instructor for VI training classes over the next four years. Dave earned his bachelor's degree in Geological Engineering in 1977 and his master's degree in Civil Engineering in 1980, both from the University of Toronto, Canada. He is a registered professional engineer in Colorado.

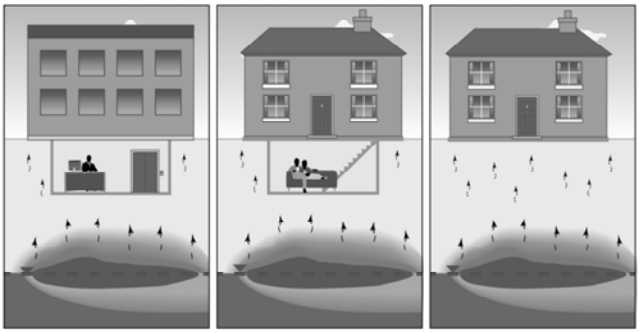


No associated notes.

7

What is Vapor Intrusion (VI)? What is Petroleum Vapor Intrusion (PVI)?

- Vapor Intrusion (VI) is the process by which volatile vapors partition from contaminated groundwater or other subsurface sources and migrate upward through vadose zone soils and into overlying buildings
- Petroleum vapor intrusion (PVI) is a subset of VI that deals exclusively with petroleum hydrocarbon (PHC) contaminants



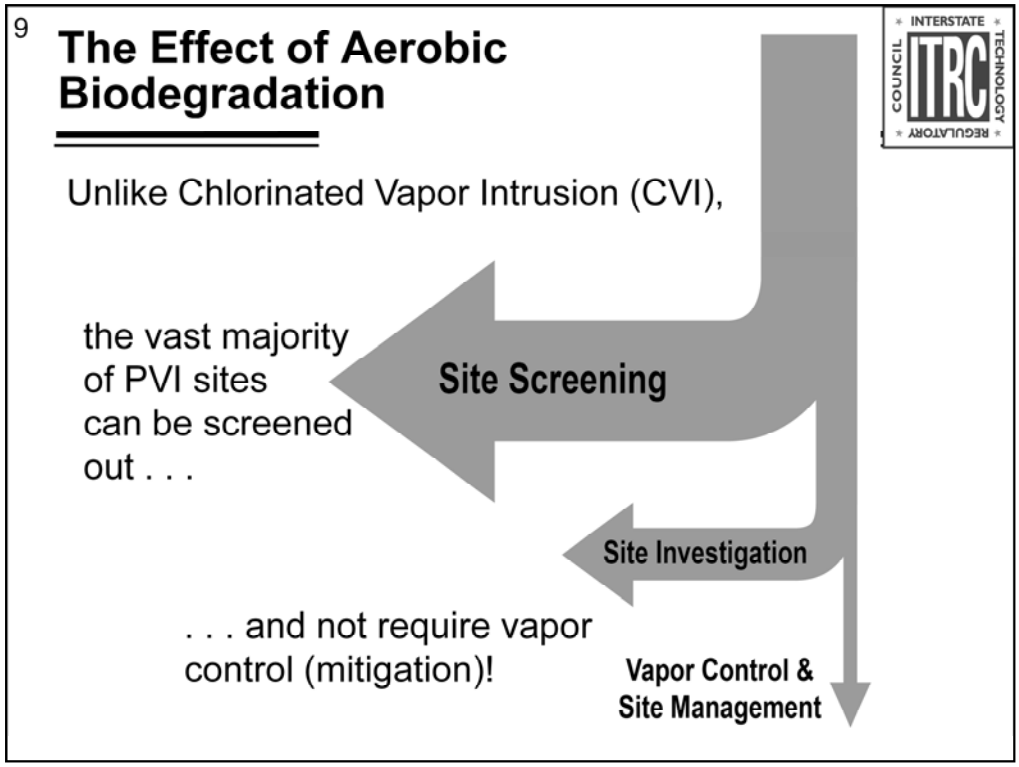
No associated notes.

8

Aerobic Biodegradation - Key to Limiting PVI

- Defining feature of PVI
  - Distinguishes it from Chlorinated Vapor Intrusion (CVI)
- Breakdown of chemicals by microorganisms in vadose zone soils
- PHC-degrading bacteria found in all environments
  - Consumes hydrocarbons in the presence of O_2
- Limits transport and effects of PHC vapors
- Previous guidance based on CVI which doesn't address biodegradation and therefore is overly conservative.

No associated notes.



No associated notes.

10

PVI – What is the Big Deal?

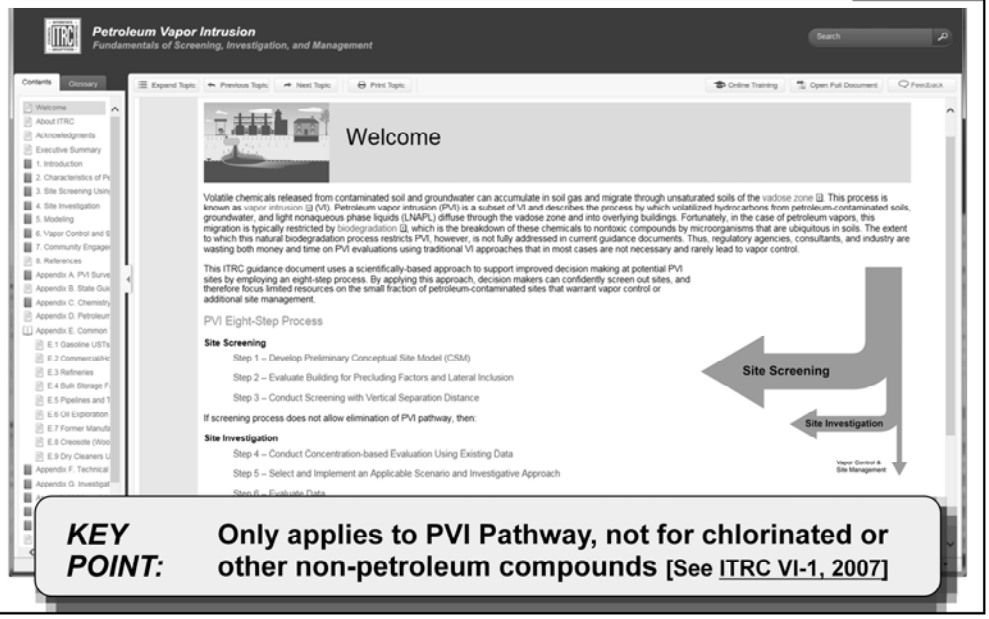
- **Lack of guidance and training** to support confident decision making
- **Experience with chlorinated compound vapor intrusion** (CVI) inappropriately heightens concern for PVI
- **Limited resources** identified a need for a prioritization process to focus on sites with greatest potential for PVI
- **Financial impacts** (e.g., delays in construction or property transactions)
- **Potential adverse health effects of building occupants** when vapors are present at sufficiently high concentrations

No associated notes.

11

The ITRC Solution - Guidance

Petroleum Vapor Intrusion (PVI): Fundamentals of Screening, Investigation, and Management



No associated notes.

12

How ITRC's PVI Guidance Relates to Other Documents

- Builds on the existing ITRC Vapor Intrusion (VI) guidance (VI-1, 2007) which focused primarily on chlorinated compounds vapor intrusion (CVI)
  - Can be a companion to the ITRC VI 2007 guidance or stand alone
- Complements the USEPA Office of Underground Storage Tank (OUST) PVI guidance document (June 2015)
  - Limited to USTs in comparison to ITRC PVI document applicability to various types of petroleum sites

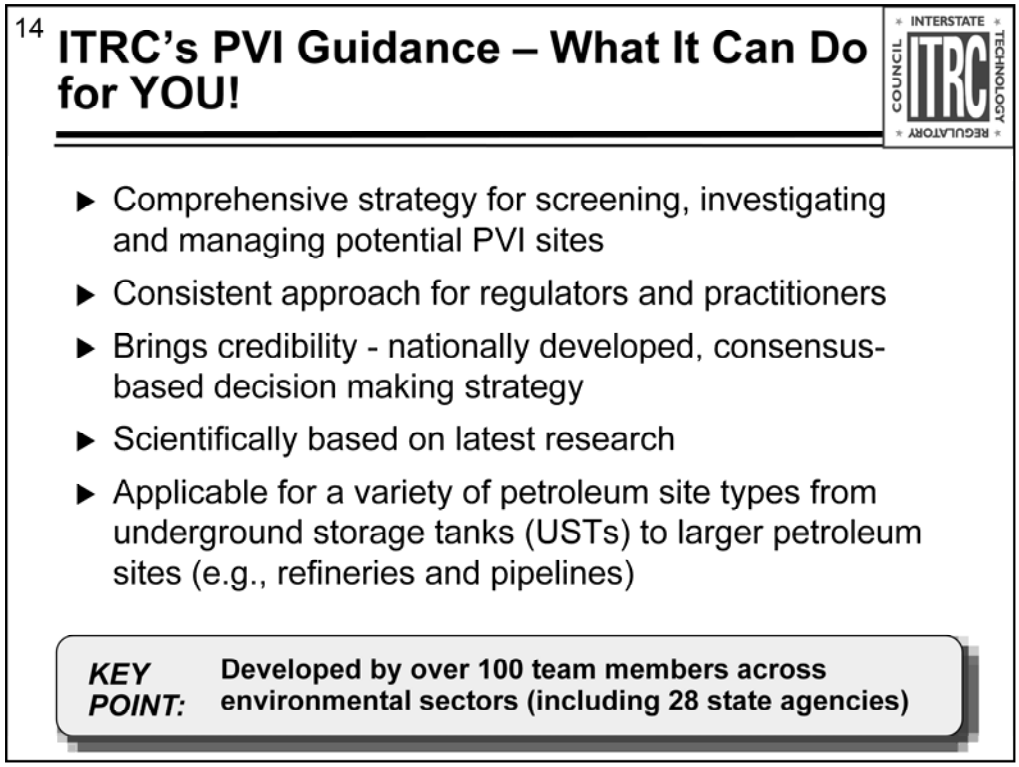
No associated notes.

13

Intent of Using PVI Screening Method Based on Vertical Screening Distance

- Produce consistent and confident decisions that are protective of human health
- Minimize investigative efforts at sites where there is little risk of a complete PVI pathway
- Prioritize resources for sites with the highest risk for a complete PVI pathway

No associated notes.



No associated notes.

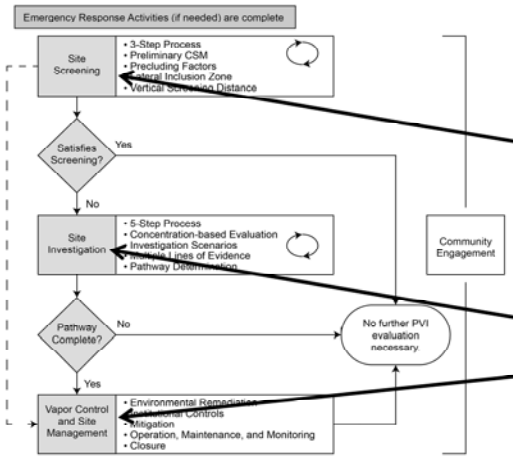
15

ITRC's PVI Assessment Strategy

Handout provided

- Assumes any emergency response activities are complete

Figure 1-2. PVI strategy flowchart



- **Strategy includes:**
  - **Site screening using Vertical screening distance**
  - **Site investigation**
  - **Vapor Control and Site Management**

ITRC PVI-1, 2014: Figure 1-2

No associated notes.

16

Users Follows Step-Wise Approach

Handout provided

Site Screening:

Step 1: Develop preliminary conceptual site model (CSM)

Step 2: Evaluate site for precluding factors and lateral inclusion

Step 3: Screen building using vertical separation distance

Site Investigation (if necessary):

Step 4: Conduct concentration-based evaluation using existing data

Step 5: Select and implement applicable scenario and investigative approach

Step 6: Evaluate data

Step 7: Decide if additional investigation warranted?

Step 8: Decide if the PVI pathway complete?

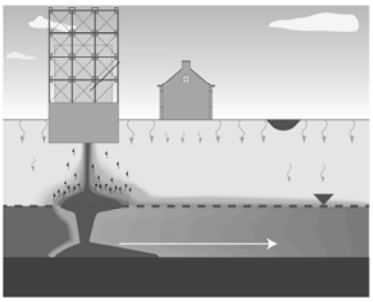
No associated notes.

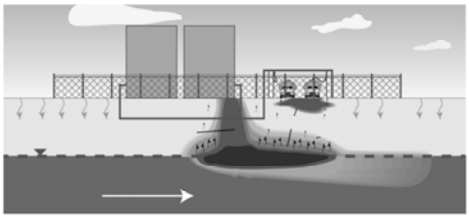
17

ITRC PVI Guidance Applicability Beyond Gas Stations…….

Poll Results

- Gasoline and diesel USTs
- Commercial/home heating oil UST
- Refineries
- Bulk storage facilities
- Pipeline/transportation
- Oil exploration/production sites
- Former Manufactured Gas Plants
- Creosote facilities
- Dry cleaners using petroleum solvents

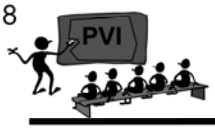




ITRC PVI-1, 2014: Appendix E

No associated notes.

18

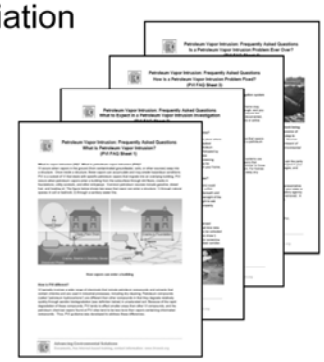


Community Engagement Be Prepared!

INTERSTATE COUNCIL ITRC TECHNOLOGY REGULATORY

Community Engagement

- PVI investigation can be disconcerting and intrusive to the public
- Be prepared to address PVI-specific concerns and questions that are likely to arise during any phase of investigation, mitigation, or remediation
- Community Engagement FAQs (Appendix K)
  - What is PVI?
  - What to Expect in a PVI Investigation
  - How is a PVI Problem Fixed?
  - Is a PVI Problem Ever Over?



ITRC PVI-1, 2014: Appendix K – Frequently Asked Questions Fact Sheets

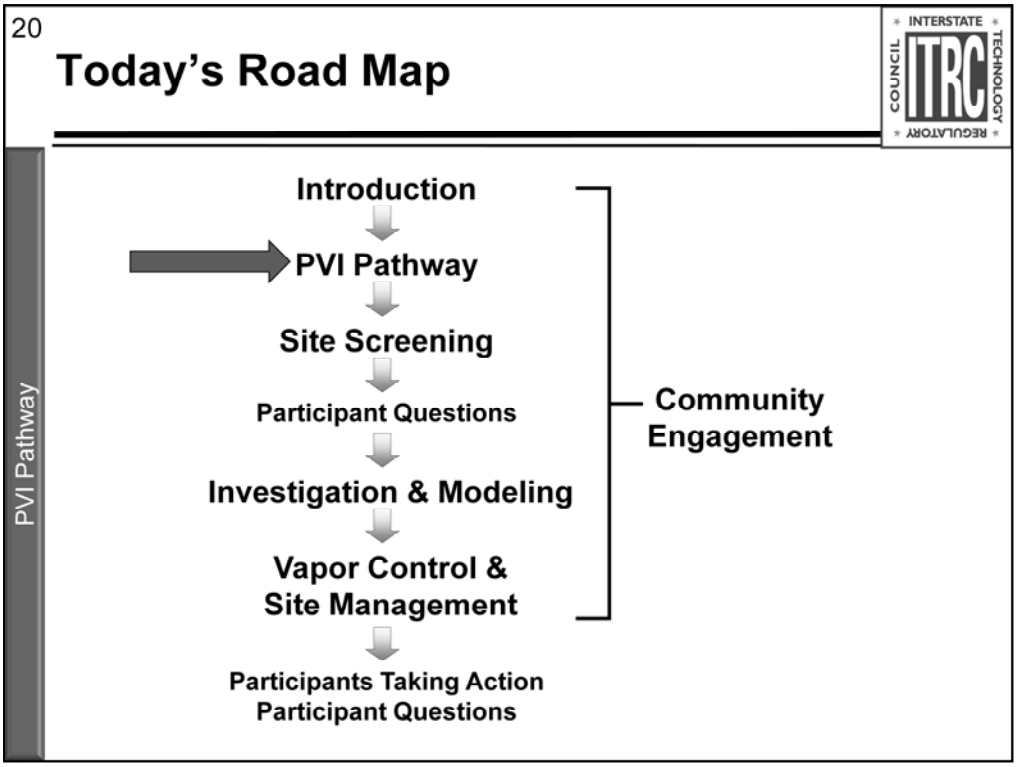
No associated notes.

19

After Today's Training You Should Know:

- When and how to use ITRC's PVI document
- Important role of biodegradation in the PVI pathway (in contrast to chlorinated solvent contaminated sites)
- Value of a PVI conceptual site model (CSM) and list its key components
- How to apply the ITRC PVI 8 step decision process to:
  - Screen sites for the PVI pathway
  - Take action if your site does not initially screen out
    - Investigation and Modeling
    - Vapor Control and Site Management
- When and how to engage with stakeholders

No associated notes.



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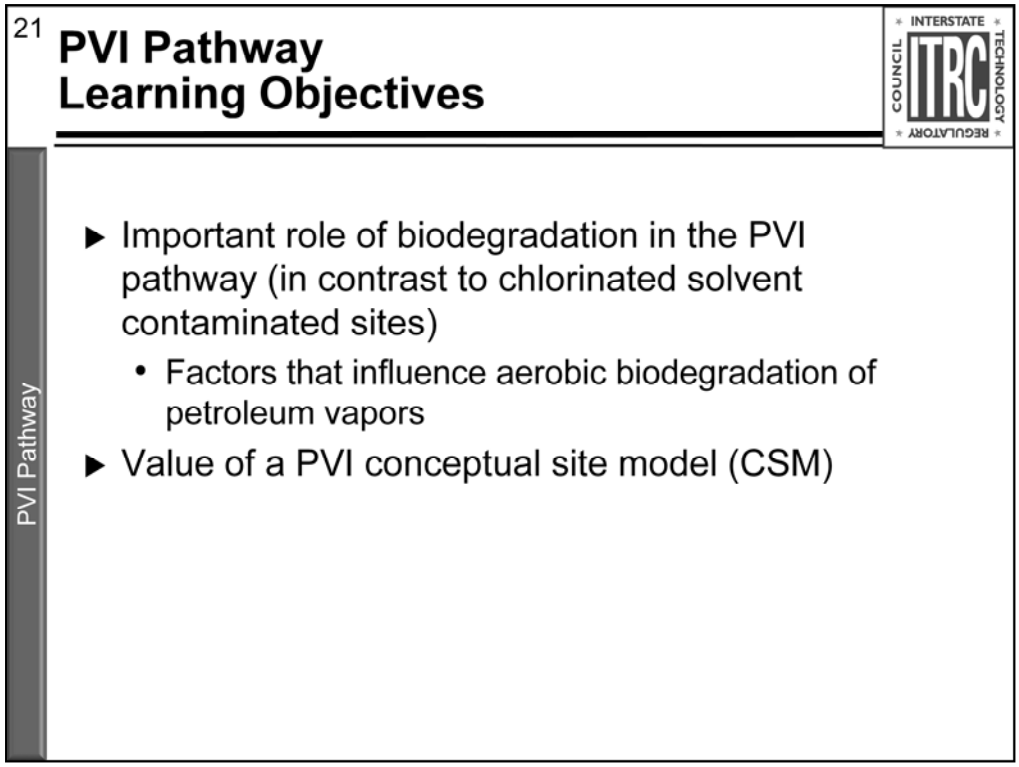
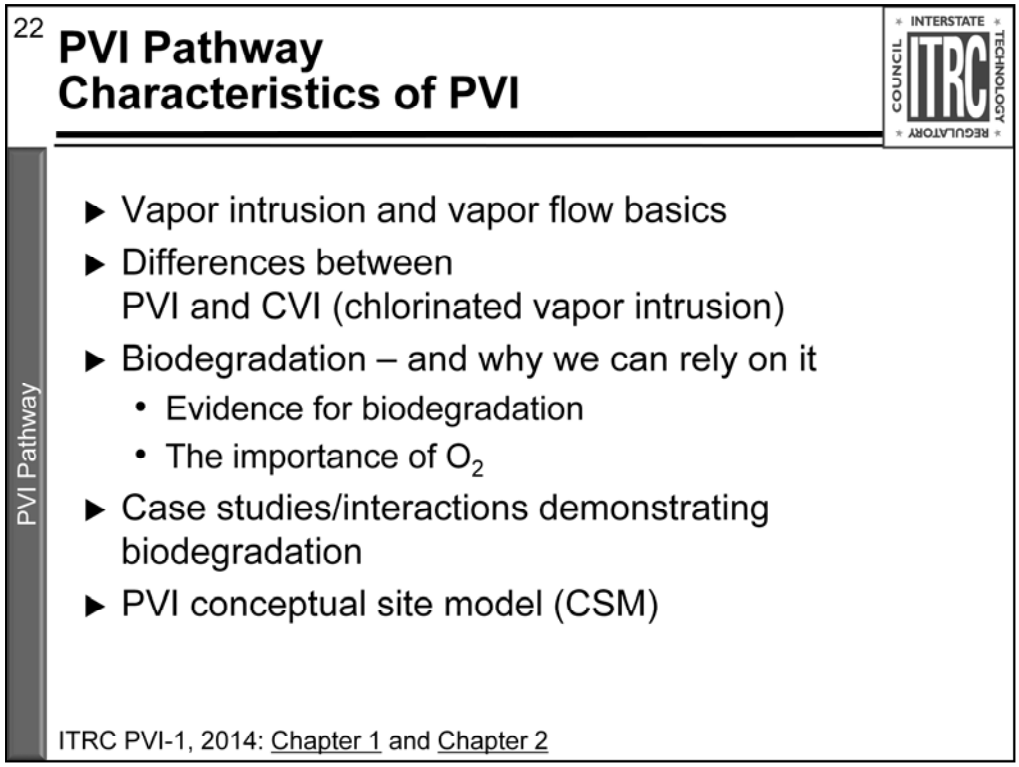


Biodegradation

3 factors: distance, concentration, oxygen (O2)



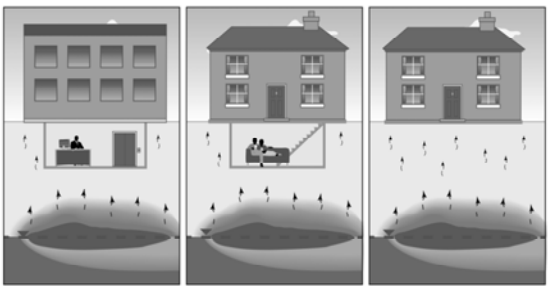
No associated notes.

23

Vapor Intrusion – Vapor Flow Limited By:

PVI Pathway

- Buildings (air exchange, positive pressure, background)
- Building foundations (intact, no cracks or unsealed penetrations)
- Vadose zone
  - High soil moisture or clay (no vapor migration)
  - Aerobic biodegradation
  - Lateral offset
- Source and groundwater
  - Clean water lens over source, clay layers
  - Finite source mass, saturated vapor limits



KEY POINT: **Presence of subsurface source does not always result in observed vapor intrusion.**

CSM

4 compartments or components:

Building, foundation, soil layer (separating), vapor source

Vapors need to get from ‘source’ to enclosure to be a risk.

In many instances petroleum vapors can’t (don’t) make it from the source to the enclosure.

For any one or more of the listed reasons

We focus on aerobic biodegradation, because it is significant and nearly ubiquitous.

24

Vapor Impacts to Indoor Air, NOT Related to VI Pathway

PVI Pathway

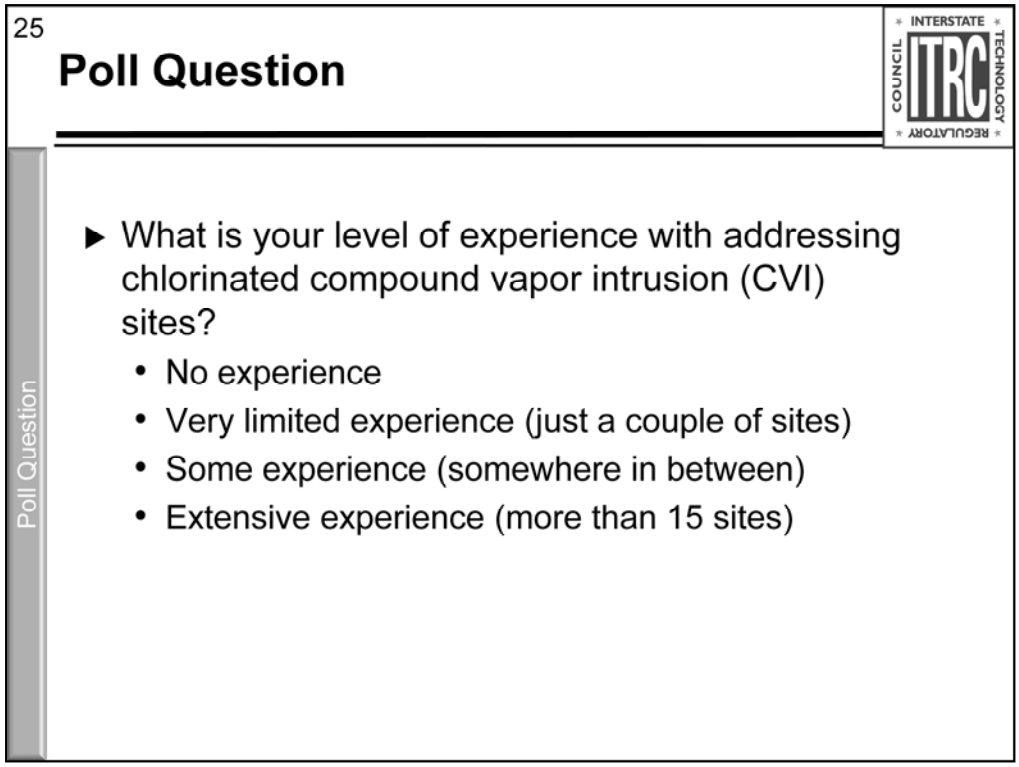
Other potential issues:

- Ambient outdoor air quality
- Vapors off-gassing from tap water
- Impacted water or product inside a building
- Household or commercial products stored or used in a building
- Building materials containing volatile compounds
- Household activities

There are other conceptual models for vapor intrusion.

Not covered here.

There's also other potential risk 'impacts' at sites (groundwater ingestion, soil contact, etc.), again, not covered here.



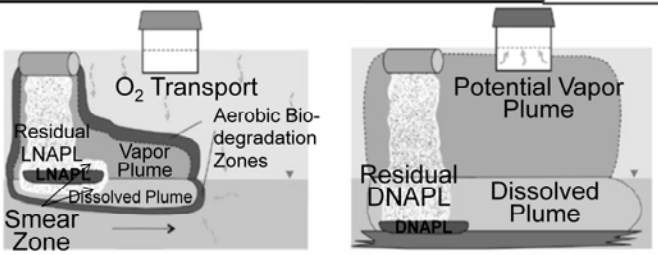
No associated notes.

26

Differences Between PVI and CVI

PVI Pathway

Figure: Petroleum Hydrocarbons And Chlorinated Solvents Differ In Their Potential For Vapor Intrusion (PDF). EPA. *March 2012.*



Variable	PVI	CVI
Type of chemical	non-chlorinated hydrocarbon	chlorinated hydrocarbon
Example	Benzene	perchloroethylene (PCE)
Source Type	LNAPL	DNAPL
Aerobic biodegradation	**Consistently very rapid**	Consistently very limited
Vapor intrusion potential	low	High
Degradation products	CO_2, H_2O	intermediates

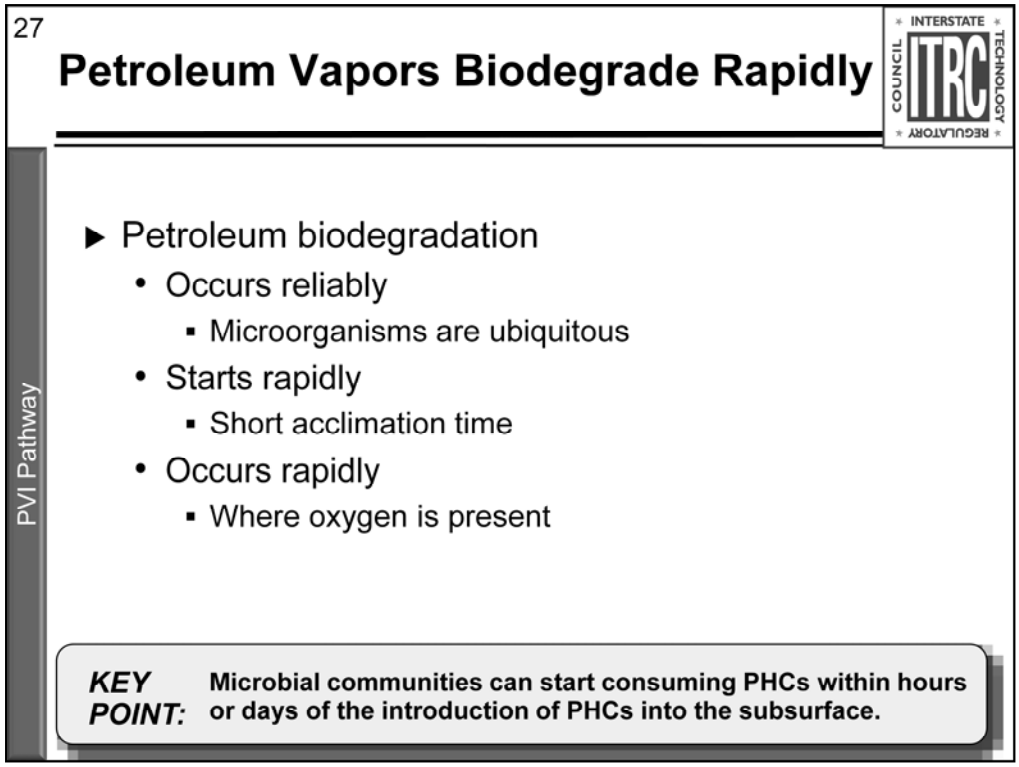
KEY POINT: **Soil vapor clouds for CVI are bigger than for PVI. Why? Answer: Aerobic Biodegradation**

Graphic is from an EPA publication (as noted)

Petroleum Hydrocarbons And Chlorinated Solvents Differ In Their Potential For Vapor Intrusion (PDF). EPA. March 2012.

http://www.epa.gov/oust/cat/pvi/index.htm

Key: different chemicals behave differently



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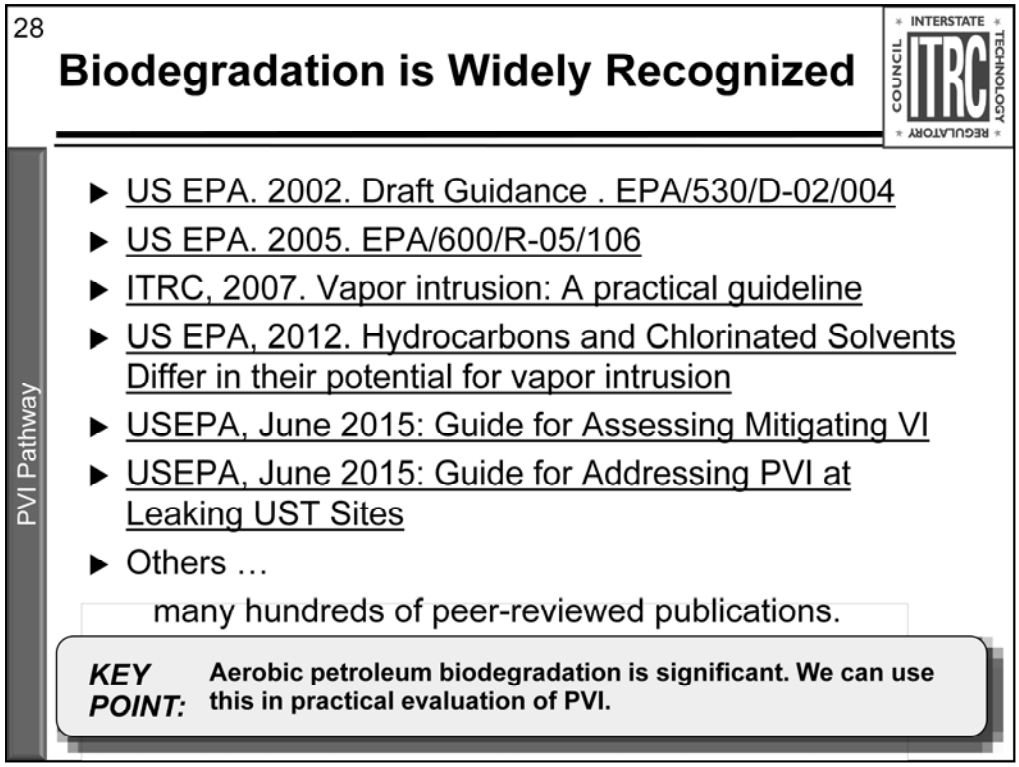


Biodegradation gets mentioned in regulatory guides (as listed).

Also there are many hundreds (if not near thousands) of publications referring to petroleum chemical biodegradation.

Refs [for information]:

US EPA. 2002. Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA/530/D-02/004, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC, Washington, D.C., November, 2002: pp. 52.

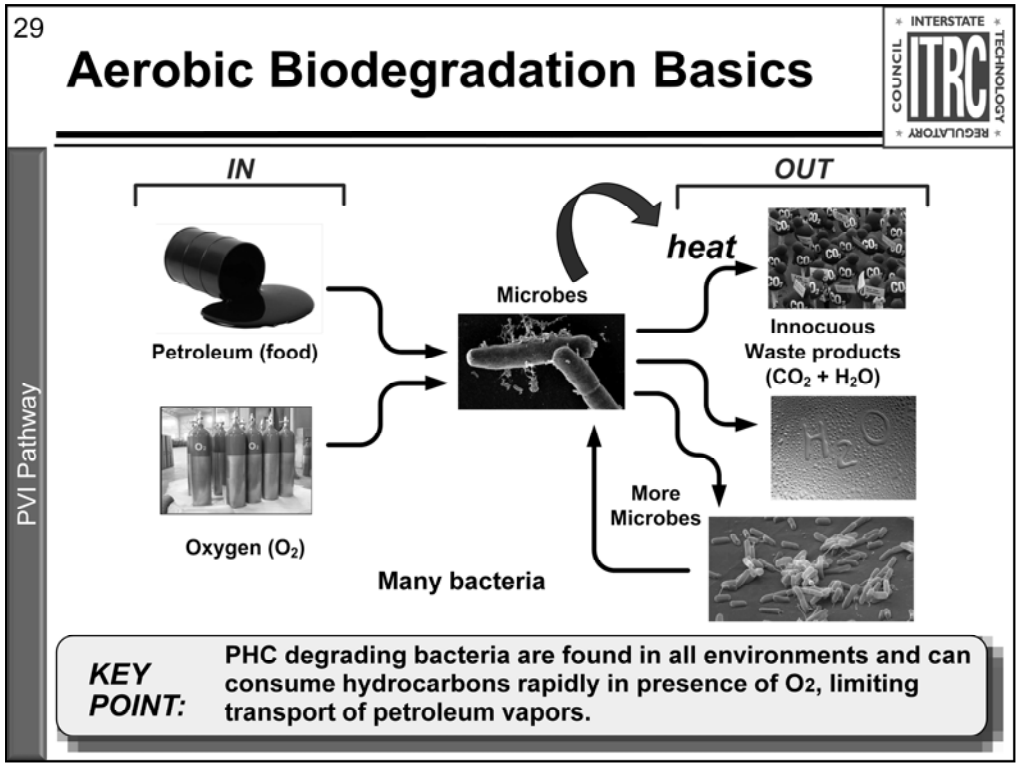
Tillman, F.D., and J.W. Weaver. 2005. Review of recent research on vapor intrusion. EPA/600/R-05/106, U. S. Environmental Protection Agency Office of Research and Development, Washington, DC, September, 2005: pp. 41.

ITRC. 2007. Vapor intrusion: A practical guideline. Interstate Technology & Regulatory Council, Washington, D.C., January, 2007: pp. 74.

US EPA. 2011. Petroleum Hydrocarbons And Chlorinated Hydrocarbons Differ In Their Potential For Vapor Intrusion. United States Environmental Protection Agency, Washington, D.C., September, 2011: pp. 13.

Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites, U.S. Environmental Protection Agency, Office of Underground Storage Tanks, Washington, D.C. EPA 510-R-15-001. June 2015.

OSWER TECHNICAL GUIDE FOR ASSESSING AND MITIGATING THE VAPOR INTRUSION PATHWAY FROM SUBSURFACE VAPOR SOURCES TO INDOOR AIR, U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response June 2015, OSWER Publication 9200.2-154.



No associated notes.

30

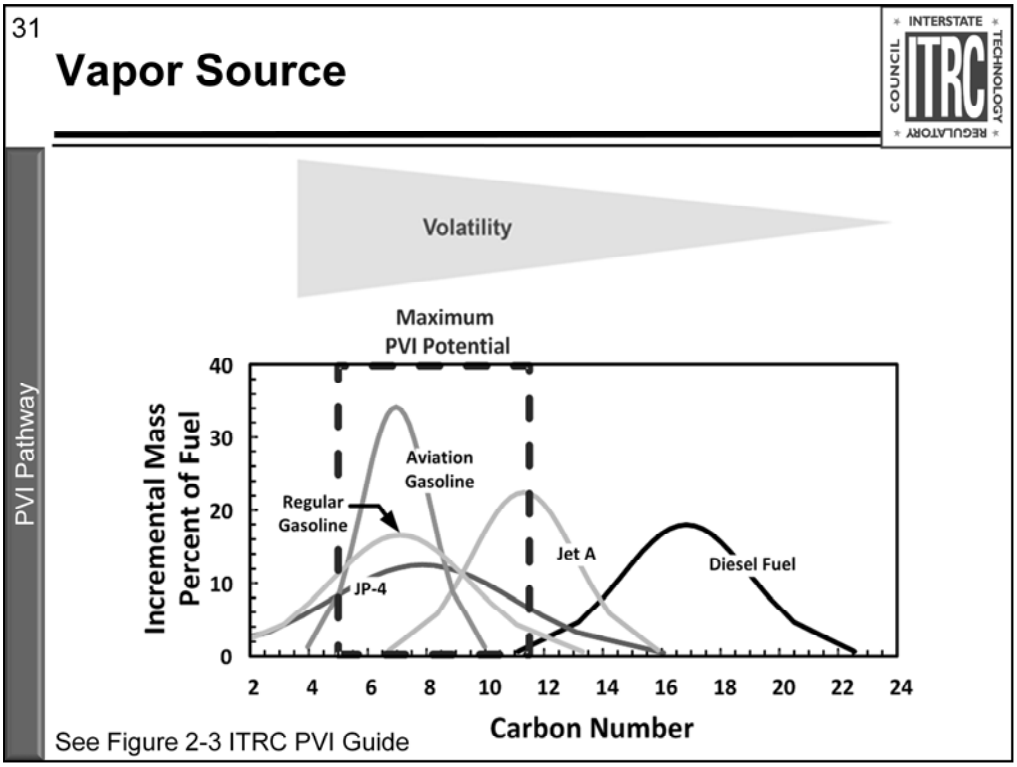
Influences on Extent and Rate of Biodegradation

PVI Pathway

Key factors:

- Concentration of vapor source
- Distance vapors need to travel to potential receptors
- Presence of O_2 between source and potential receptors

No associated notes.

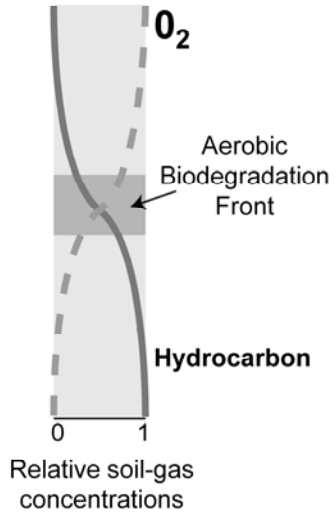


No associated notes.

32

Observed Petroleum Soil Gas Profiles

PVI Pathway



Lower Concentration Source	Higher Concentration Source
Dissolved Groundwater Source	**LNAPL** Source
Clean Soil Model	**Dirty** Soil Model
Deeper 'reaction zone'	**Shallower** 'reaction zone'
Lower VOC surface flux	**Higher** VOC surface flux
Lower Oxygen Demand	**Higher** Oxygen Demand

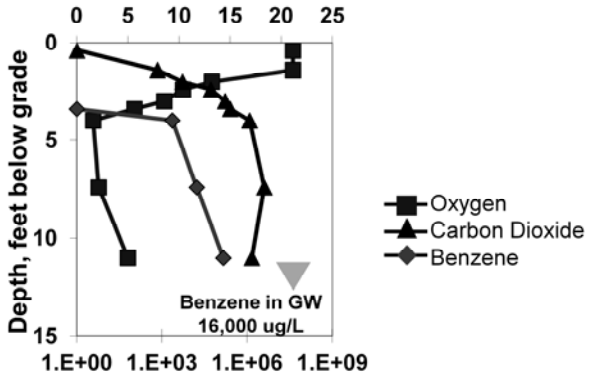
This shows a 'slice' of the conceptual model: The soil compartment

33

Evidence for Aerobic Biodegradation

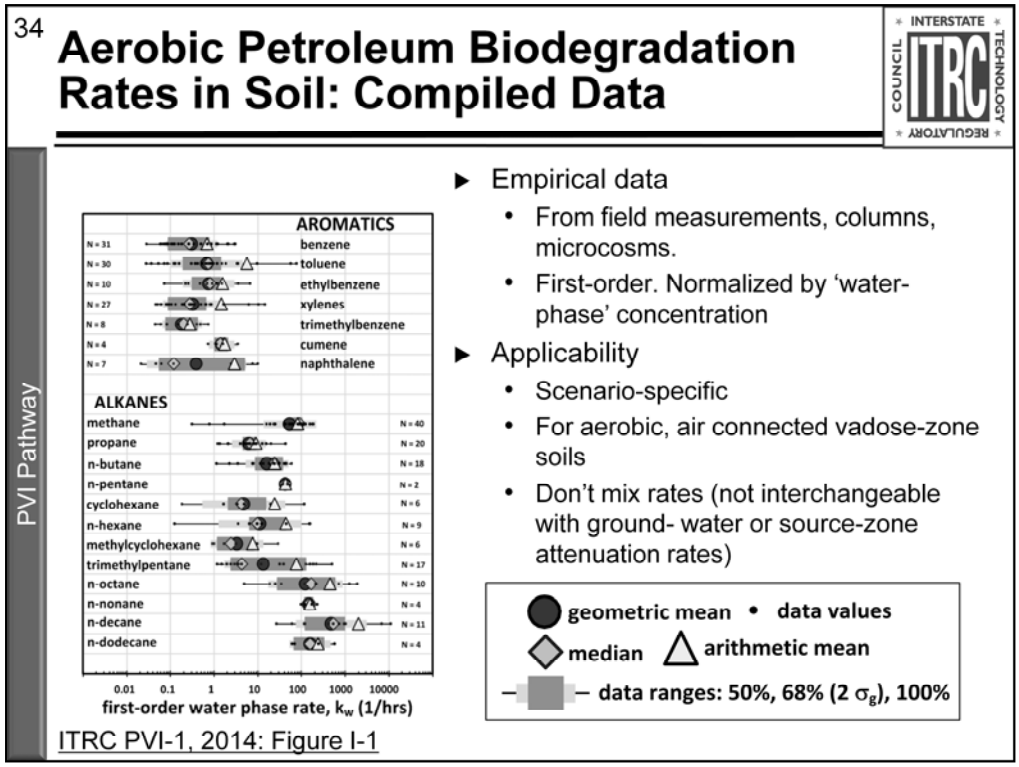
PVI Pathway

- Inverse relationship of oxygen and petroleum vapors
- Inverse relationship of oxygen and carbon dioxide



Beaufort, SC NJ-VW2 (Lahvis,et al., 1999)

This shows a 'slice' of the conceptual model: The soil compartment



From the soil gas profiles data on the prior slide, as well as a lot of other field and laboratory data, we can estimate degradation rates.

Aerobic data.

For air-connected vadose zone soils.

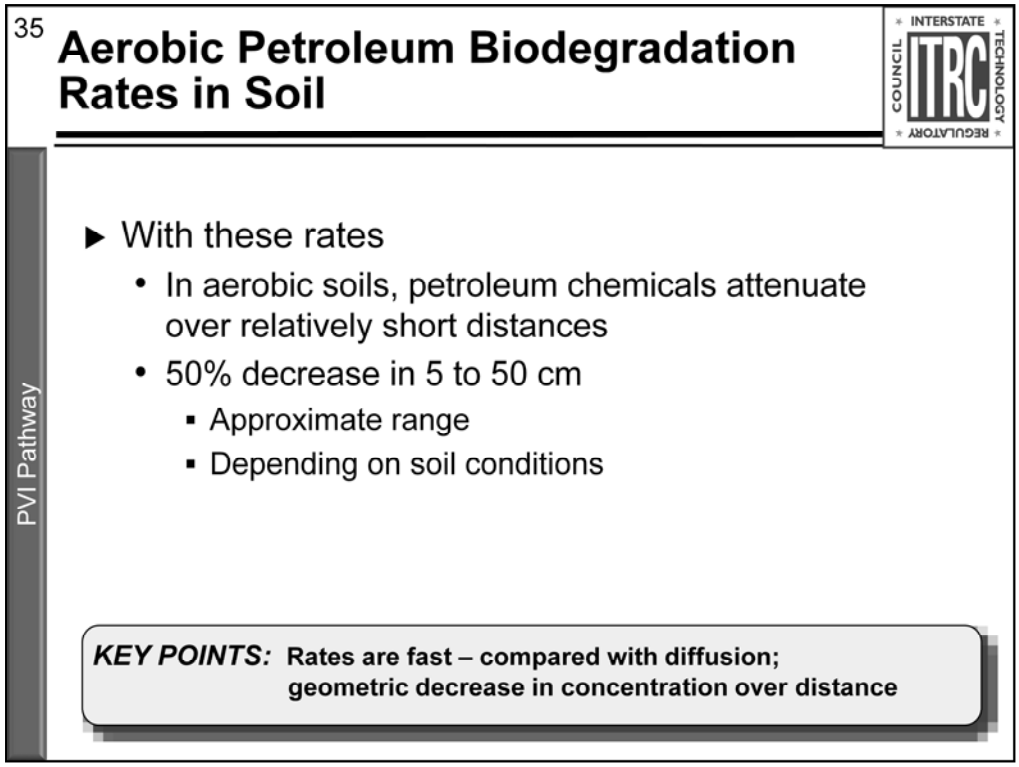
This is from the ITRC PVI guide if you want more detail.

Overall, these rates are fast (compared to soil diffusion); but not infinite.

Final note that these rates are specific to the scenario (vadose zone soils).

They are normalized to 'water phase' concentrations; since the biodegradation occurs in the water phase and at rates proportional to water-phase concentration.

Other rates (groundwater, LNAPL source depletion) are different; don't mix them up.



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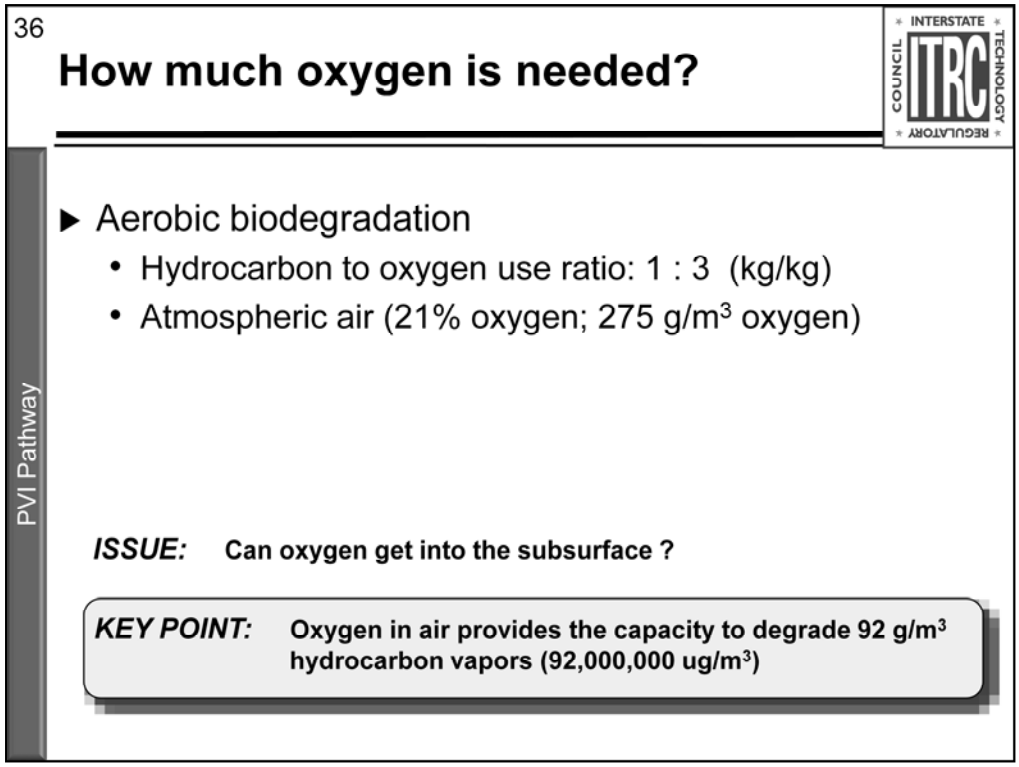

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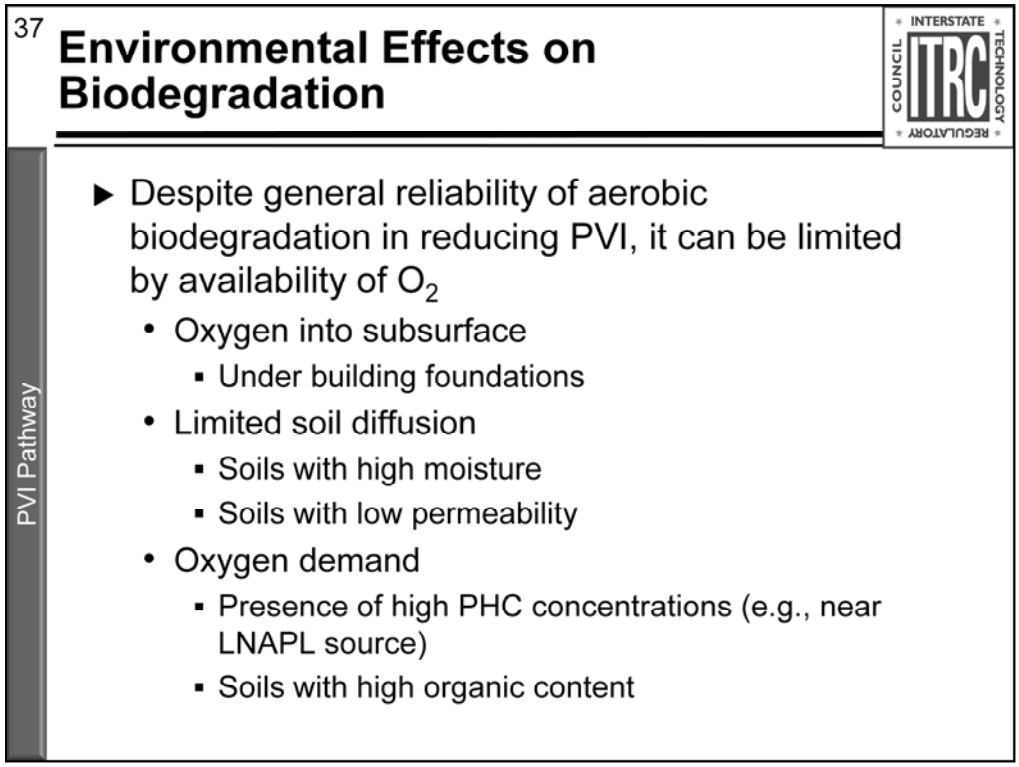
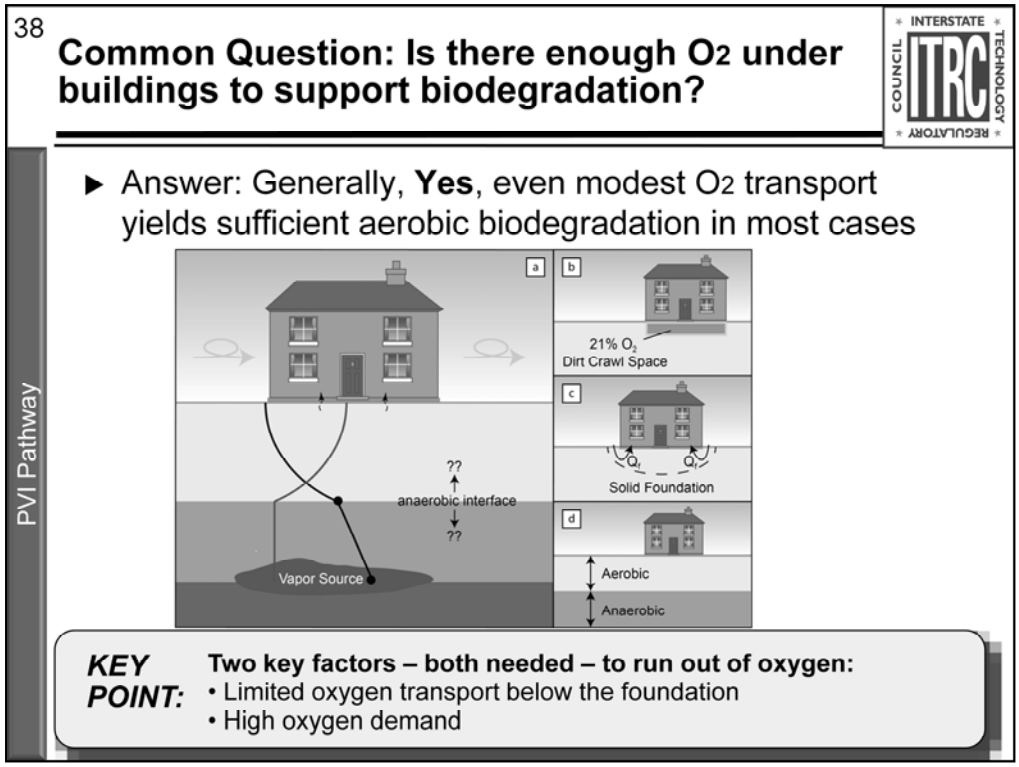


While occurs reliably, can be limited

Depends on O2 into soil

Factors such as foundations, soils, distance (in soil) can limit oxygen in the subsurface.

Also oxygen demand from other petroleum chemicals, or from organic matter in soil (such as very peaty soils) will have high oxygen demand.



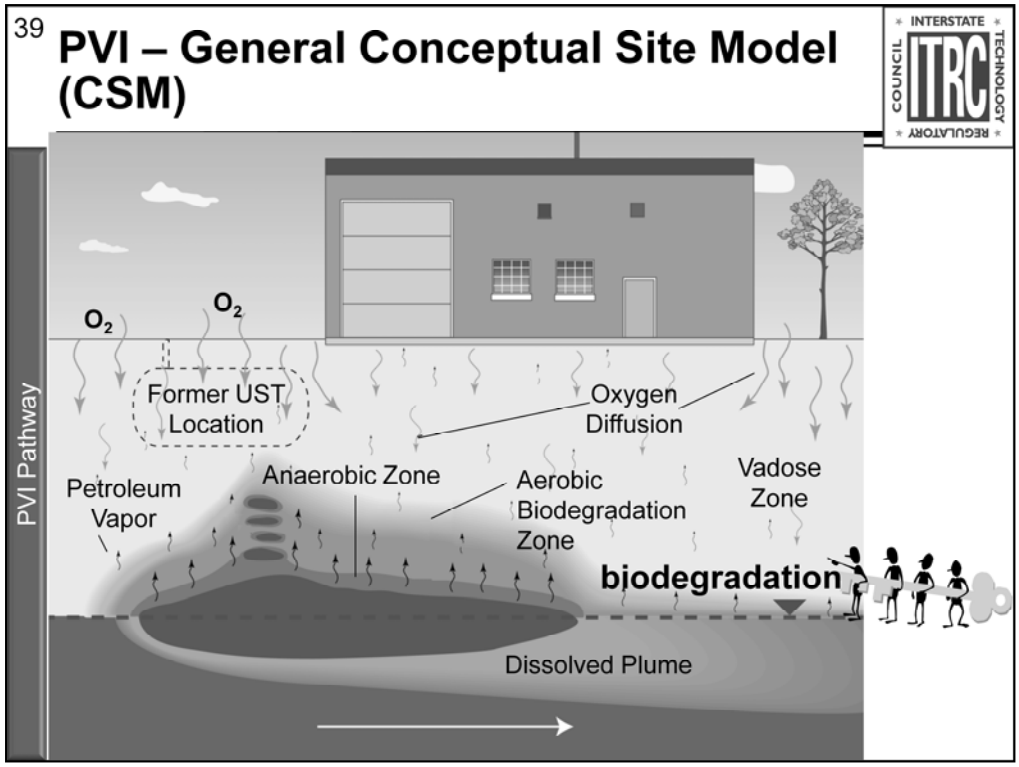
Question:

Does O_2 get into soils?

Answer:

Generally yes.

It is hard to keep 21% O_2 in ambient air out of unsaturated soils.



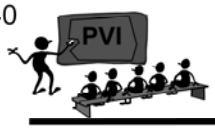
Showing a figure for a – revisited – conceptual model.

Shows both petroleum vapors and O2

Degradation zone within the soil layer

Separation between the vapor ‘source’ and the building foundation.

40



Community Engagement
What is PVI?

INTERSTATE COUNCIL ITRC TECHNOLOGY REGULATORY

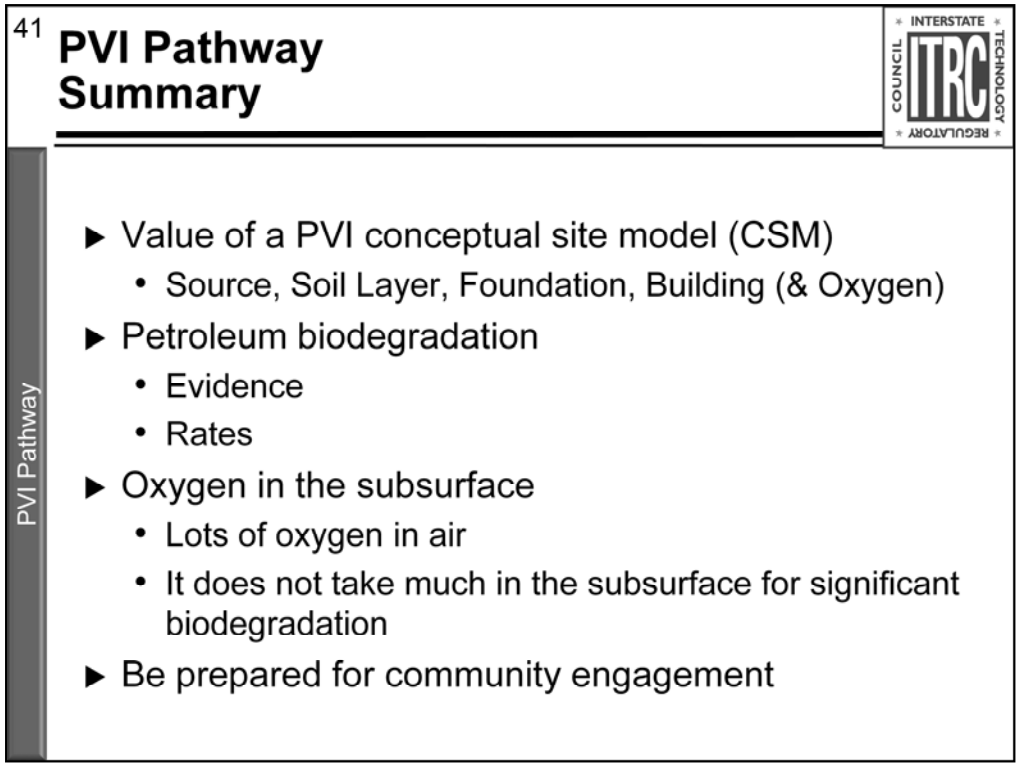
Community Engagement

- What is VI? What is PVI?
- What is aerobic biodegradation
- What is the most common cause of PVI?
- Where is PVI most likely to occur
- What are the health effects caused by PVI?
- What do I do if I suspect that PVI is occurring?
- Where can I find more information about PVI?

Petroleum Vapor Intrusion: Frequently Asked Questions
What is Petroleum Vapor Intrusion?
(PVI FAQ Sheet 1)

ITRC PVI-1, 2014: Appendix K – Frequently Asked Questions Fact Sheets

No associated notes.



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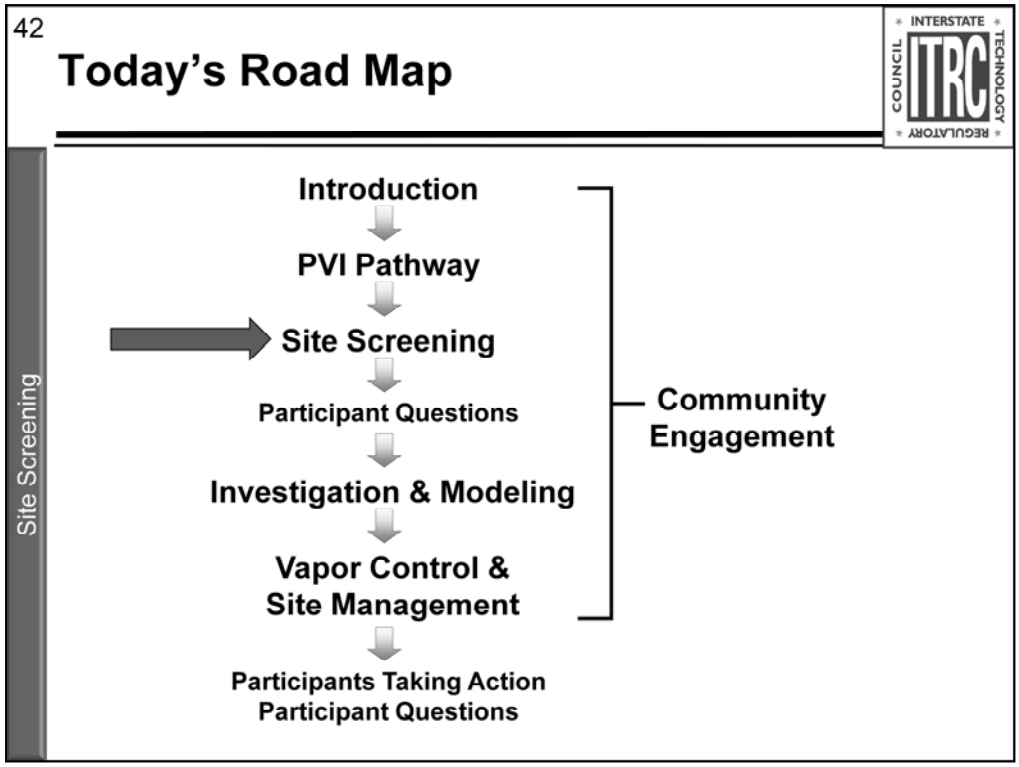

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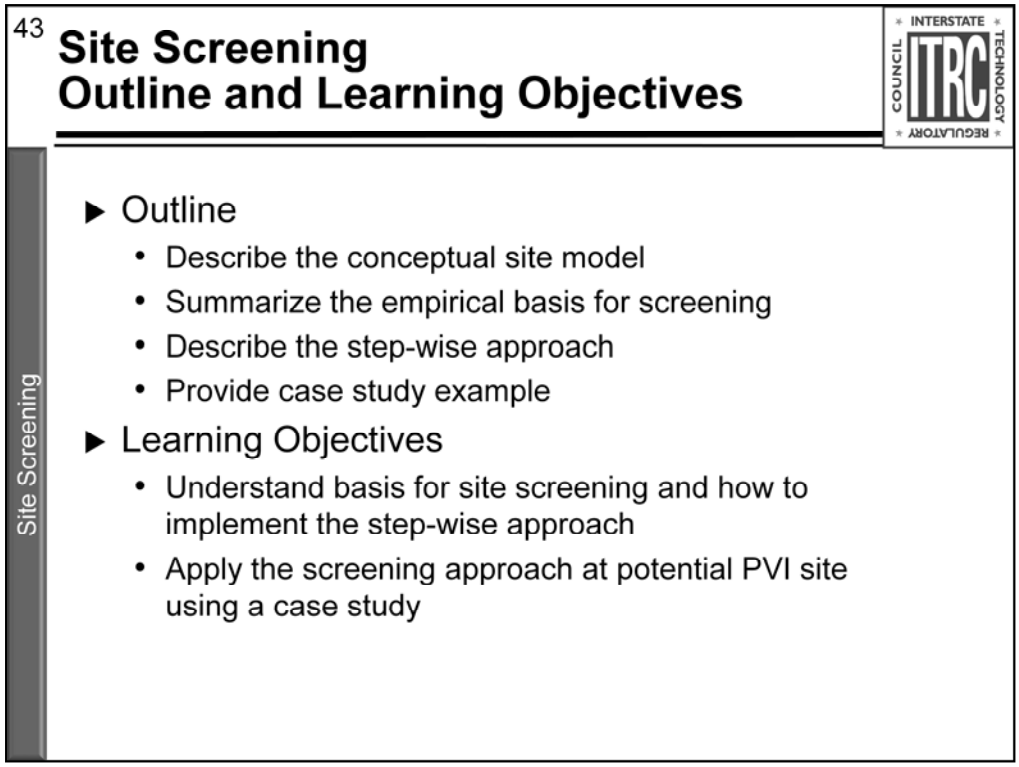

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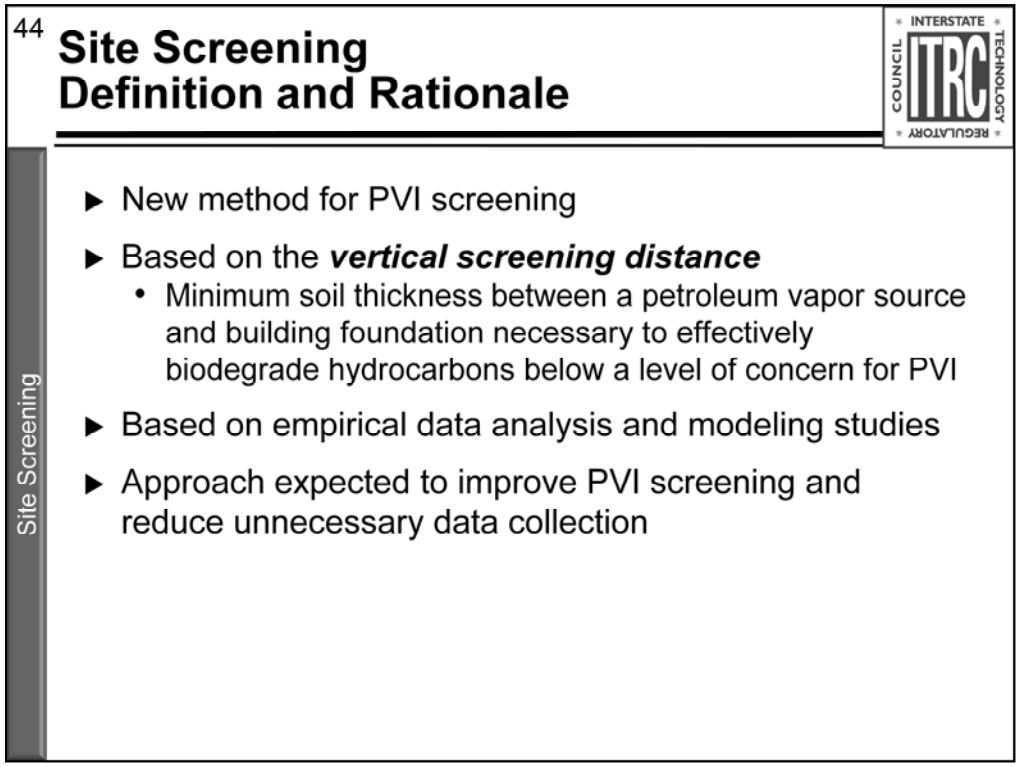

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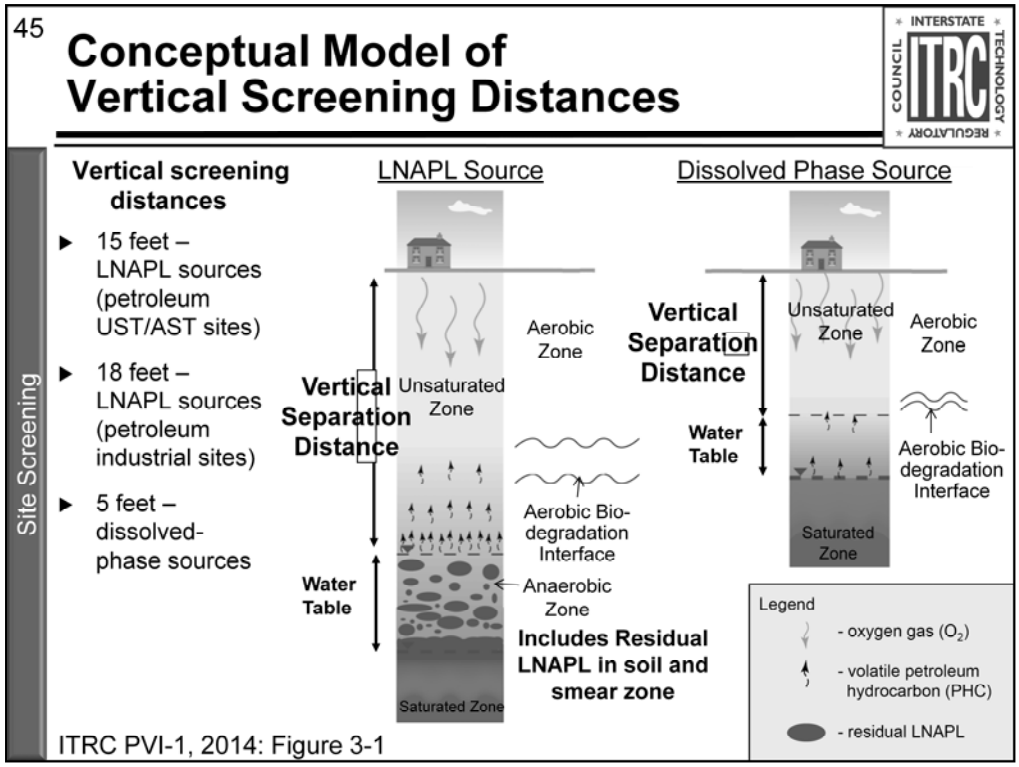
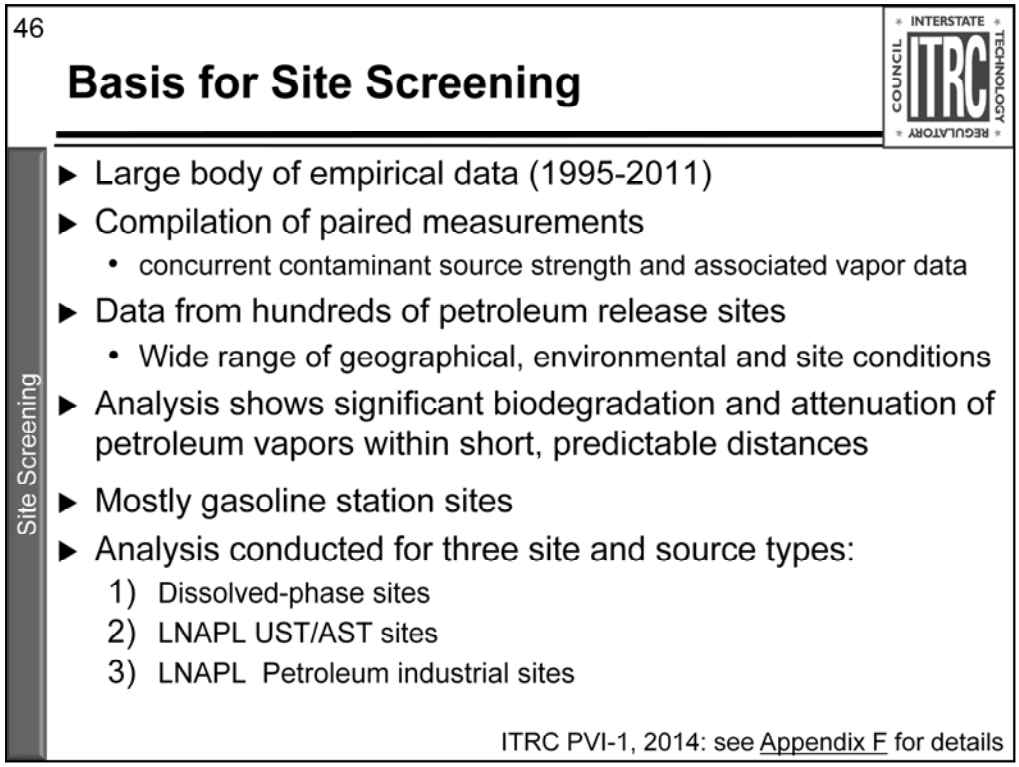


UST – underground storage tanks

AST – above ground storage tanks



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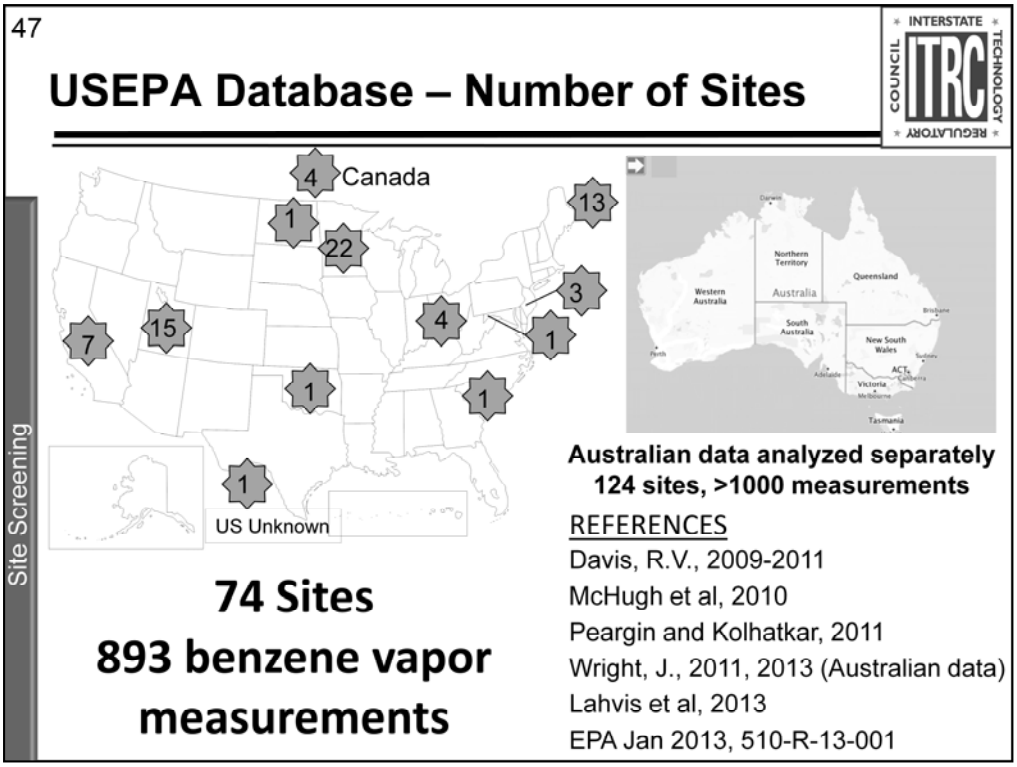

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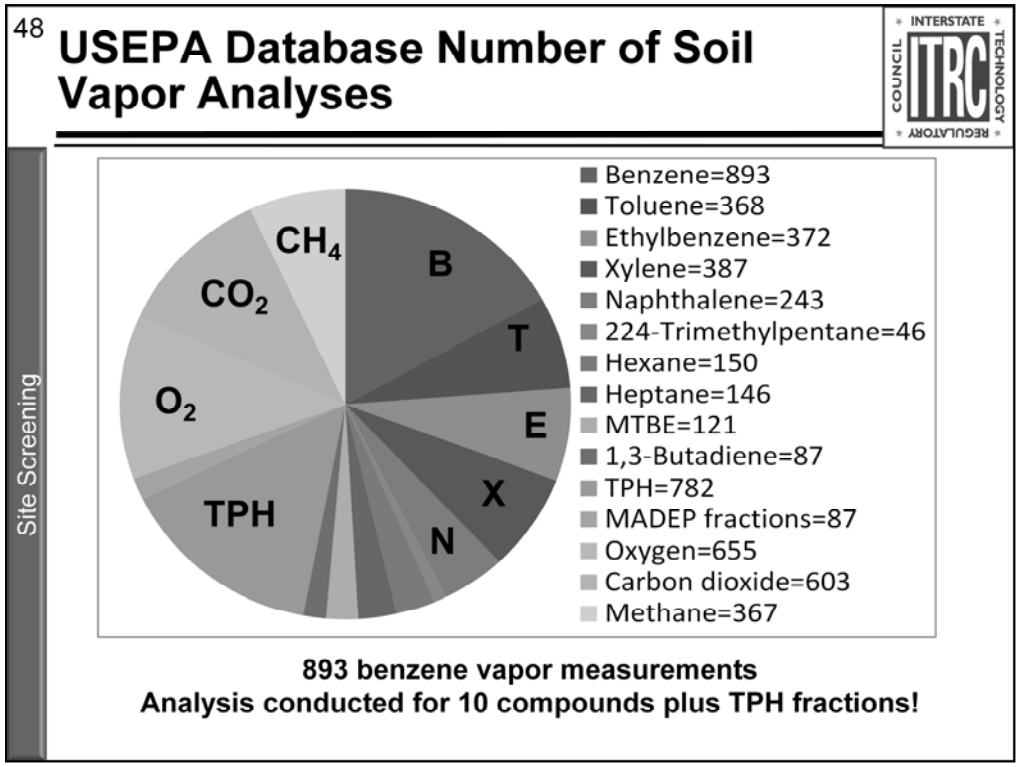

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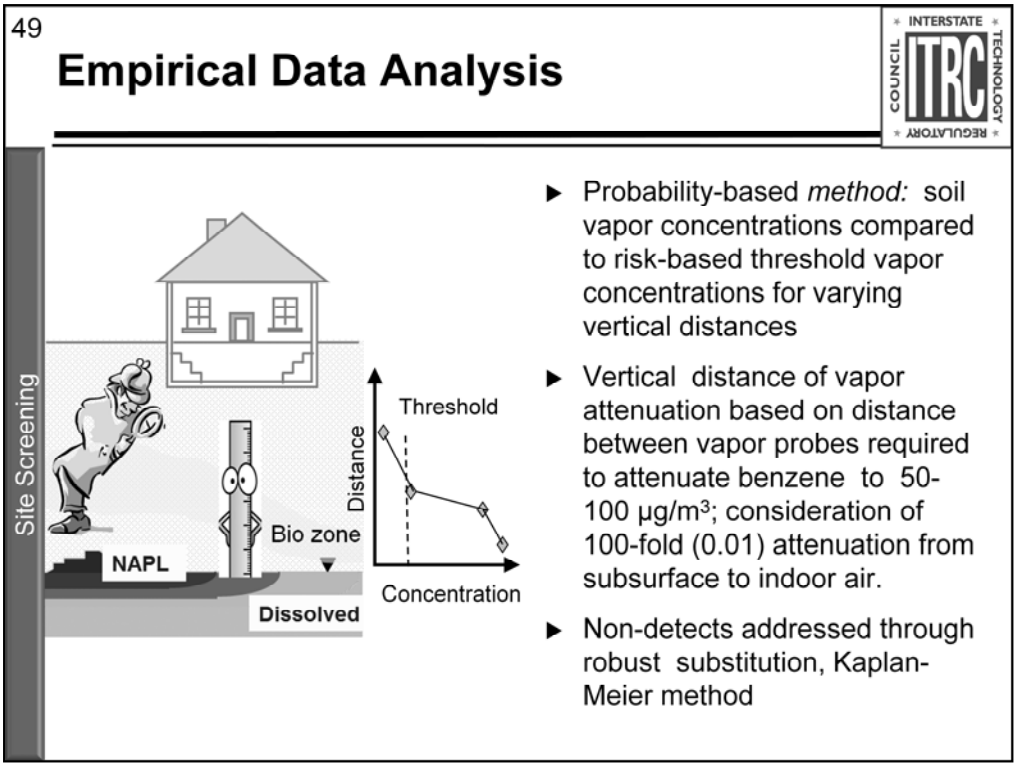

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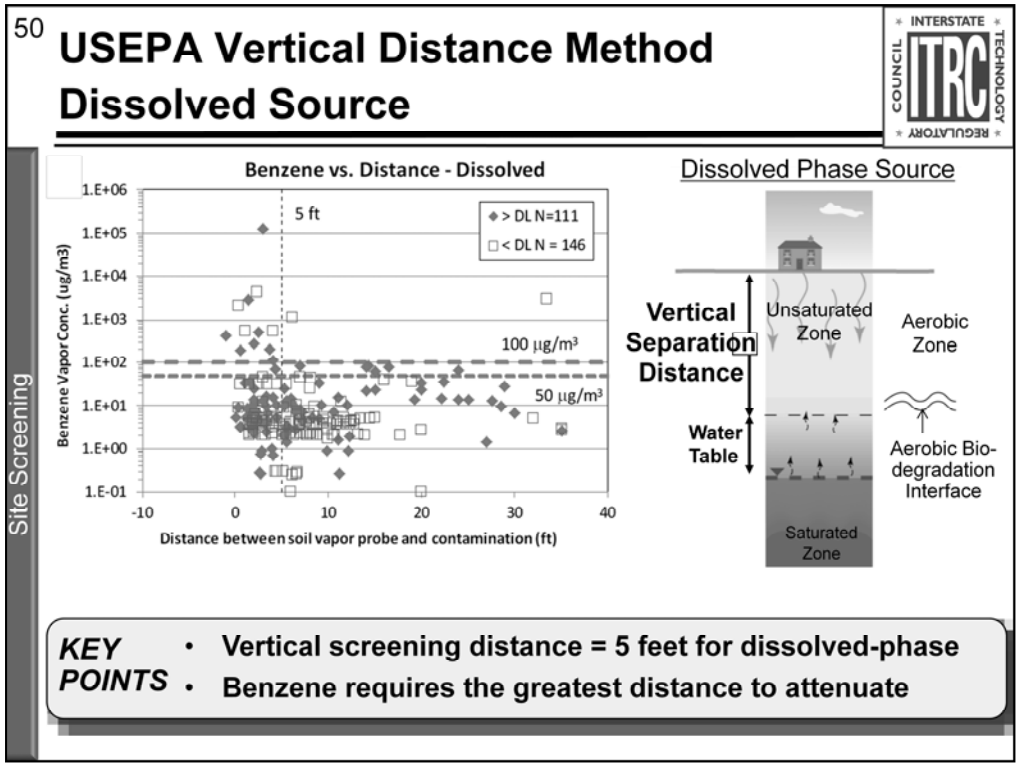

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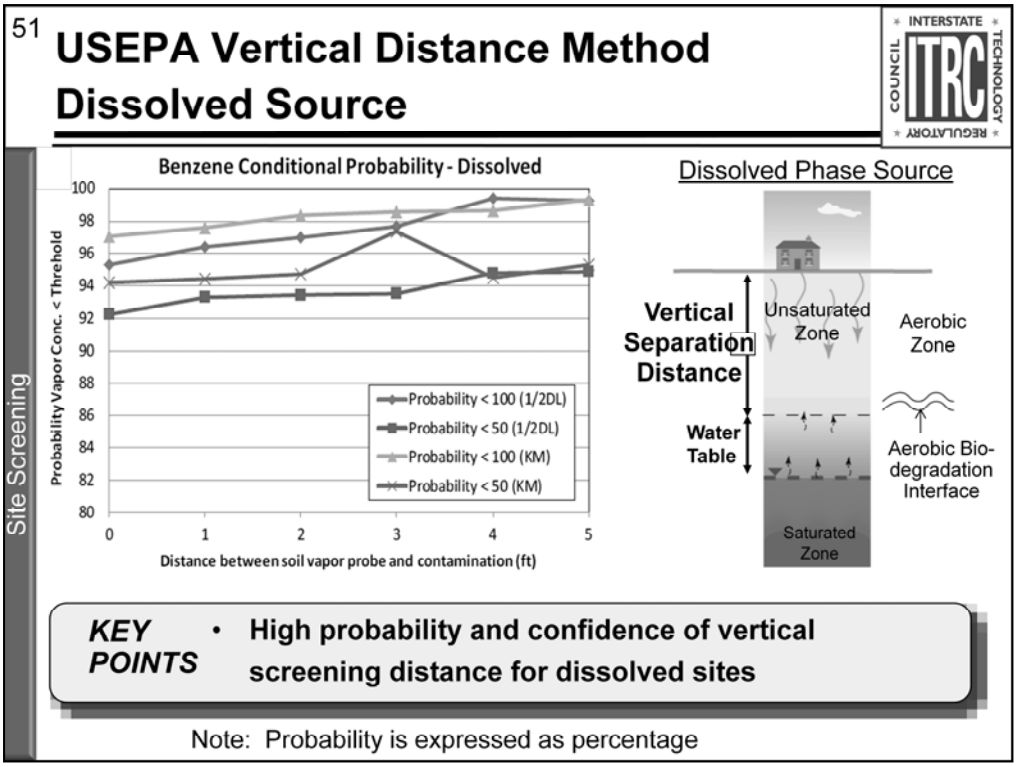

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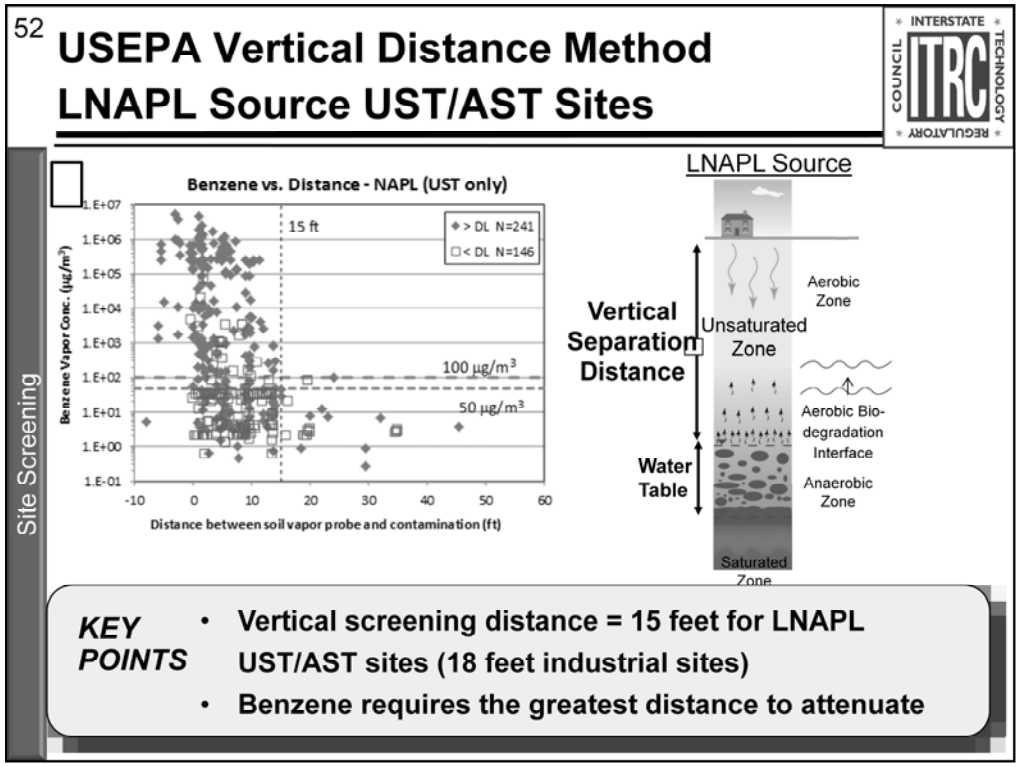
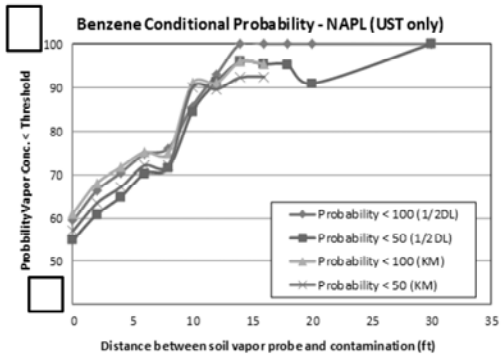


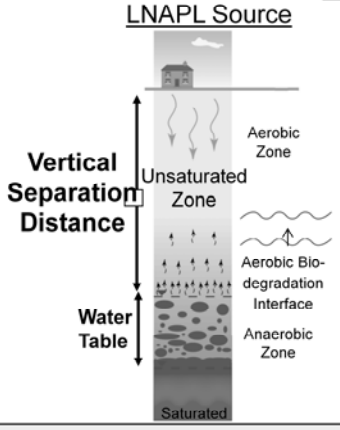
No associated notes.

53

USEPA Vertical Distance Method LNAPL Source UST/AST Sites

Site Screening





KEY POINTS

- **High probability and confidence of vertical screening distance for small UST/AST sites**
- **Slightly less confidence in industrial sites due to small data set**

No associated notes.

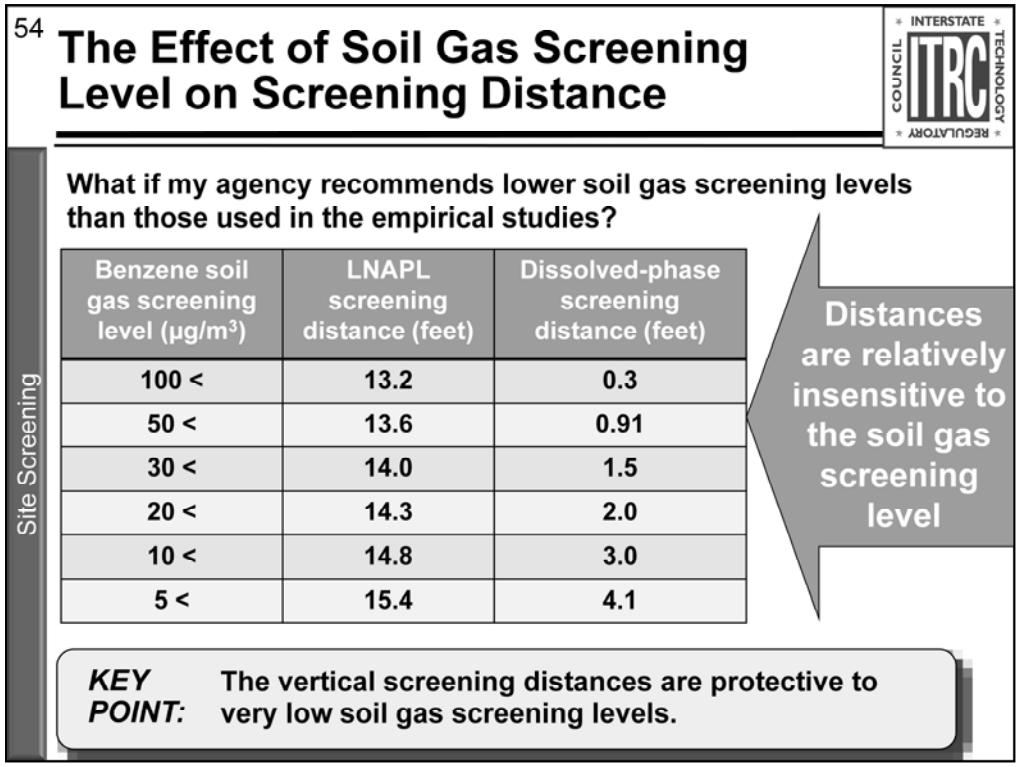
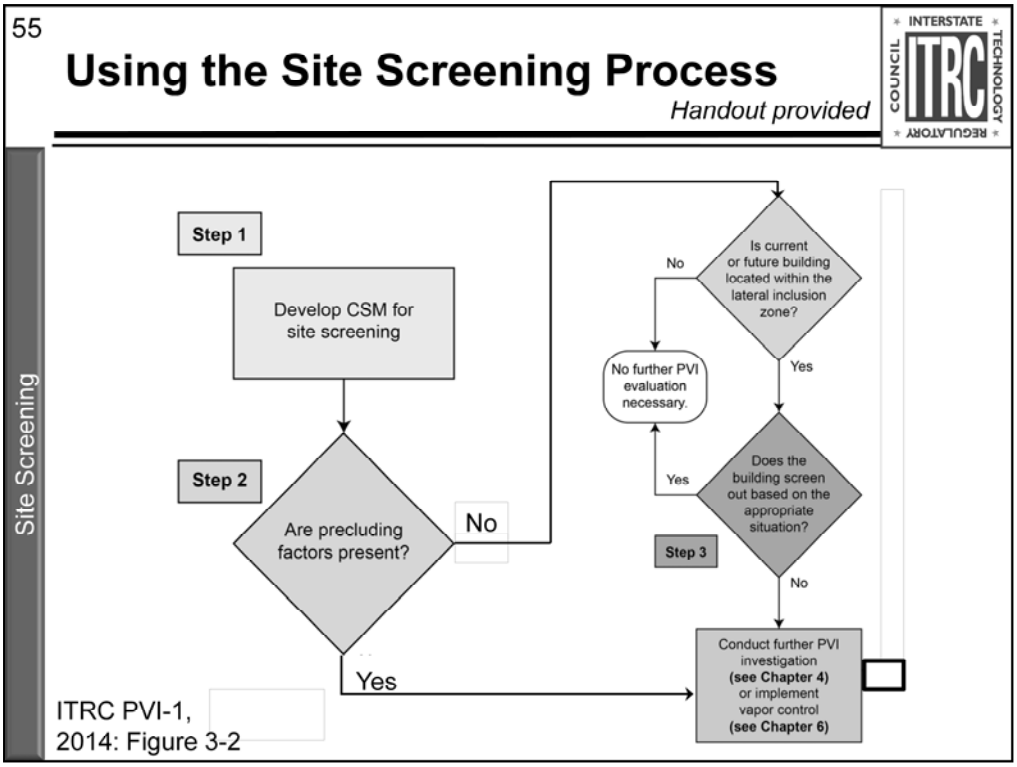


Table from Appendix F



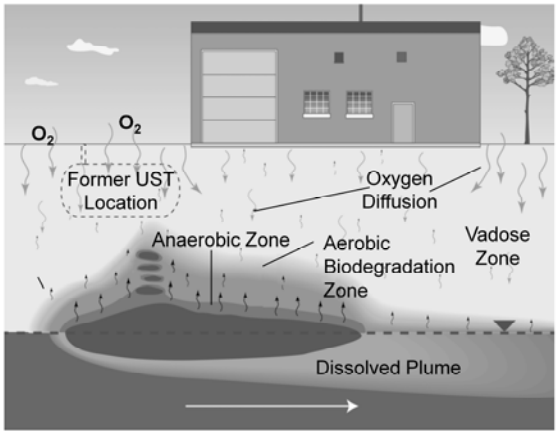
No associated notes.

56

Step 1: Develop Conceptual Site Model (CSM)

Site Screening

- Preliminary CSM using soil and groundwater data collected as part of routine initial site investigation
- Visualization of site conditions, allows for evaluation of contaminant sources and impacted media, migration pathways, and potential receptors
- For PVI CSM
  1. Site type
  2. Petroleum vapor source
  3. Extent of source
  4. Precluding factors
  5. Lateral inclusion zone
  6. Vertical separation distance



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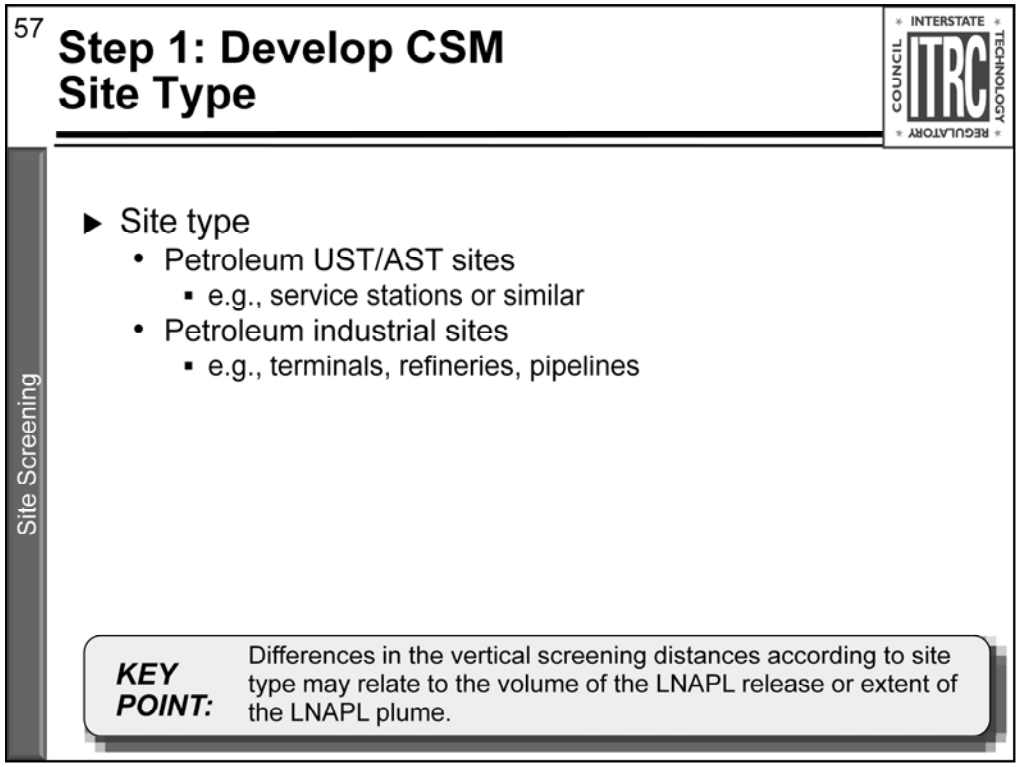
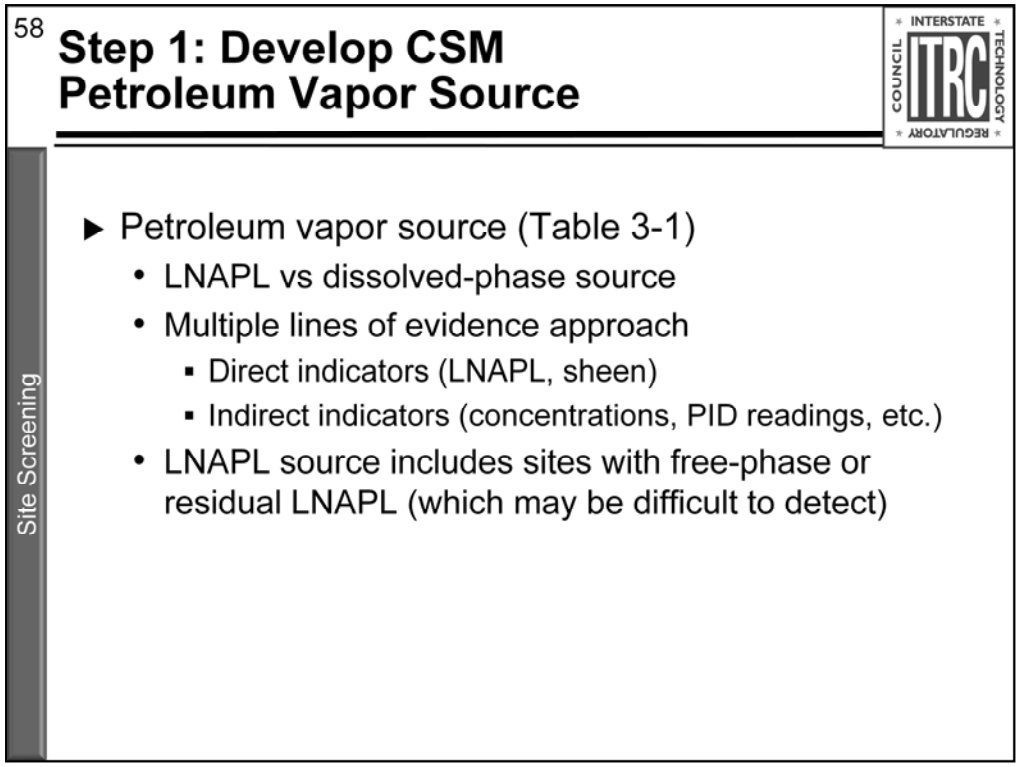


No associated notes.



No associated notes.

59

Step 1: Develop CSM Petroleum Vapor Source

Site Screening

Table 3-1. General LNAPL indicators for PVI screening

Indicator	Comments
Groundwater	
• Benzene: > 1 - 5 mg/L • $TPH_{(gasoline)}$: > 30 mg/L • BTEX: > 20 mg/L • Current or historical presence of LNAPL (including sheens)	There is not a specific PHC concentration in groundwater that defines LNAPL because of varying product types and degrees of weathering.
Soil	
• Current or historical presence of LNAPL (including sheens, staining) • Benzene > 10 mg/kg • $TPH_{(gasoline)}$ > 250 - 500 mg/kg • Ultraviolet fluorescence (UV) or laser induced fluorescence (LIF) fluorescence response in LNAPL range • PID or FID readings > 500 ppm	• The use of TPH soil concentration data as LNAPL indicators should be exercised with caution. • TPH soil concentrations can be affected by the presence of soil organic matter. • TPH soil concentrations are not well correlated with TPH or O_2 soil gas concentrations (Lahvis and Hers 2013b).
Location relative to UST/AST	
• Adjacent (e.g., within 20 feet of) a known or suspected LNAPL release area or petroleum equipment	The probability of encountering LNAPL increases closer

Notes:

1 One or more of these indicators may be used to define LNAPL.

2 Value used in the derivation of screening distances by USEPA (2013a) and Lahvis and Hers (2013b).

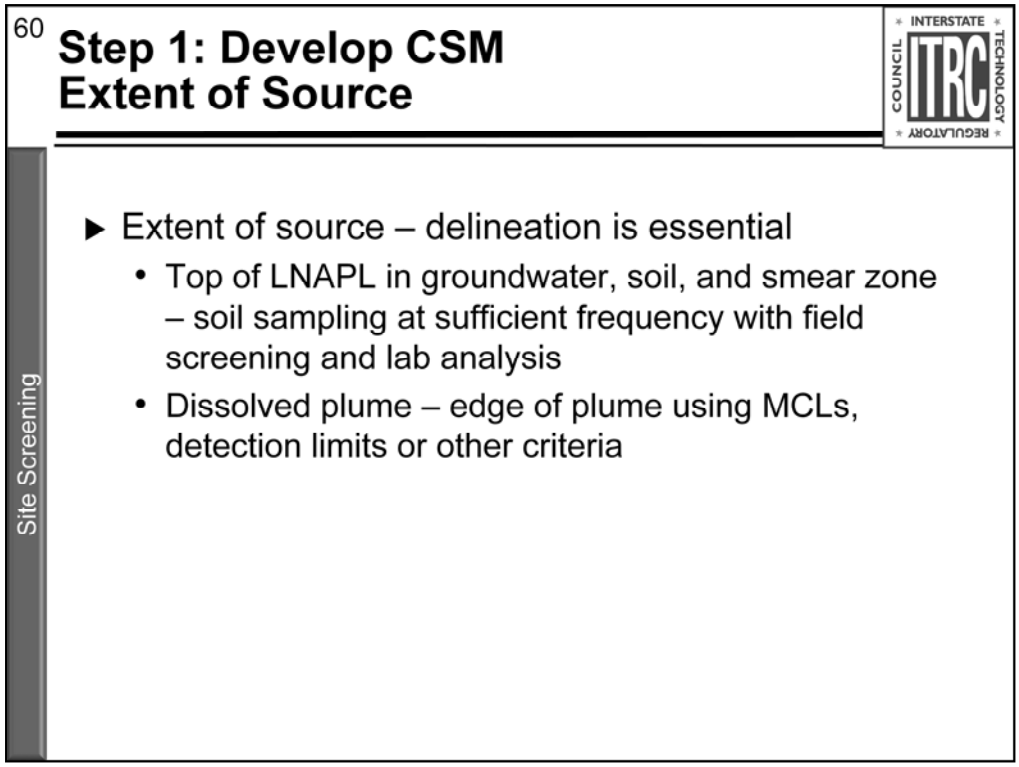
3 Value used in the derivation of screening distances by Peargin and Kolhatkar (2011).

4 Value used in the derivation of screening distances by USEPA (2013a).

5 Value recommended by Lahvis and Hers (2013b).

6 Value is from ASTM E2531-06.

7 Value recommended by USEPA (2013a) and Lahvis and Hers (2013b).



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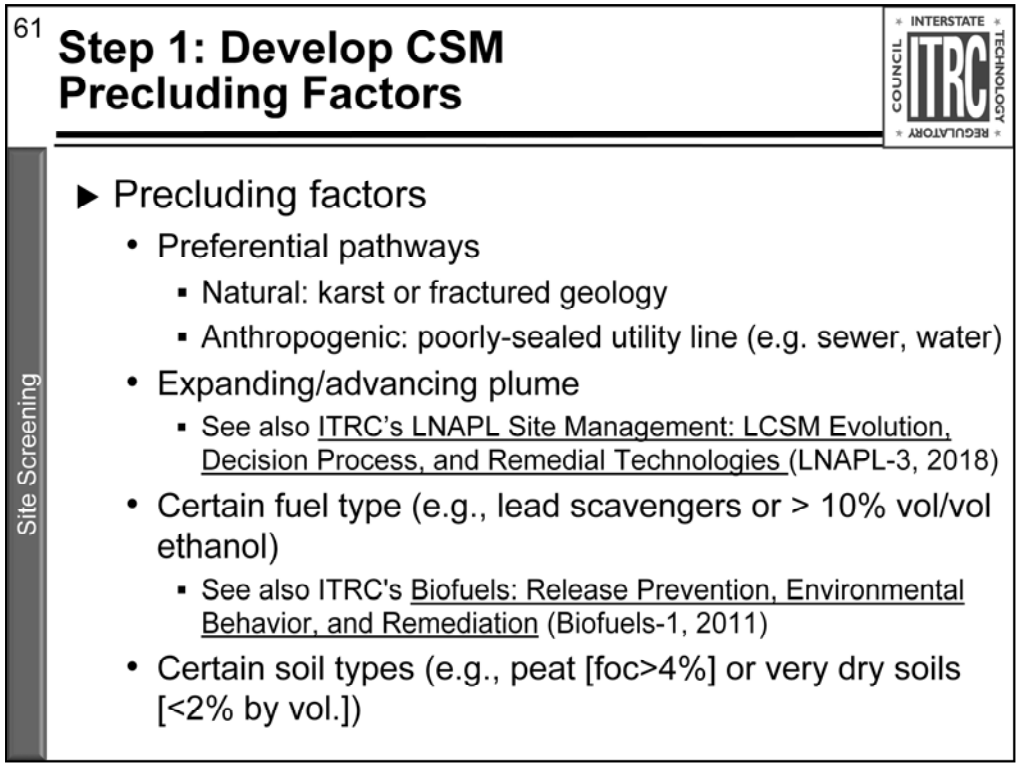
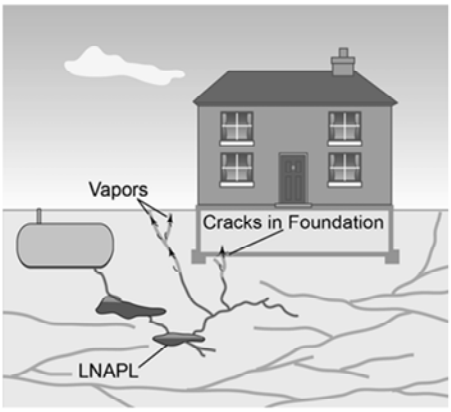


No associated notes.

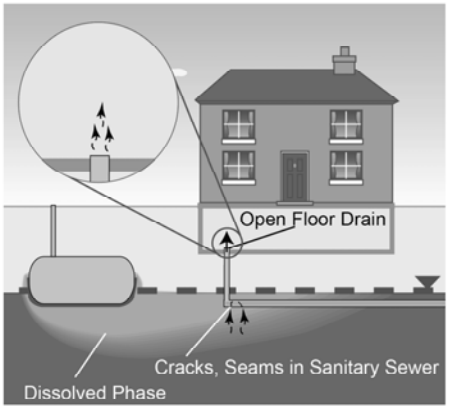
62

Precluding Factors – Preferential Pathways

Site Screening



Precluding factor: fractured or karst geology



Precluding factor: conduit intersecting source and entering building

ITRC PVI-1, 2014: Figure 3-3, 3-4

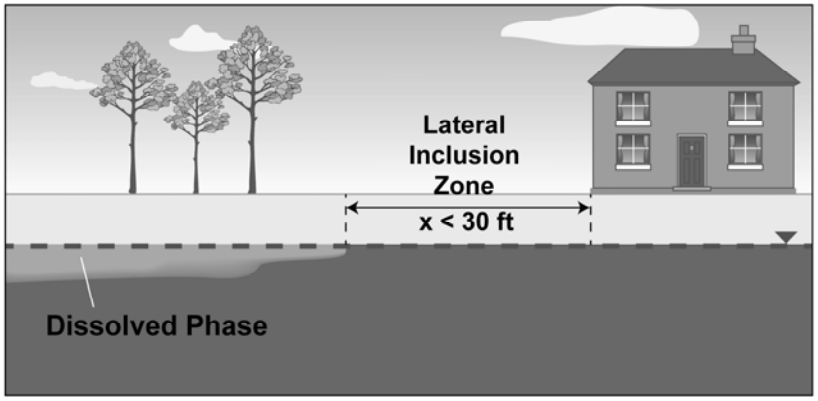
No associated notes.

63

Step 1: Develop CSM Lateral Inclusion Zone

Site Screening

- Lateral inclusion zone
  - 30’ from leading edge of contamination to building
  - Leading edge defined by regulatory level



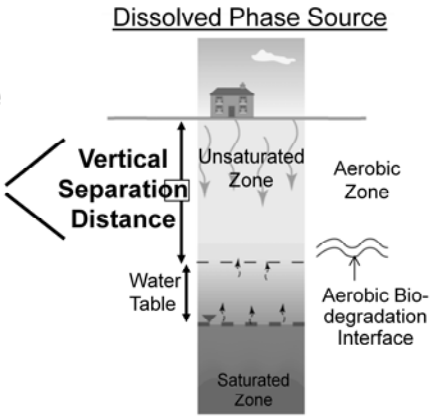
No associated notes.

64

Step 1: Develop CSM
Vertical Separation Distance

Site Screening

- Vertical separation distance
  - Measured from top of the petroleum vapor source to the bottom of the building foundation
    - Consider water table fluctuations



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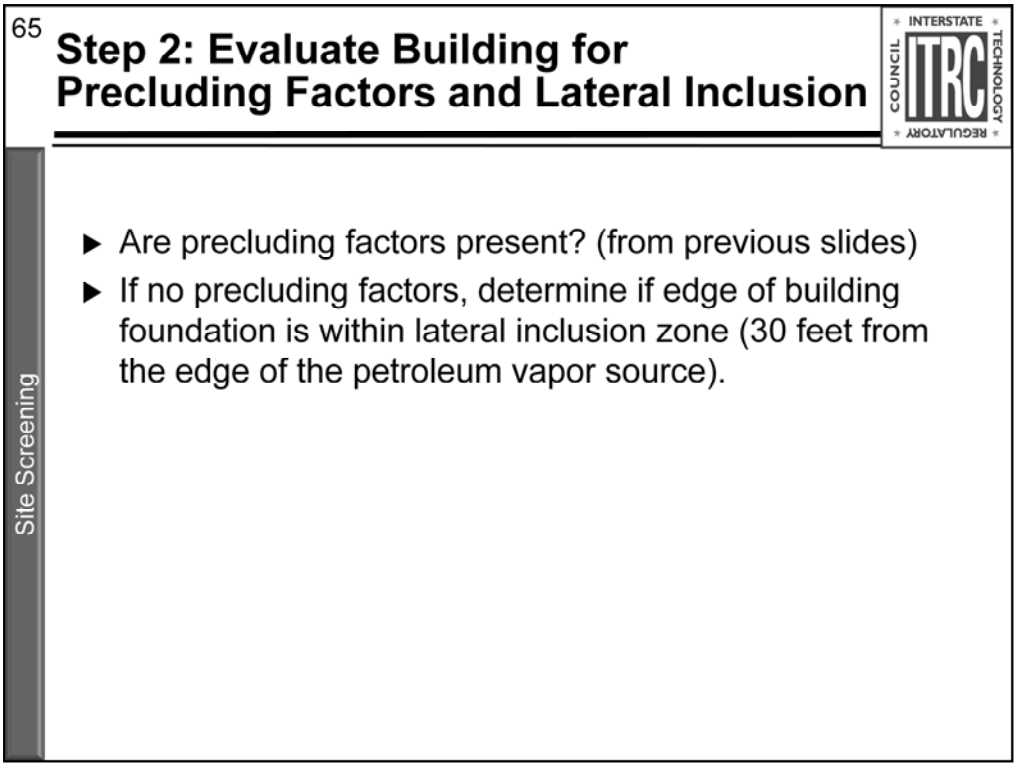


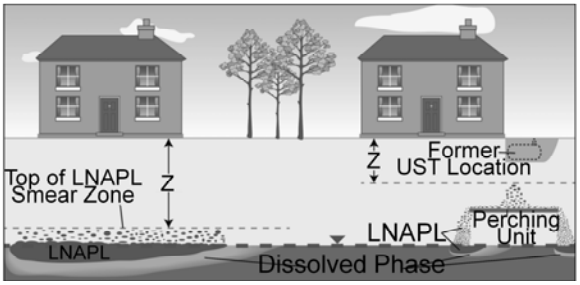
No associated notes.

66

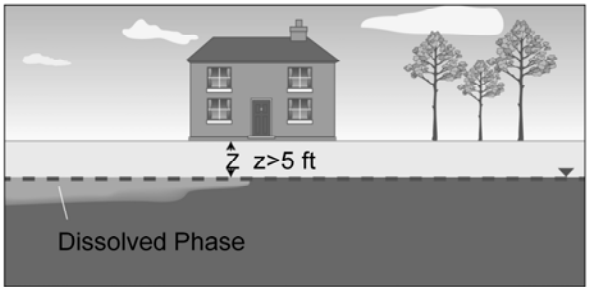
Step 3: Conduct Screening with Vertical Separation Distance

Site Screening

- LNAPL
  - Petroleum UST/AST = 15 ft
  - Industrial = 18 ft



- Dissolved Phase Source
  - All petroleum site types = 5 ft



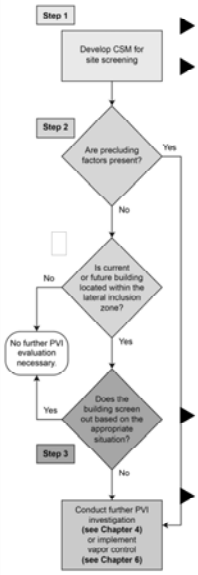
ITRC PVI-1, 2014:
Figure 3-5, 3-6

No associated notes.

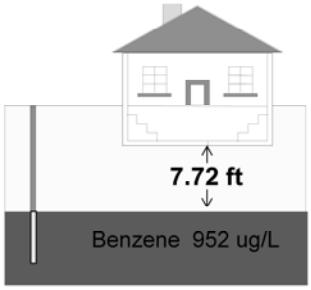
67

Case Study Using Vertical Screening: Santa Clara, Utah

Case Study

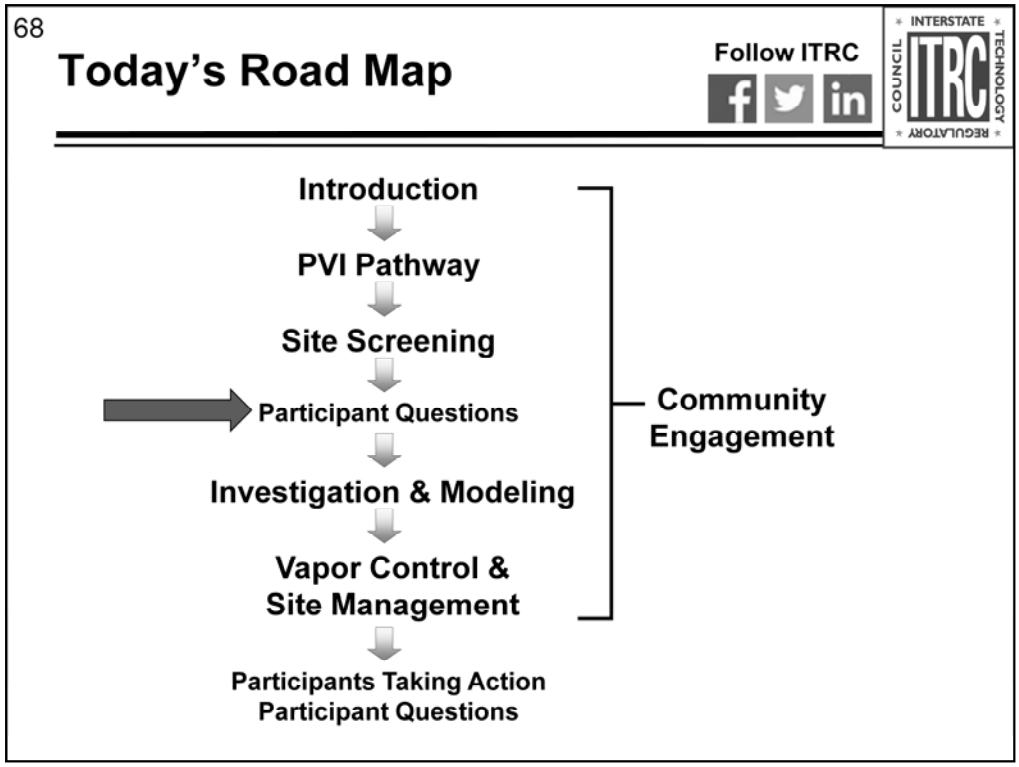


- Step 1: Develop CSM
- Step 2:
  - Precluding Factors?
    - No preferential pathways
    - Plume stable/shrinking
    - No lead scavengers and <10% ethanol
  - Within Lateral Inclusion Distance?
    - Yes (building <30 ft from dissolved source)
- Step 3: Sufficient Vertical Separation?
  - Yes (Dissolved source 7.72 ft below basement slab)
- Further PVI Investigation?
  - UT DEQ determined PVI pathway not complete



Courtesy Robin Davis UT DEQ

No associated notes.



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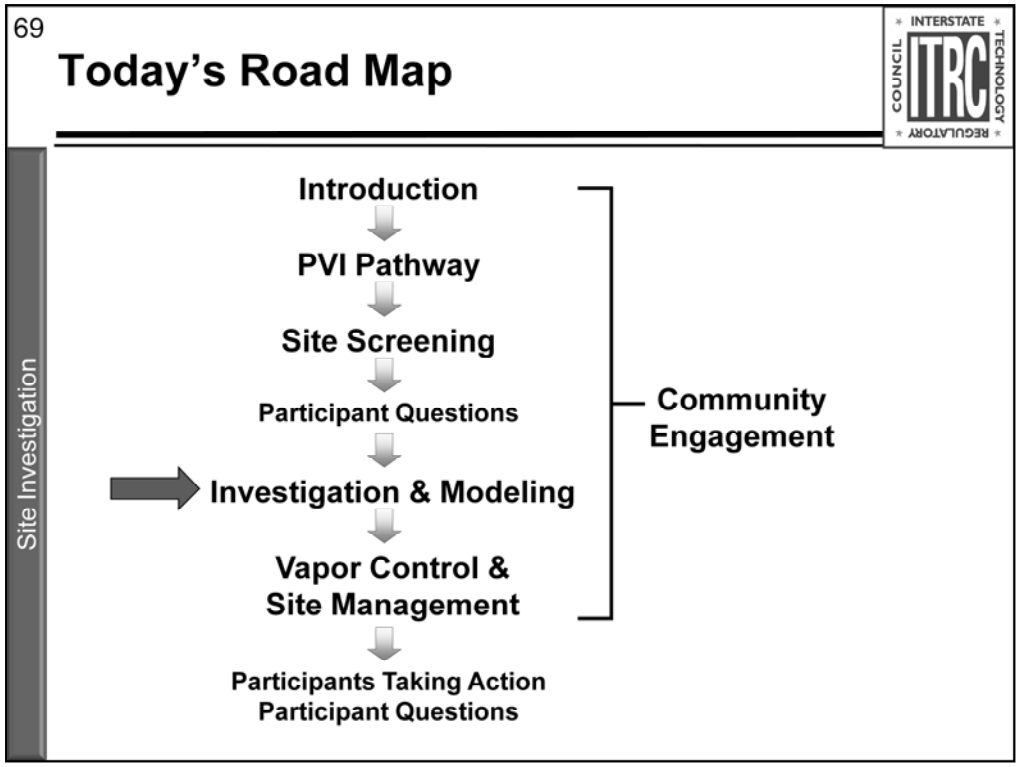


No associated notes.

70

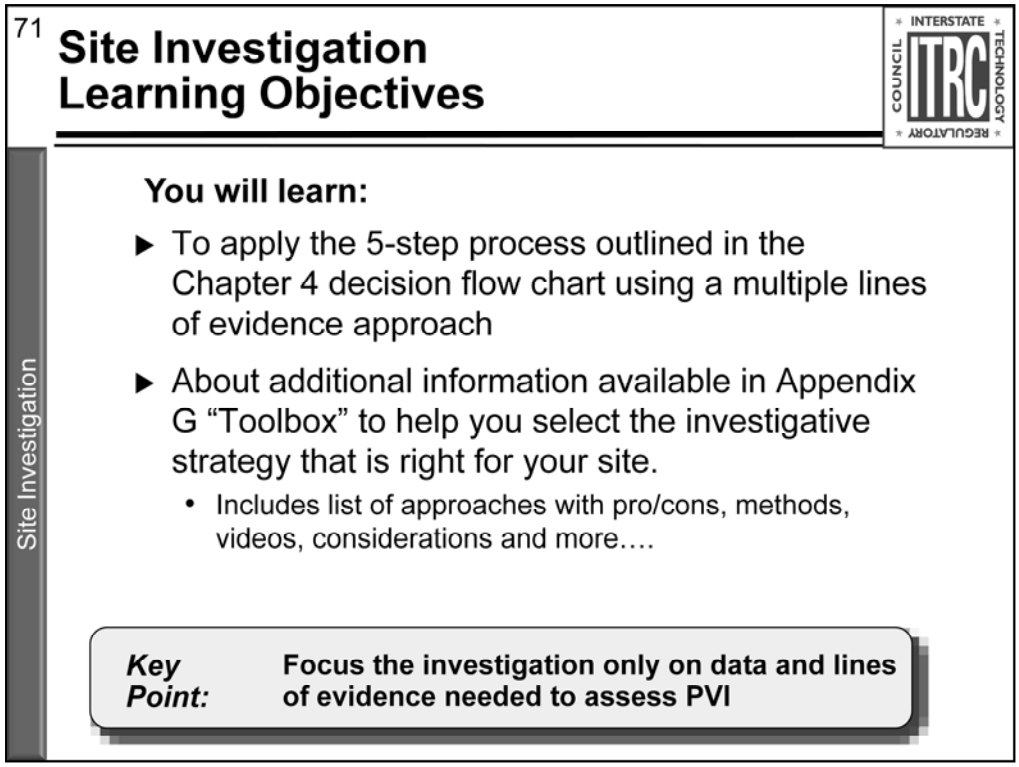
Site Investigation Overview

Site Investigation

- Site Screening (Chapter 3) did not eliminate PVI from further consideration due to:
  - Insufficient vertical separation distance
  - Precluding factors
  - Regulatory requirements
- What now?

- Site Investigation (Chapter 4) and Investigation Methods and Analysis Toolbox (Appendix G)

No associated notes.



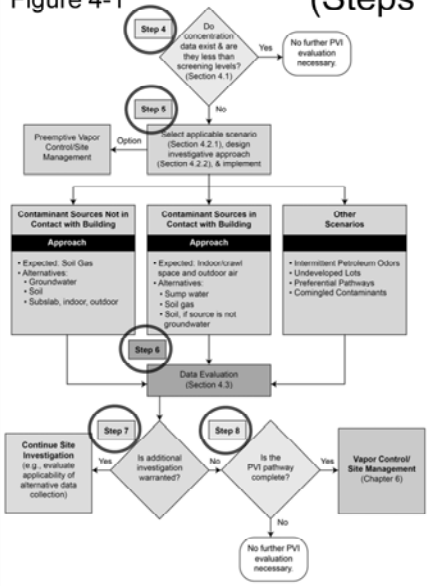
No associated notes.

72

Site Investigation Process and Flow Chart

Site Investigation

Figure 4-1



(Steps 1-3 in Chapter 3, Site Screening)

Step 4: Concentration-Based Evaluation

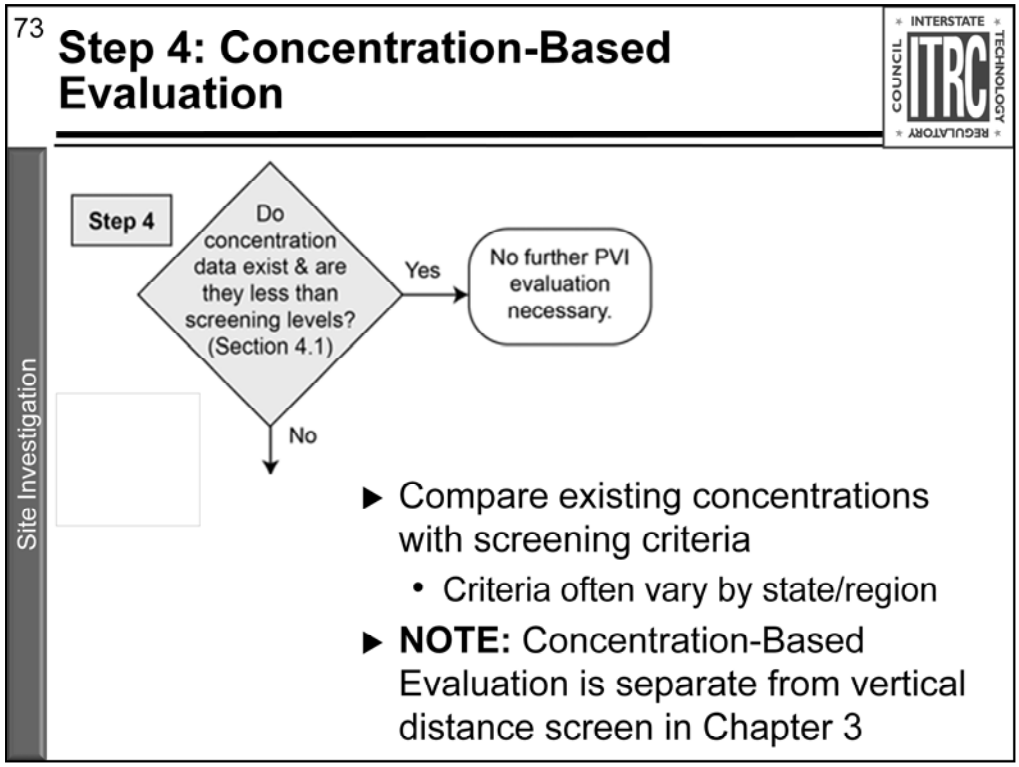
Step 5: Select Scenario and Design Investigation Approach

Step 6: Evaluate Data

Step 7: Determine Need for Additional Investigation

Step 8: Determine if PVI Pathway Complete

No associated notes.



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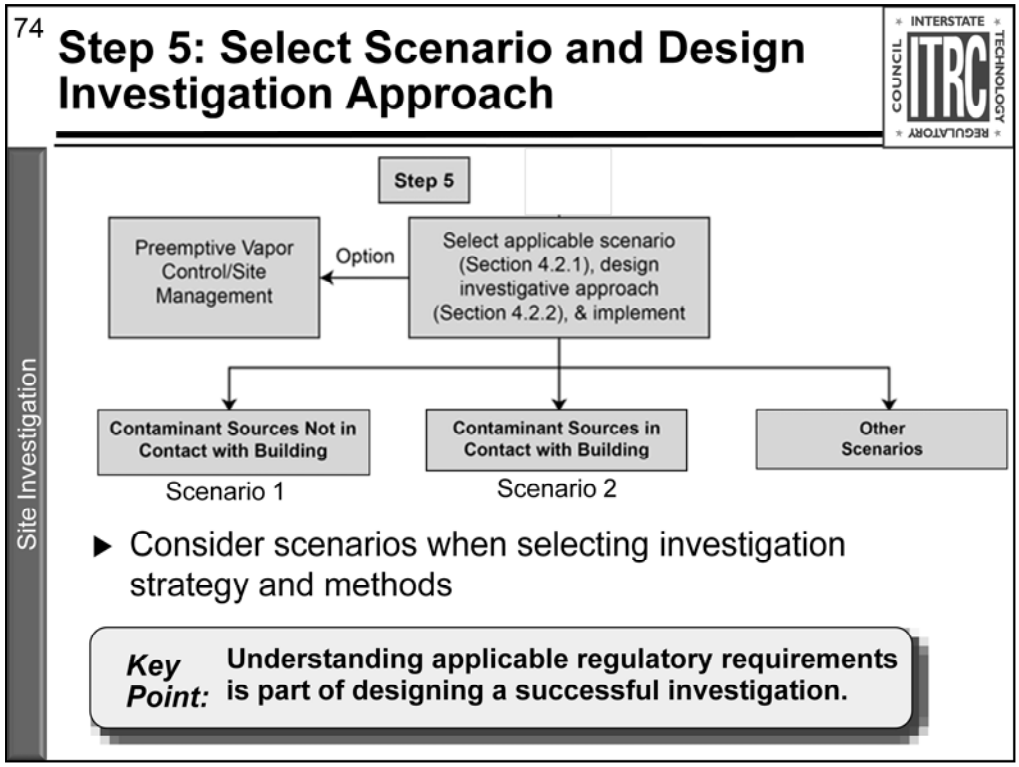

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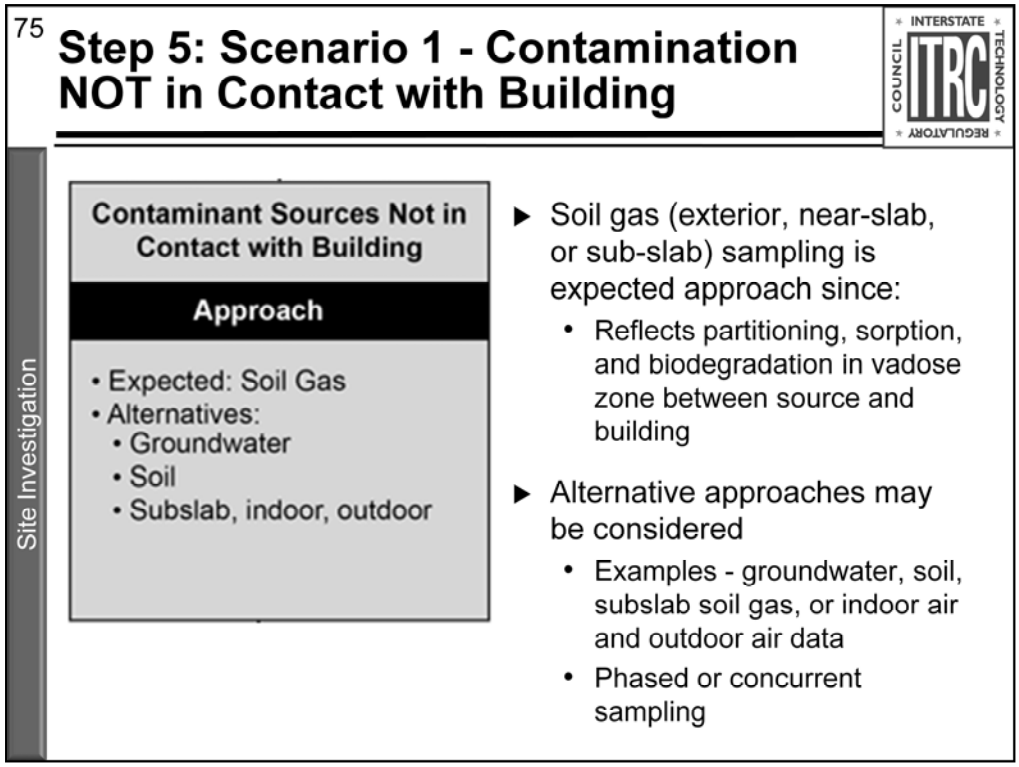

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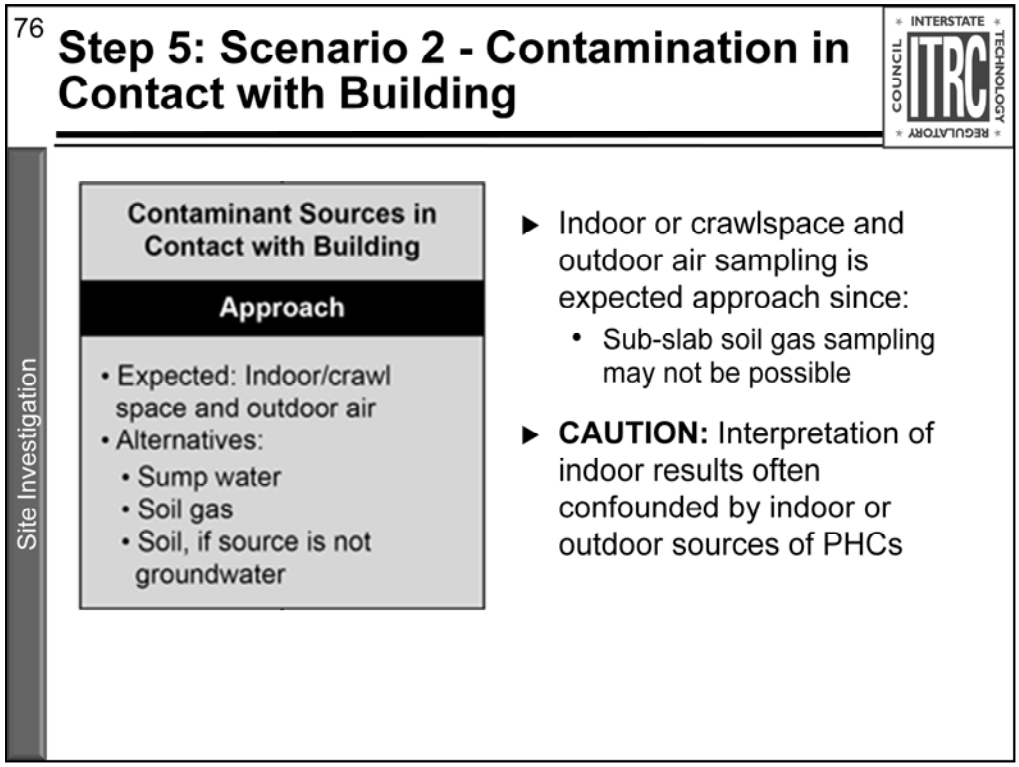

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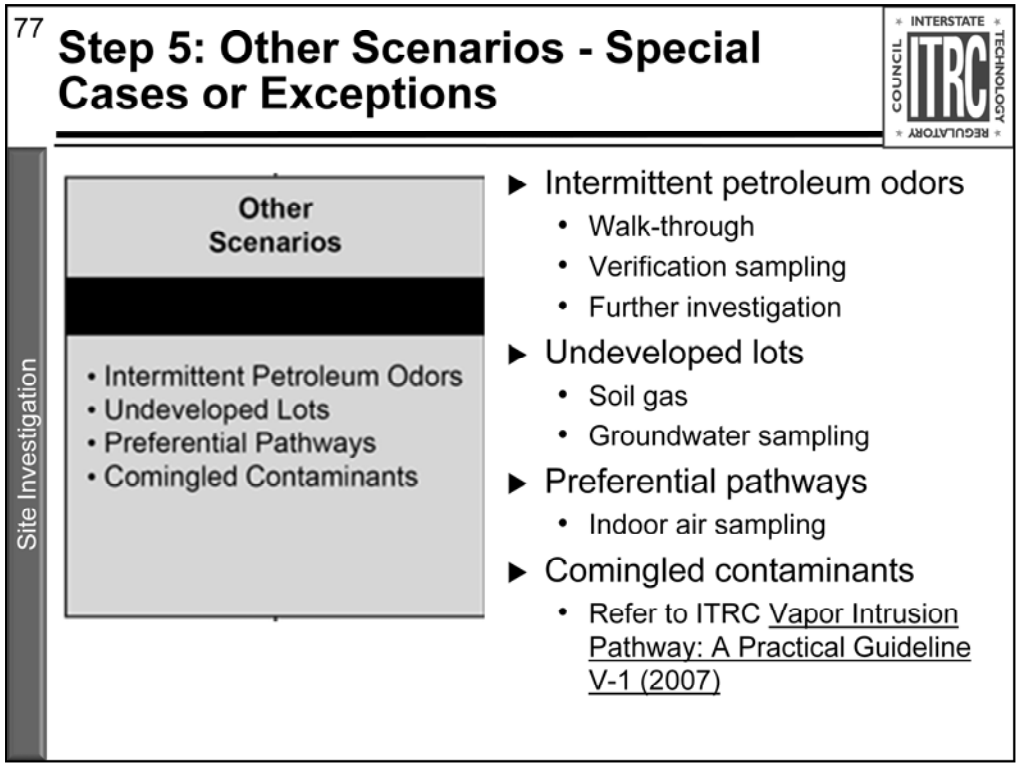

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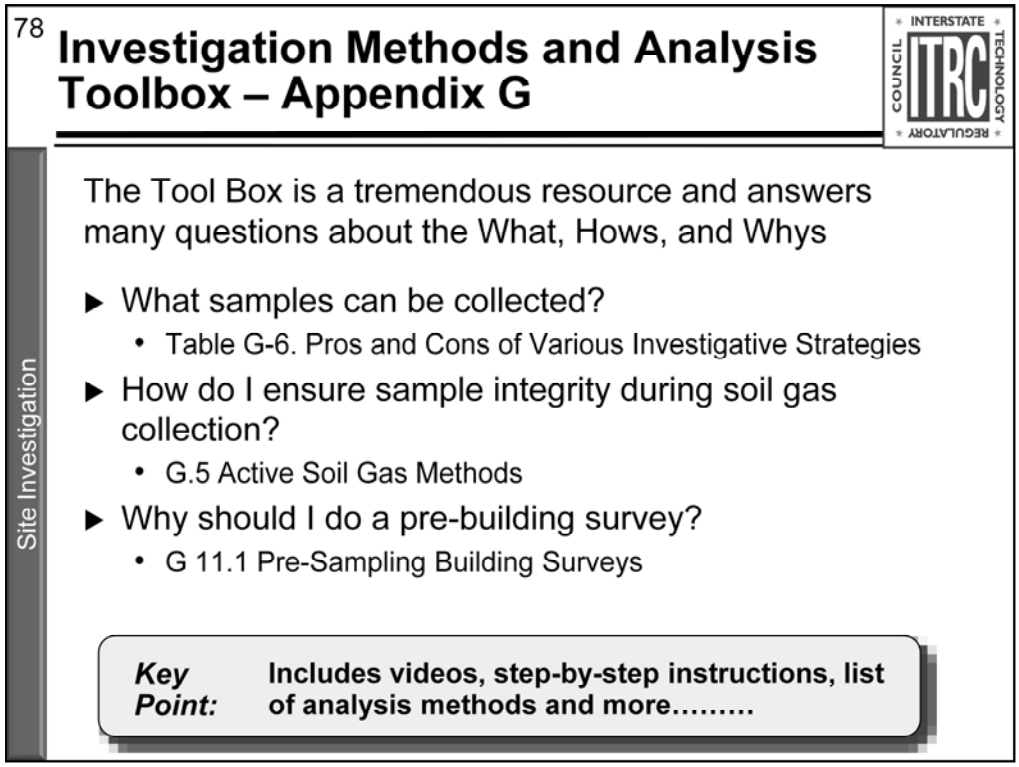

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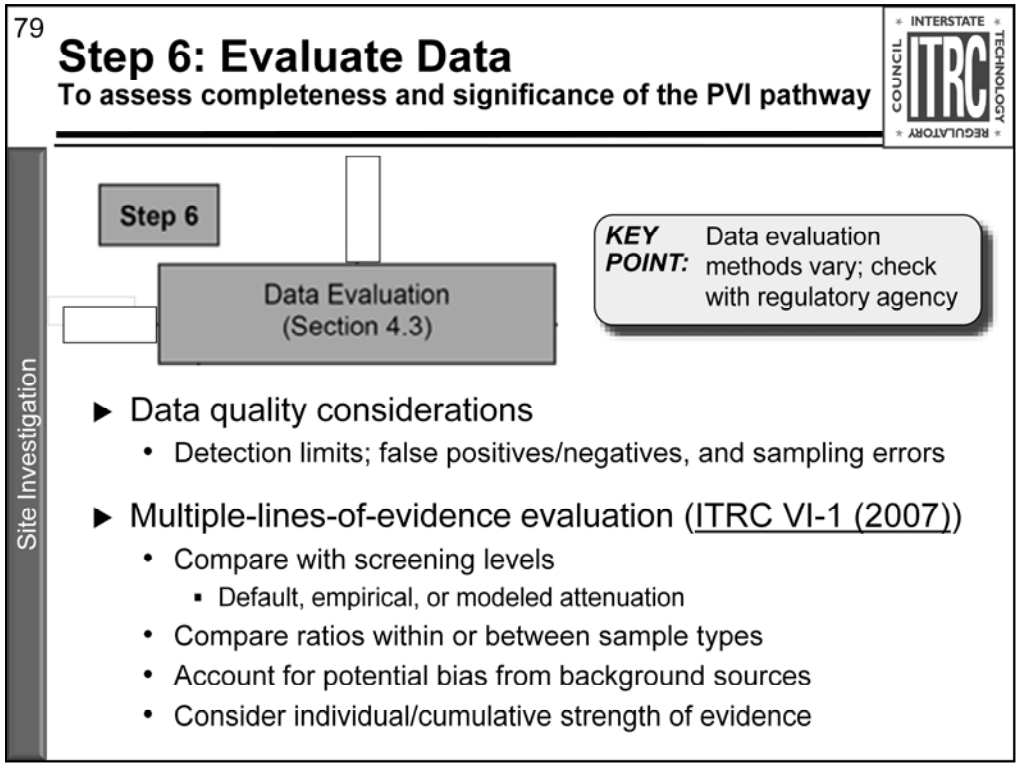
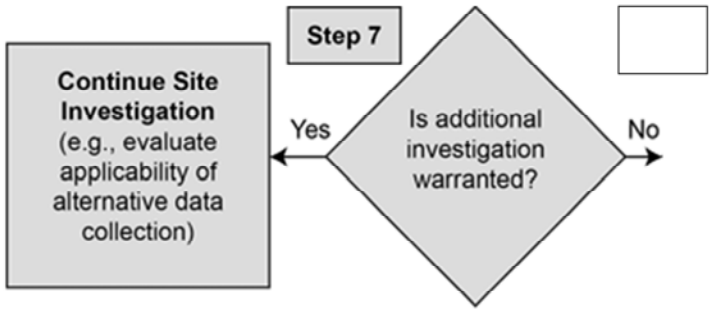


No associated notes.

80

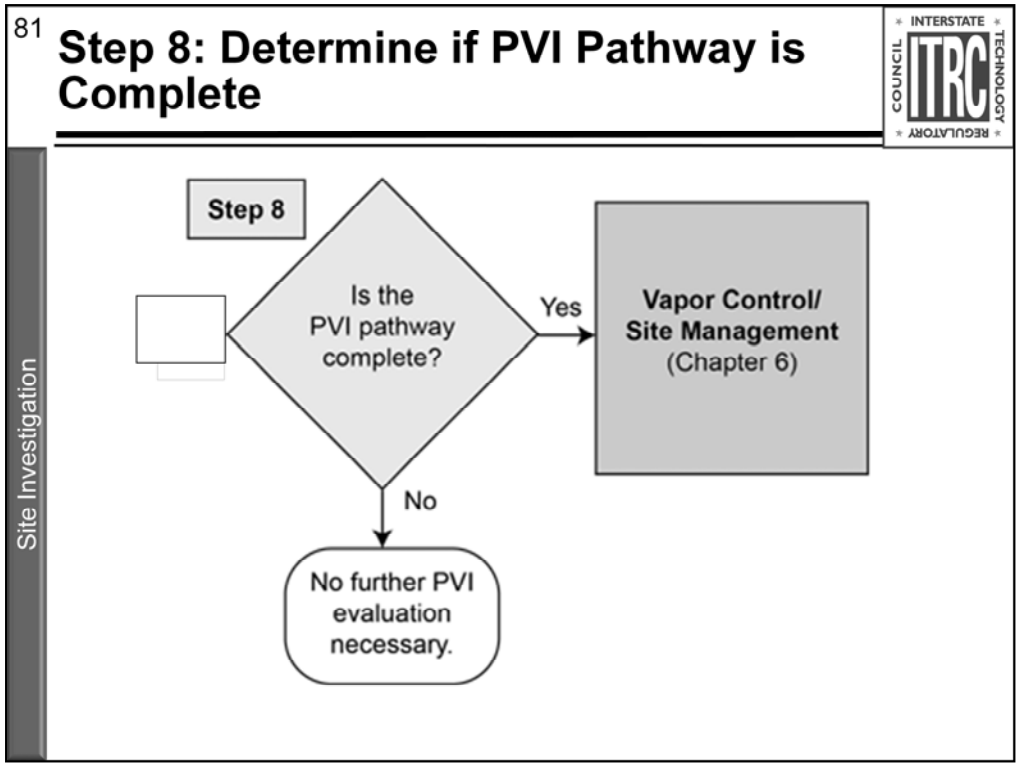
Step 7: Determine Need for Additional Investigation

Site Investigation



- This step reflects iterative nature of PVI investigations
- Considerations
  - Delineation of pVOCs adequate?
  - All potentially affected buildings considered?
  - Evidence sufficiently strong to support decision?
  - Vapor controls can be considered at any step

No associated notes.



No associated notes.

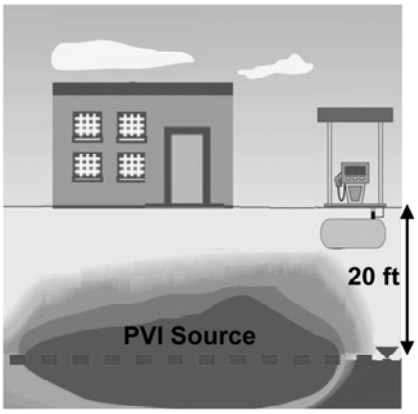
82

Case Study – Background

Case Study

Case Study

- Gasoline/Diesel Station in Salina, UT
- Operated since 1971
- Black top /concrete surface
- Silty/sand interbedded with fine-grained sand
- Groundwater at 20 ft bgs
- Petroleum releases from dispensers, product lines, and USTs



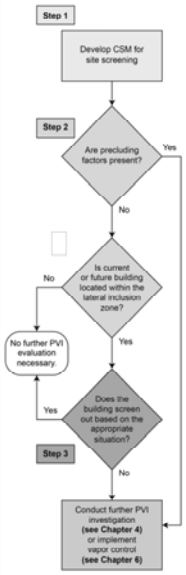
Courtesy Robin Davis UTDEQ

No associated notes.

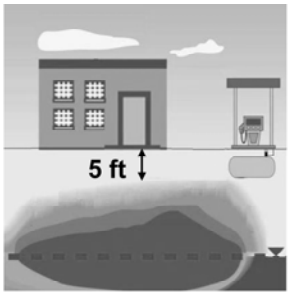
83

Case Study – PVI Screening

Case Study



- Step 1: Develop CSM
- Step 2:
  - Precluding Factors?
    - No preferential pathways
    - Plume stable/shrinking
    - No lead scavengers and <10% ethanol
  - Within Lateral Inclusion Distance?
    - Yes (building <30 ft from dissolved/LNAPL sources)
- Step 3: Sufficient Vertical Separation?
  - No (top of LNAPL 5 ft below slab)
- Further PVI Investigation?
  - Yes

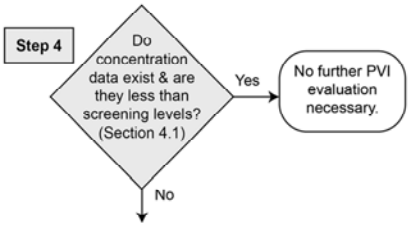


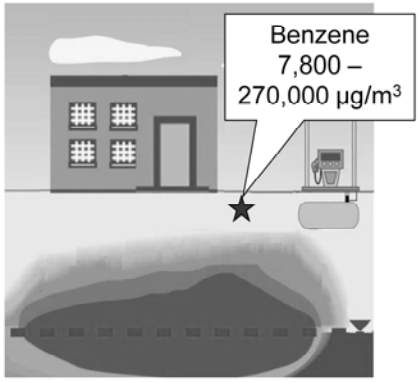
No associated notes.

84

Case Study – Site Investigation
Concentration Based Evaluation
Case Study

Case Study



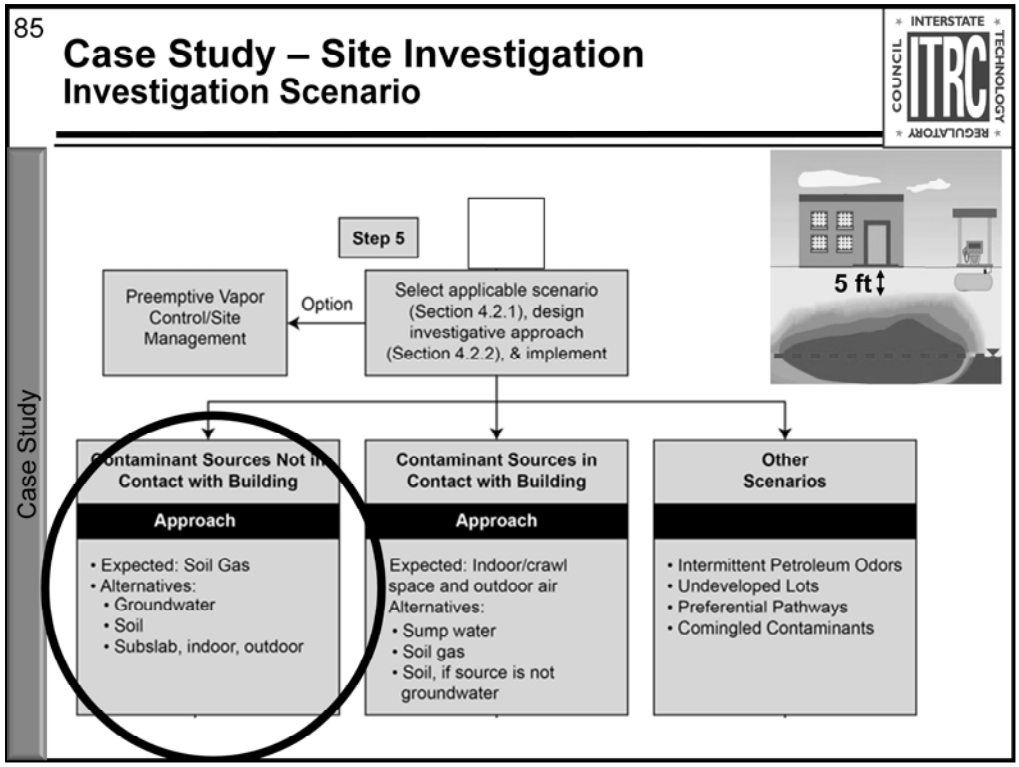


Step 4: Concentrations < Screening Levels?

- Benzene near-slab (1.5 ft bgs) soil gas: 7,800 – 270,000 µg/m^3
- Vapor intrusion screening level (VISL) = 50-100 µg/m^3 (example only)

No, concentrations are not below screening levels, go to step 5

No associated notes.



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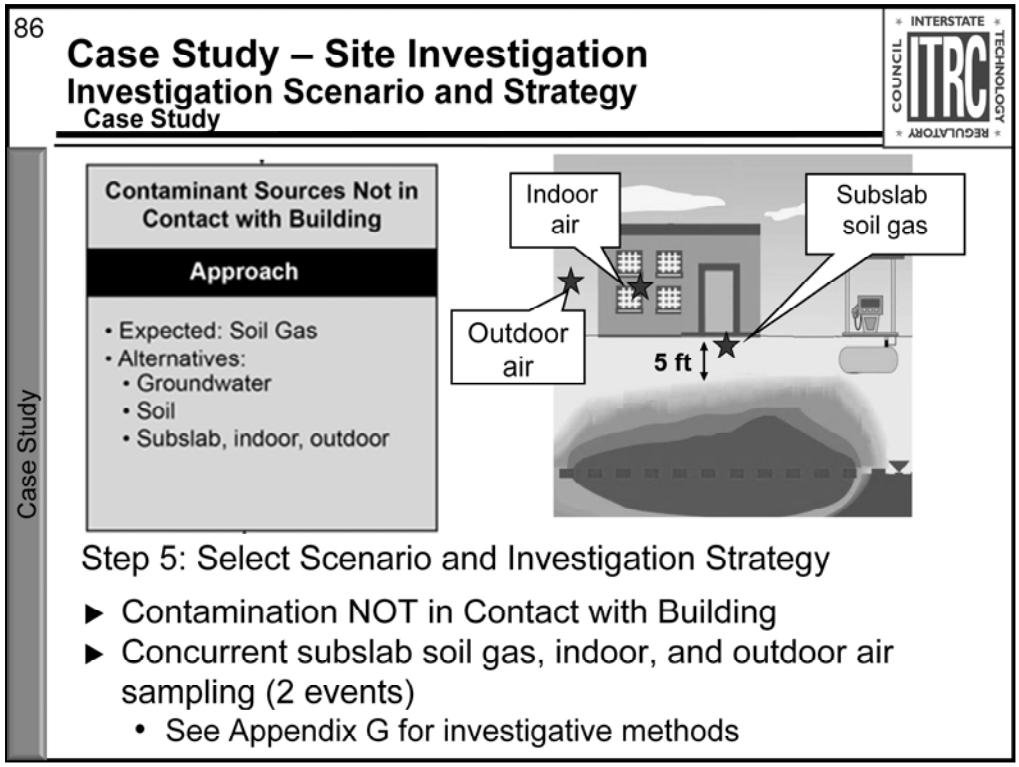

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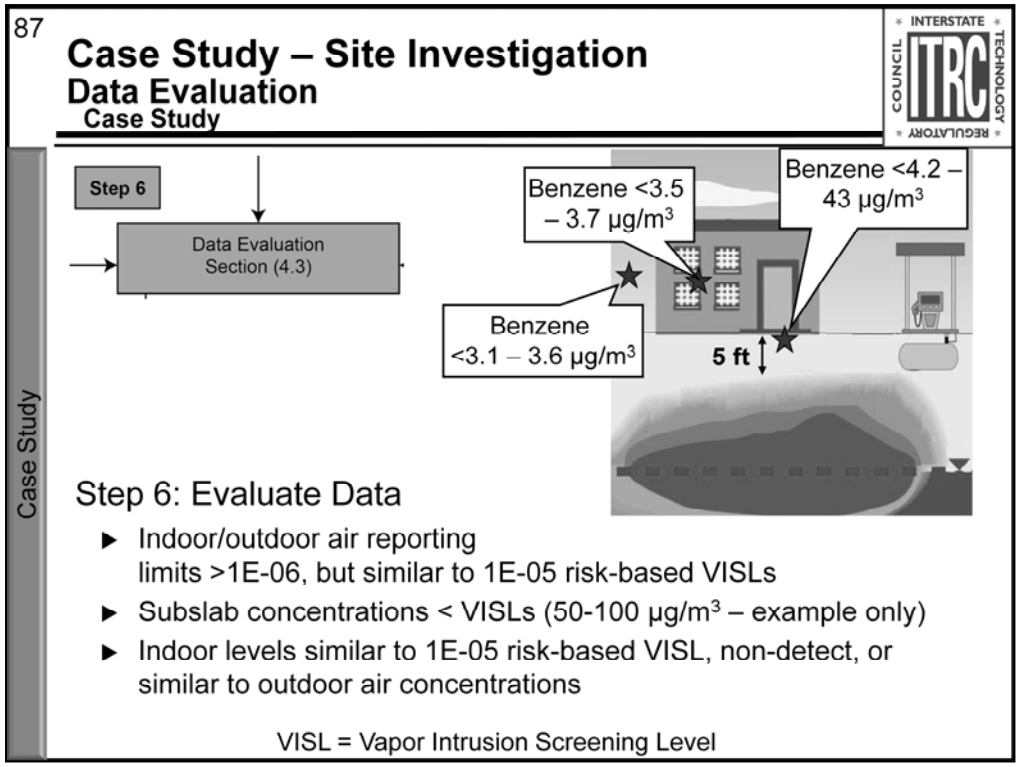


No associated notes.

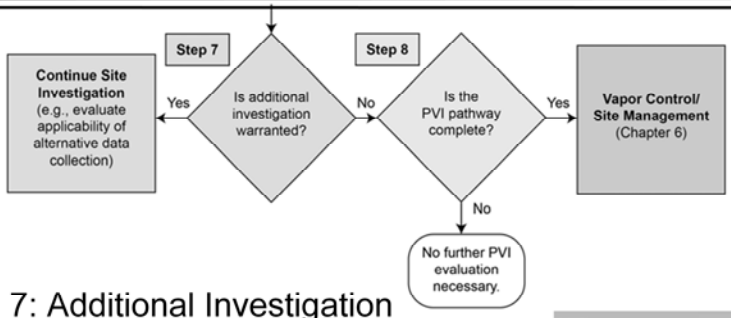
88

Case Study – Site Investigation

Additional Investigation/Pathway Complete?

Case Study

Case Study

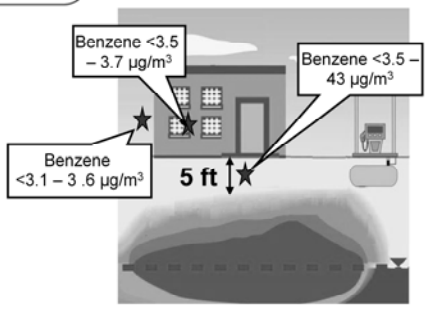


Step 7: Additional Investigation Warranted?

- No (sufficient data were available)

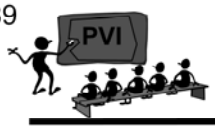
Step 8: PVI Pathway Complete?

- No, since indoor levels similar to 1E-05 risk-based VISL, non-detect, or similar to outdoor air concentrations



No associated notes.

89



Community Engagement
What to expect in a Petroleum Vapor Intrusion Investigation

INTERSTATE COUNCIL ITRC TECHNOLOGY REGULATORY

Community Engagement

- What will happen if a petroleum release happens in my neighborhood or in my local area?
- What will happen if I am asked to allow a PVI investigation to be conducted in my house?
- What happens during a PVI investigation?
- Where can I find more information about PVI investigations?

Petroleum Vapor Intrusion: Frequently Asked Questions
What to Expect in a Petroleum Vapor Intrusion Investigation
(PVI FAQ Sheet 2)

What will happen if a petroleum release happens in my neighborhood or in my local area?

What will happen if I am asked to allow a PVI investigation to be conducted in my house?

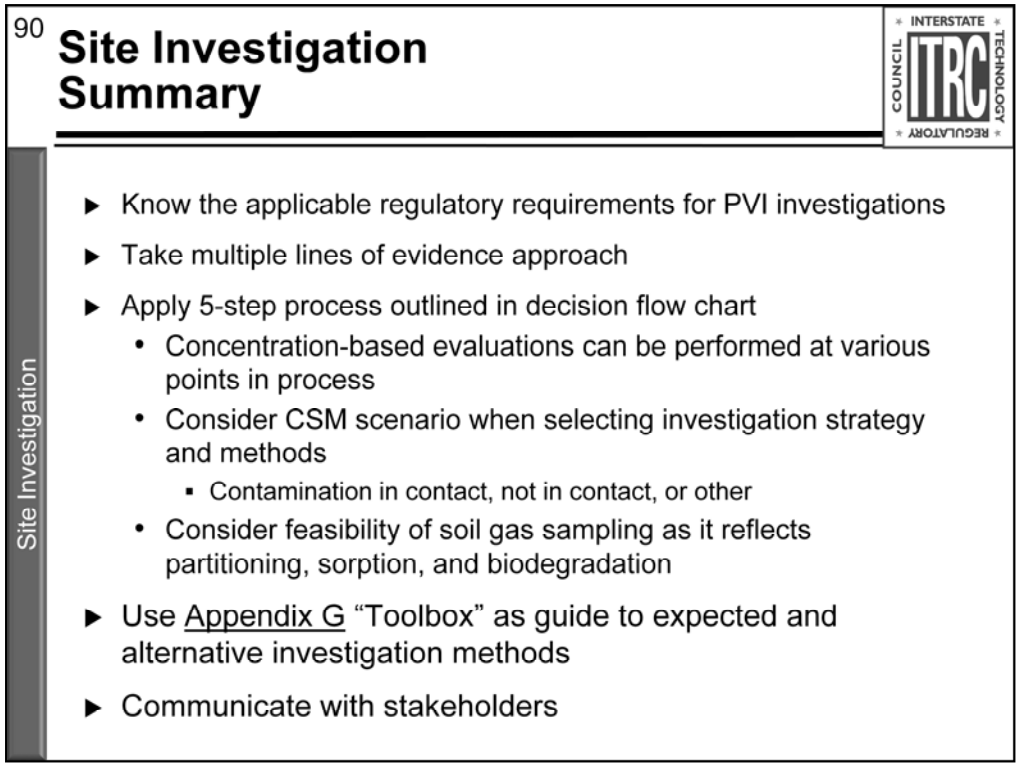
What happens during a PVI investigation?

Photos showing routine activities conducted during a PVI investigation

Advancing Environmental Solutions

ITRC PVI-1, 2014: Appendix K – Frequently Asked Questions Fact Sheets

No associated notes.



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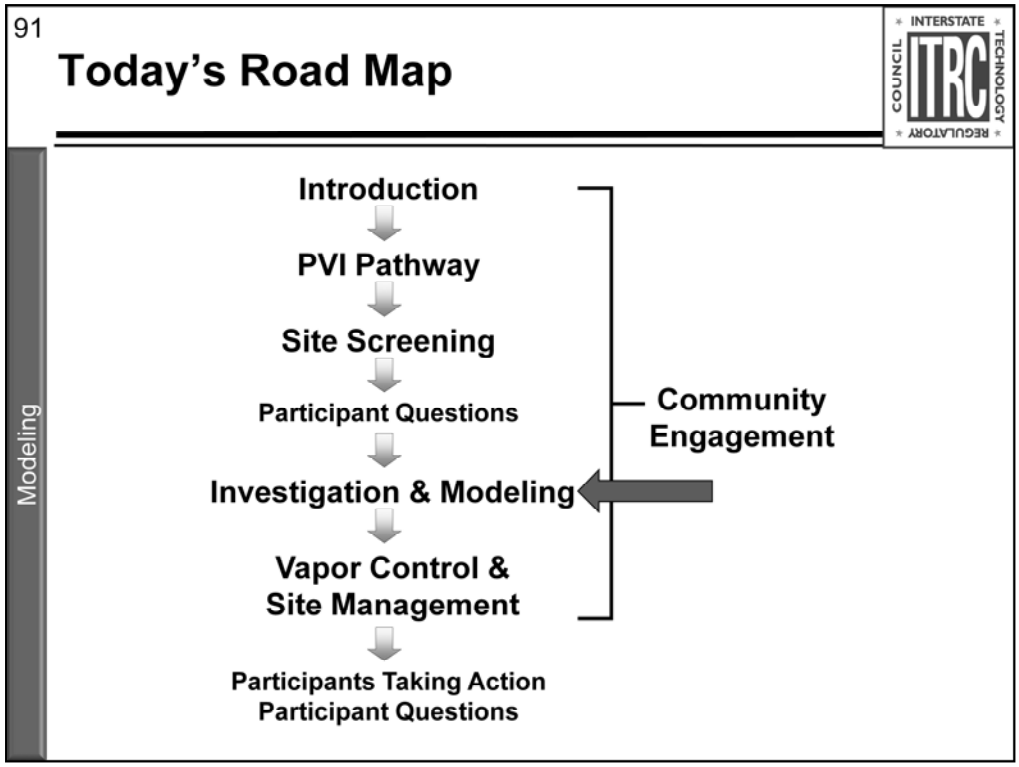

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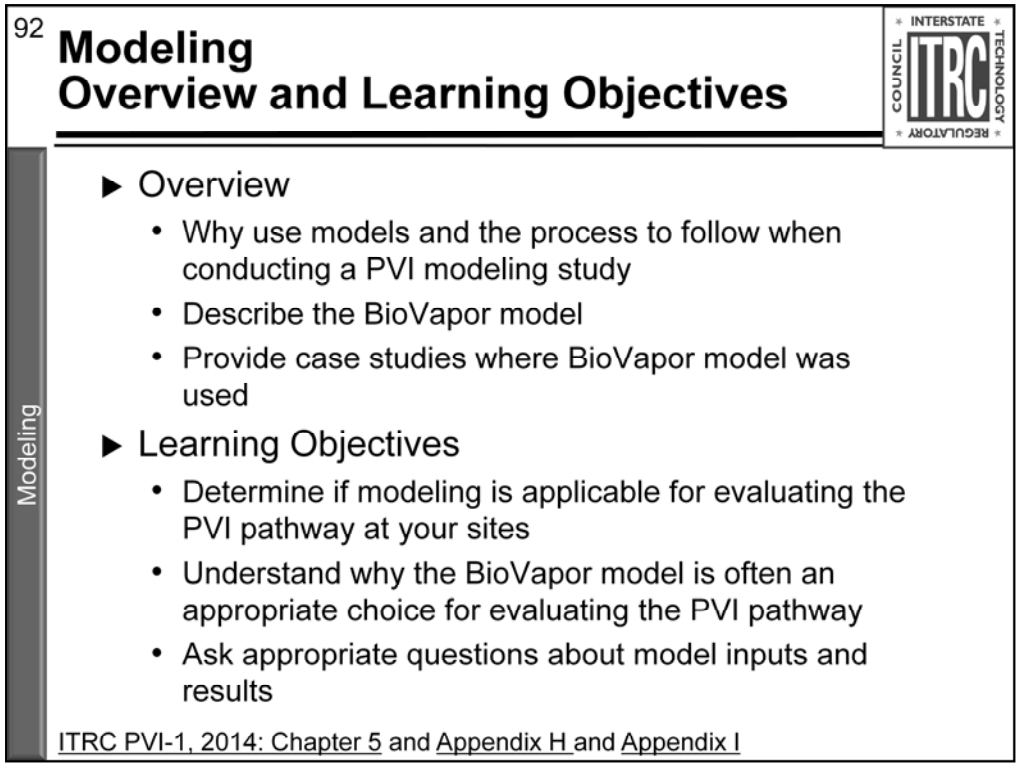

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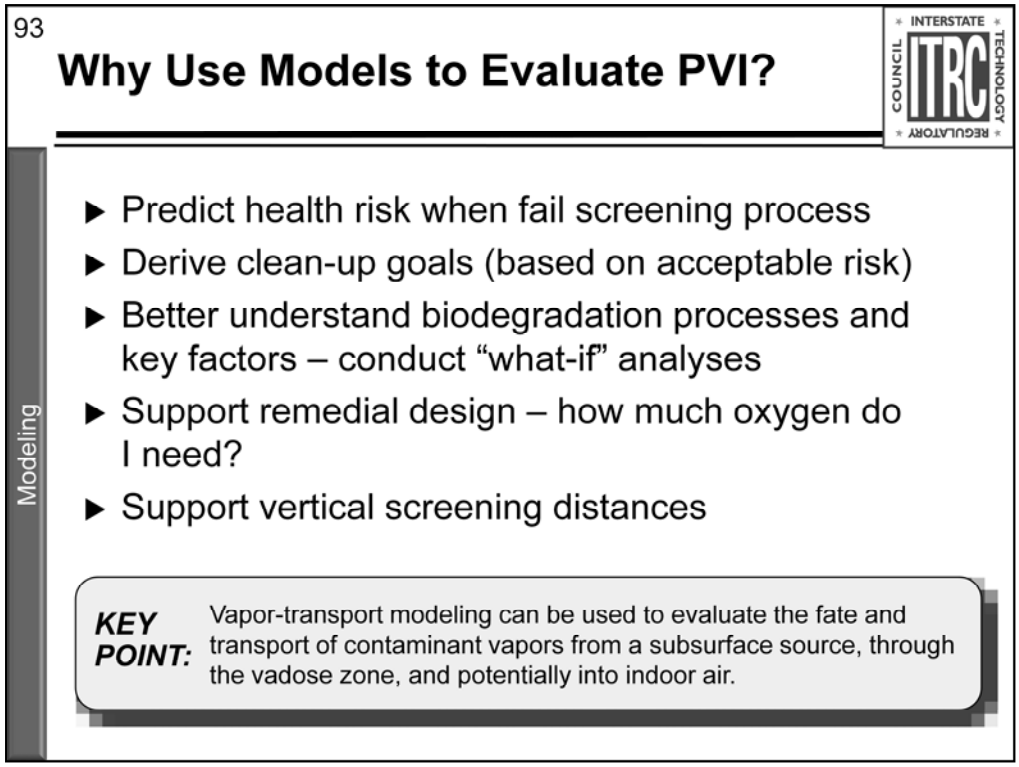

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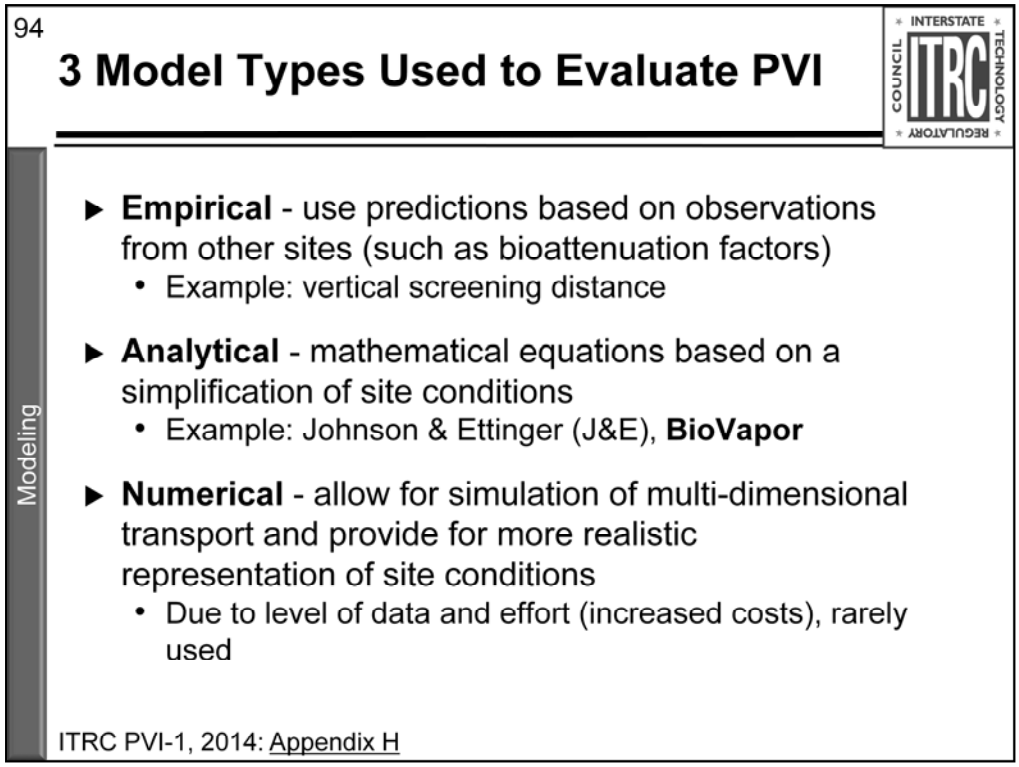

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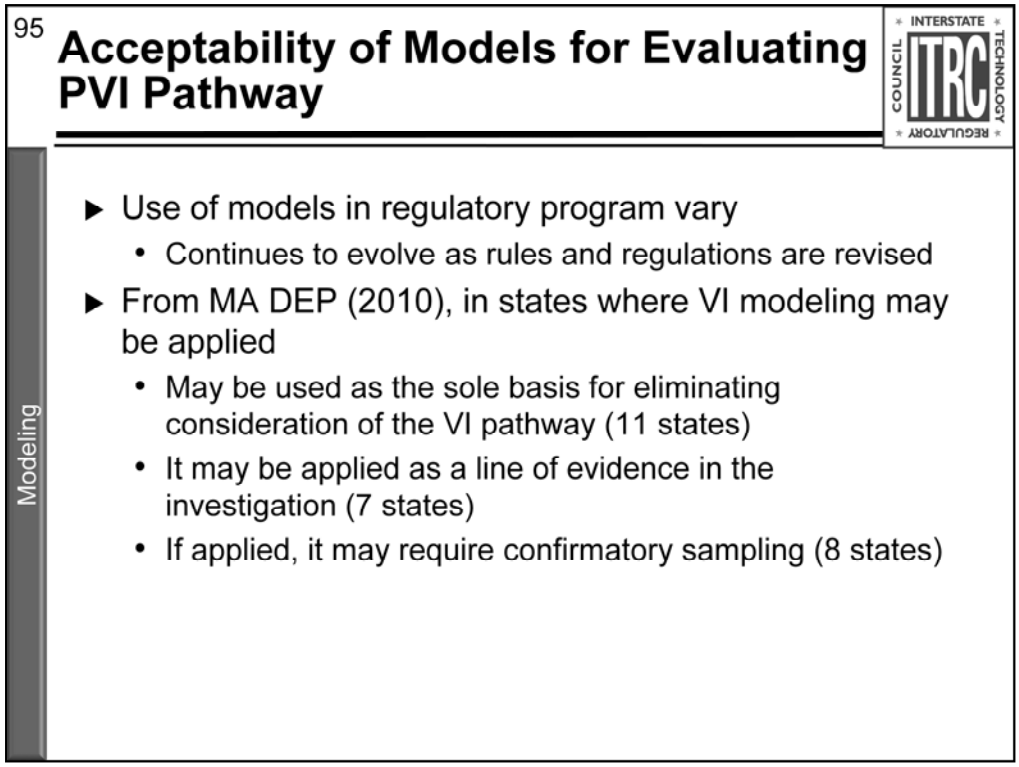

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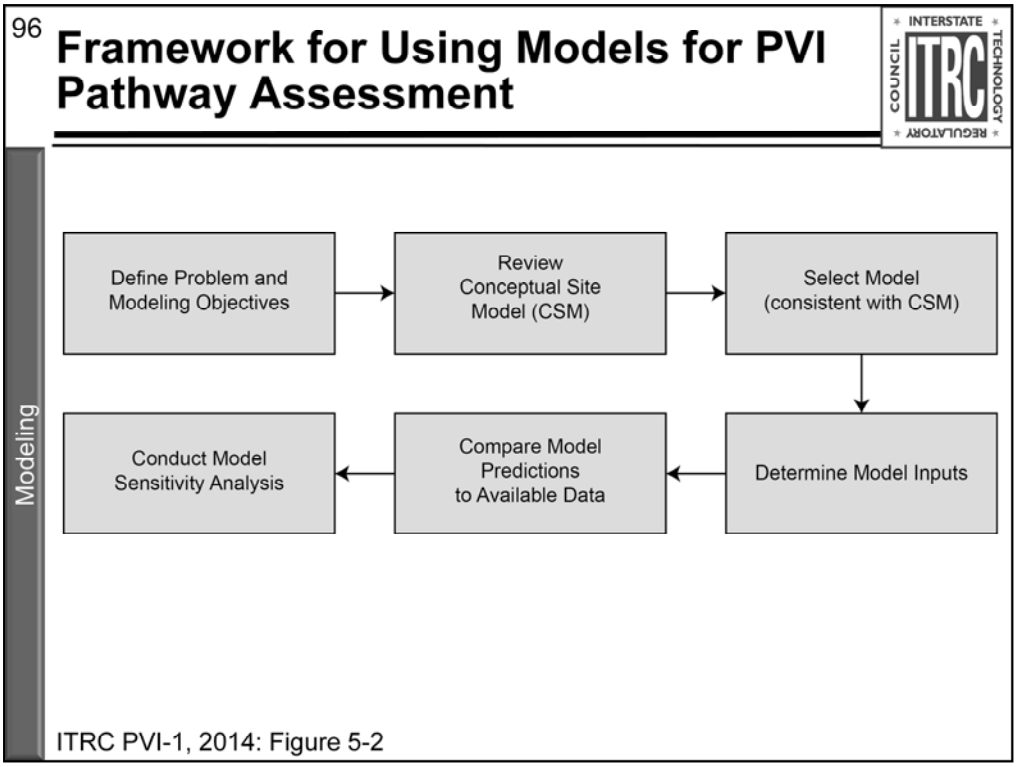


No associated notes.

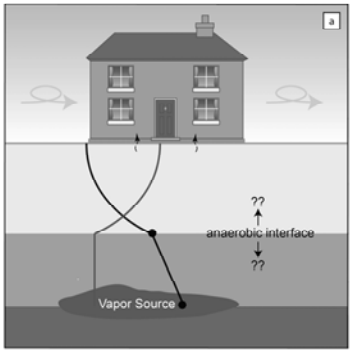
97

Overview of BioVapor Model

API: Download at: http://www.api.org

Modeling

- Why use
  - Quantify the contribution of aerobic biodegradation
  - Relatively easy to use, available, built-in parameter database
  - Reviewed and accepted by EPA, basis for EPA PVIScreen
- Model characteristics
  - Same conceptual framework as J&E but includes 'O_2-limited aerobic bio'
  - Similar caveats on model applicability and use
  - Key biodegradation inputs:
    - ***Oxygen boundary conditions***
    - ***First-order decay constant***
    - ***Baseline respiration rate***
  - Source concentrations also important



ITRC PVI-1, 2014: Table 5-1

No associated notes.

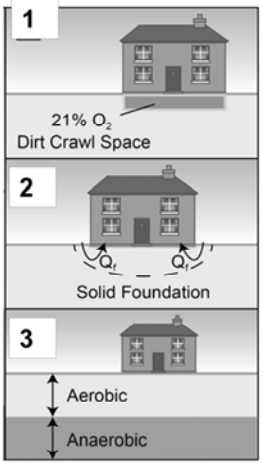
98

Oxygen in the BioVapor Model

Modeling

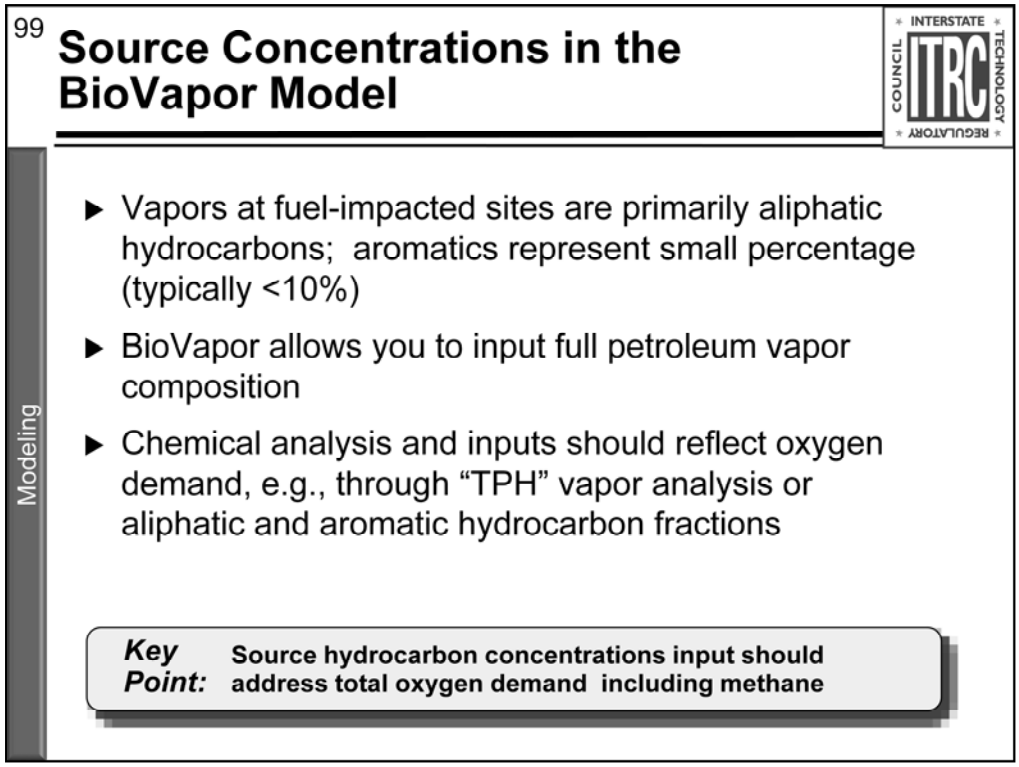
Three Options:

1. Specify O_2 concentration below foundation
   - Measure oxygen
2. Let the model balance hydrocarbon flux & oxygen consumption
   - Specify airflow under foundation ("Qf ") – determines O_2 mass transfer
3. Specify aerobic depth
   - Measure vapor profile



Key Point: **Pick one method; the others are related (and predicted) Methodology relatively unique to BioVapor (particularly #2)**

No associated notes.

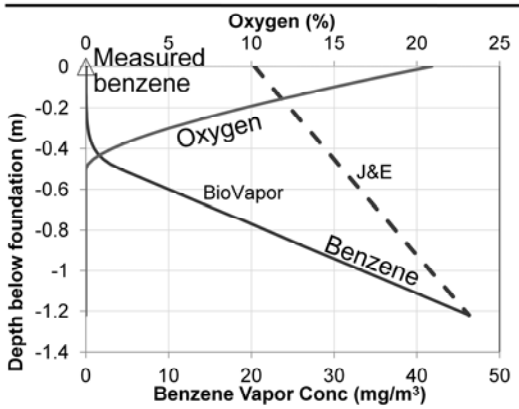


No associated notes.

100

BioVapor Case Study – Salt Lake City, UT – Dissolved Source

Case Study



GW Conc (mg/L)	Vapor Conc (mg/m^3)			
	Measured Source	Predicted Source	Measured Subslab	Predicted Subslab
TPH	12	22,600	0.14	10.9
Benzene	4	46.3	<0.005	0.006

- Shallow dissolved hydrocarbon source below townhouses (source – building separation 4ft (1.2 m))
- Source GW concentrations
  - TPH = 12 mg/L
  - Benzene 4 mg/L
- Measured subslab < predicted concentrations (model conservative)
- Modeling added line of evidence for no concern with respect to indoor air

For details see Hers & Jourabchi 2014 "*Comprehensive Evaluation of the BioVapor …*", AWMA VI Conf., Sept 10-11,'14

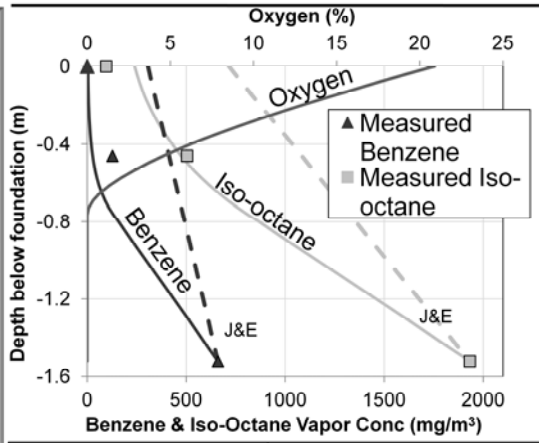
No associated notes.

101

BioVapor Case Study – Stafford, NJ – LNAPL Site

Case Study

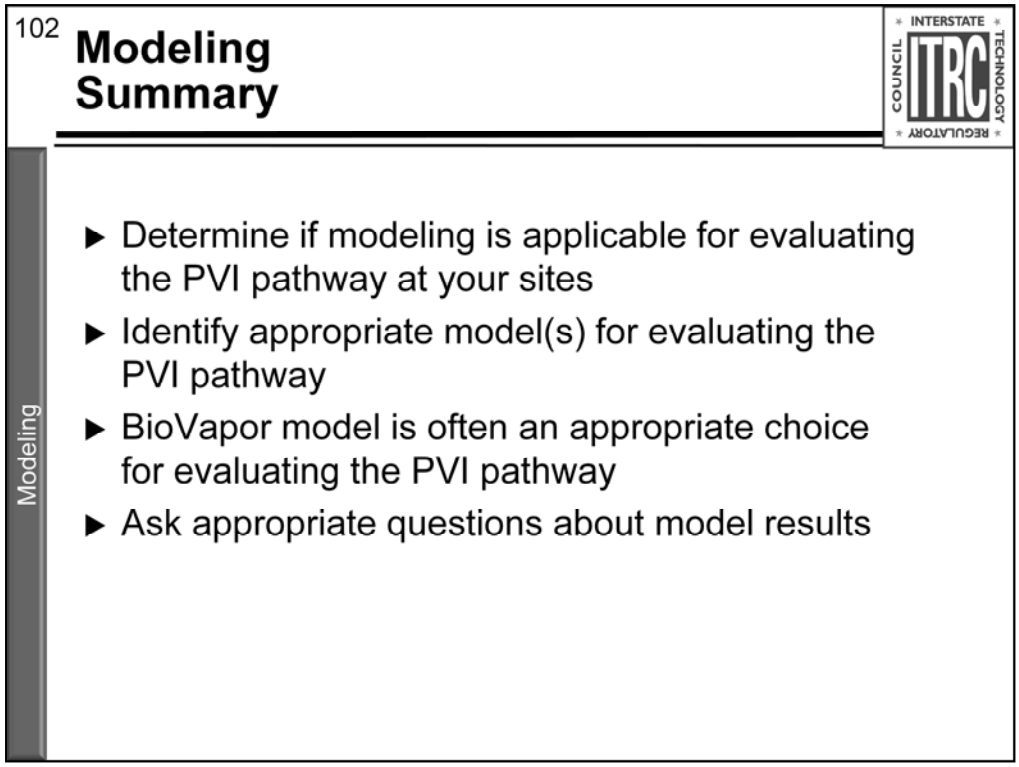
Case Study



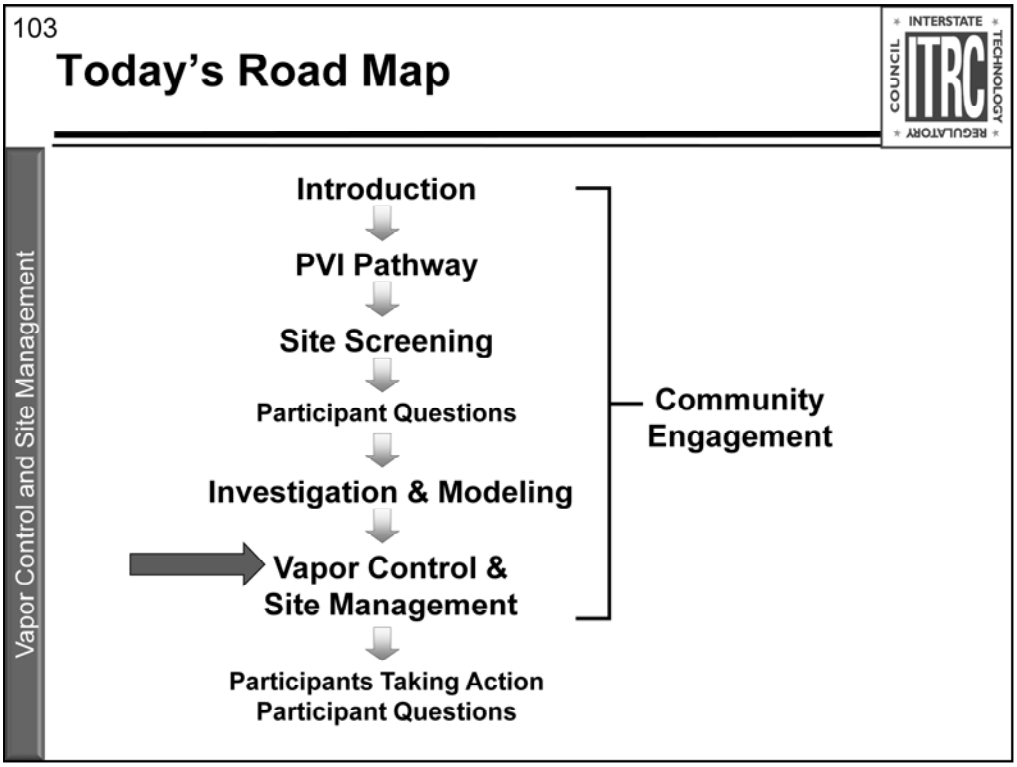
Source Vapor Conc. (mg/m³)		Indoor Air Conc. (mg/m³) Predicted	Measured
Benzene	660	0.017	<0.0025
Hexane	6,150	0.39	<0.0025
Iso-octane	1,930	0.91	0.70
MTBE	5,940	4.8	0.24

- Shallow LNAPL source below houses (source – building separation = 5ft (1.52 m))
- Source SV concentrations
  - Benzene = 660 mg/m3
  - TPH = 200,000 mg/m3
- Measured indoor air & subslab < predicted concentrations (model conservative)
- Modeling added line of evidence for evaluating background, predicts aromatics & aliphatics behavior well

No associated notes.



No associated notes.



No associated notes.

104

Vapor Control & Site Management Learning Objectives and Overview

Vapor Control and Site Management

- How **factors unique to PVI mitigation** may affect your remedy decisions
- **Types of vapor control strategies** to manage PVI when indoor air exceed mitigation action levels, or are likely to exceed screening levels in future buildings
- Where to find **more detailed information** on
  - Design, operations and maintenance (O&M) and closure of mitigation systems
  - Community engagement

ITRC PVI-1, 2014: Chapter 6

Handout provided

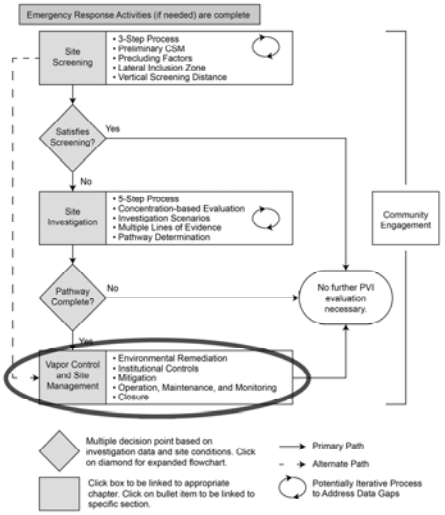
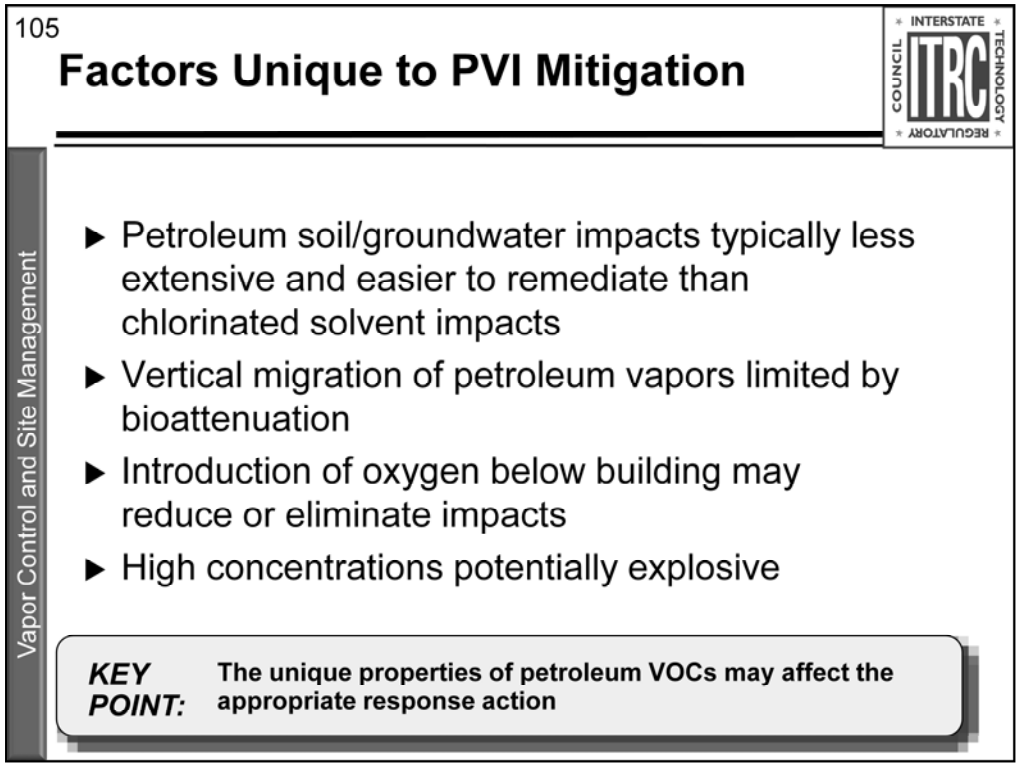


Figure 1-2. PVI strategy flowchart

No associated notes.



No associated notes.

106

Vapor Control Strategies for Petroleum Hydrocarbons

Vapor Control and Site Management

- Environmental remediation
- Mitigation
- Institutional controls

or any combination of these approaches

Figure 6-1. Small-scale soil vapor extraction (SVE) system designed to address the source of vapors. Photo Source: Vapor Mitigation Sciences, LLC.

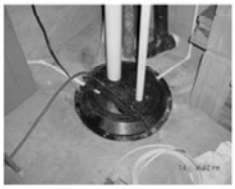
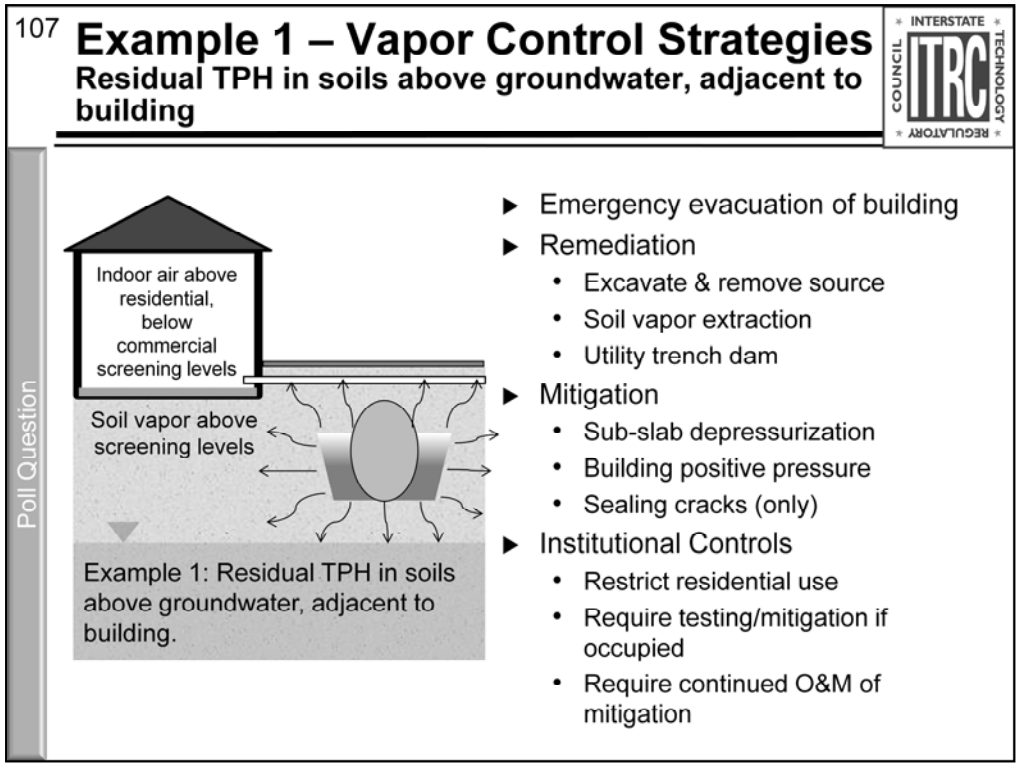


Figure J-4. Passive sump mitigation system. Photo Source: Kansas Dept. of Health and Environment

KEY POINT: **Both short-term and long-term risks should be considered to determine the appropriate response action**

No associated notes.



Which vapor control strategy is likely to be most suitable for Example 1? Select up to 3 options.

Emergency evacuation of building

Remediation: Excavate & remove source

Remediation: Soil vapor extraction

Remediation: Utility trench dam

Mitigation: Sub-slab depressurization

Mitigation: Building positive pressure

Mitigation: Sealing cracks (only)

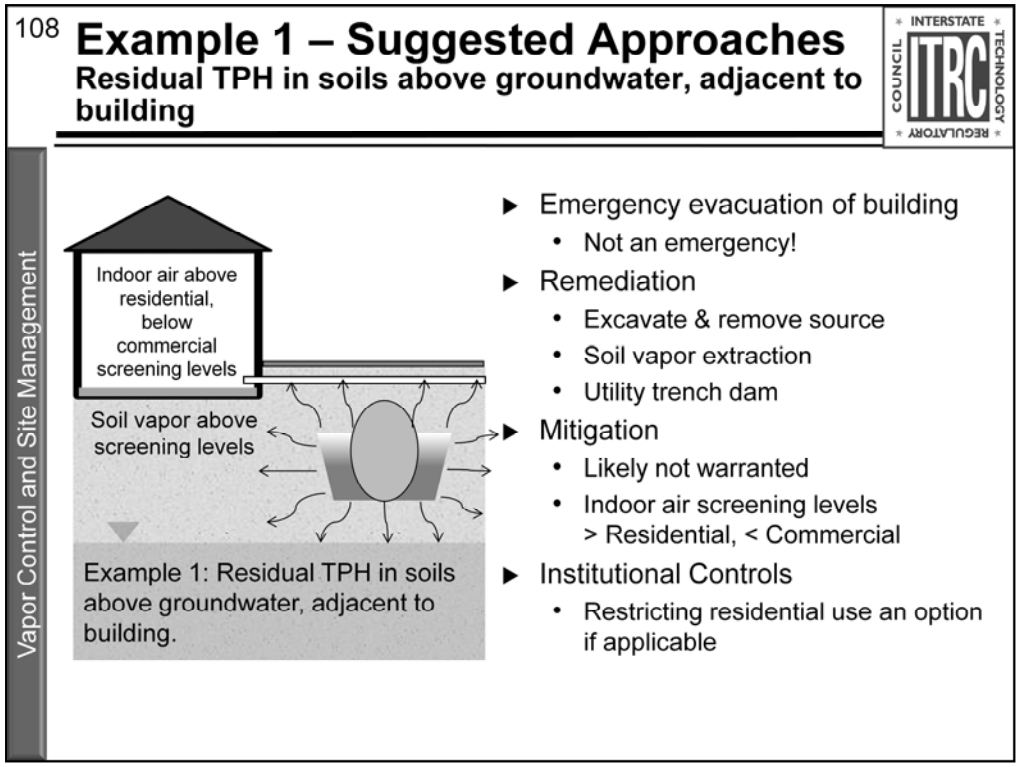
Institutional Controls: Restrict residential use

Institutional Controls: Require testing/mitigation if occupied

Institutional Controls: Require continued O&M of mitigation

Discuss what doesn't make sense in this situation, pro's and con's of the remaining options, what might be unique to PVI etc.

In this case, building mitigation would typically not make sense. Even though indoor air is above the residential SL (presumably background has been addressed or acknowledged), the concentrations are below commercial SLs, so they're not too high (also meaning that evacuation would not be warranted). Since excavation and/or SVE could likely be accomplished fairly quickly, even residential risk might be acceptable (considering the short duration of exposure). Although the source is fairly close to the building, vapor migration along the utility line is likely the main pathway, suggesting that a trench dam should be considered. ICs should not be needed in this case, assuming that active remediation is the selected approach. SVE in the source zone would likely prevent lateral movement of vapors toward the building.



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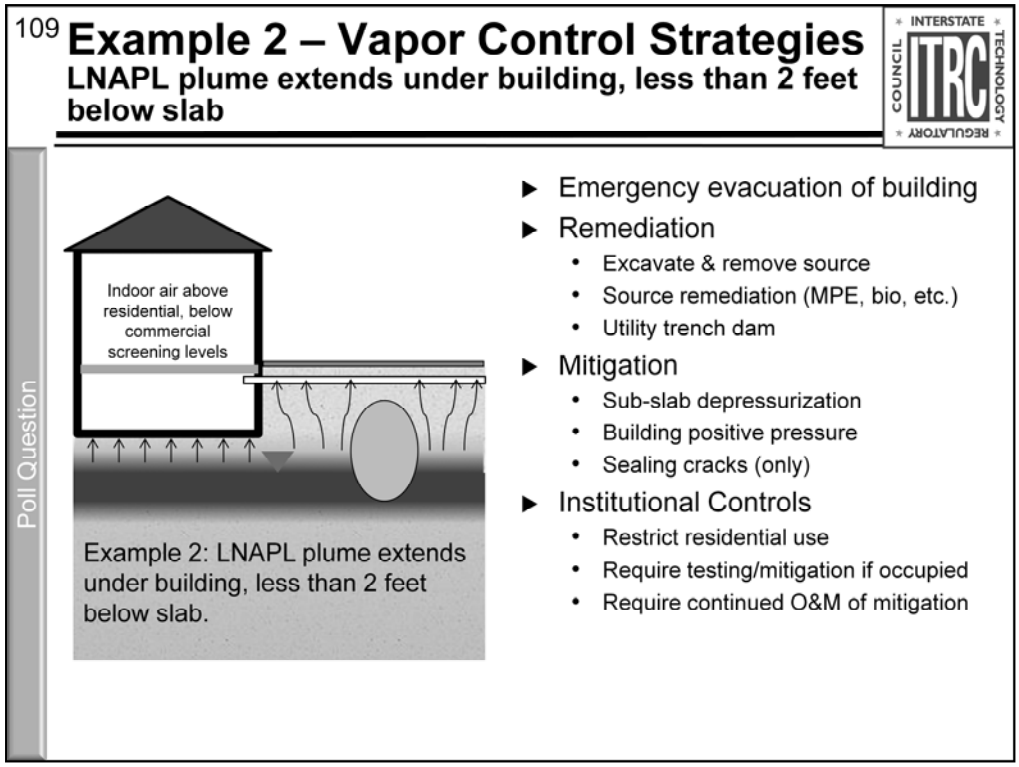
Institutional Controls: Require continued O&M of mitigation

Discuss what doesn't make sense in this situation, pro's and con's of the remaining options, what might be unique to PVI etc.

In this case, building mitigation would typically not make sense. Even though indoor air is above the residential SL (presumably background has been addressed or acknowledged), the concentrations are below commercial SLs, so they're not too high (also meaning that evacuation would not be warranted). Since excavation and/or SVE could likely be accomplished fairly quickly, even residential risk might be acceptable (considering the short duration of exposure). Although the source is fairly close to the building, vapor migration along the utility line is likely the main pathway, suggesting that a trench dam should be considered. ICs should not be needed in this case, assuming that active remediation is the selected approach. SVE in the source zone would likely prevent lateral movement of vapors toward the building.



Which control strategy is likely to be most suitable for Example 2? Select up to 3 options.

Emergency evacuation of building

Remediation: Excavate & remove source

Remediation: Source remediation (MPE, bio, etc.)

Remediation: Utility trench dam

Mitigation: Sub-slab depressurization

Mitigation: Building positive pressure

Mitigation: Sealing cracks (only)

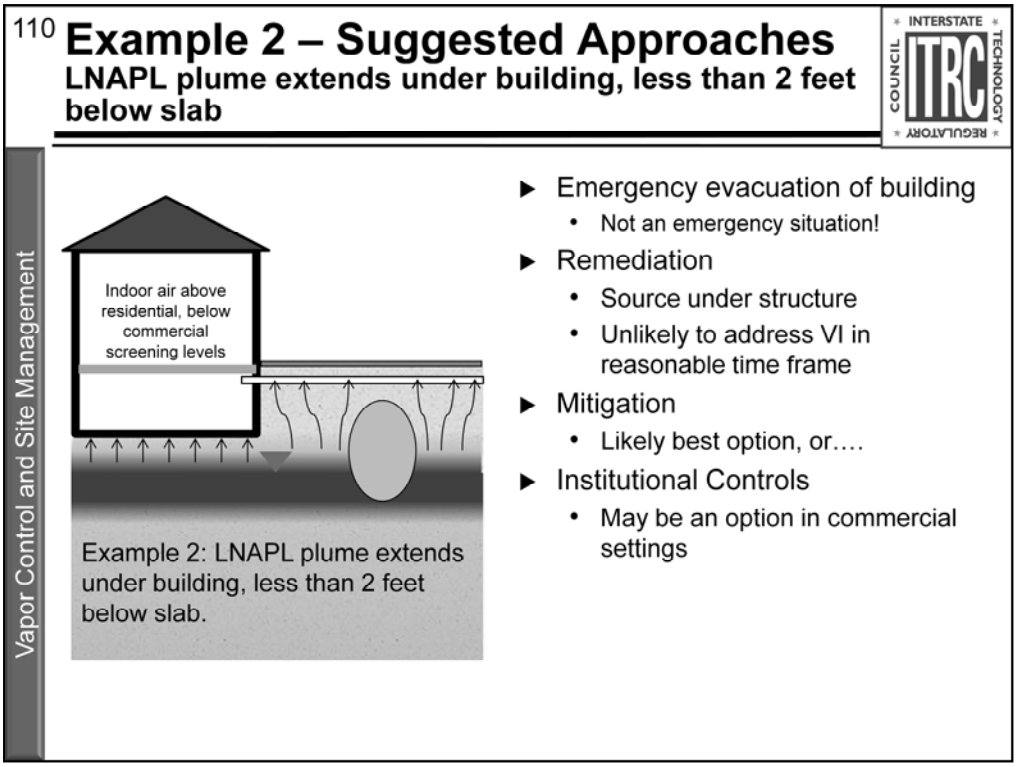
Institutional Controls: Restrict residential use

Institutional Controls: Require testing/mitigation if occupied

Institutional Controls: Require continued O&M of mitigation

Discuss what doesn't make sense in this situation, then pro's and con's of the remaining options.

In this case, the contamination is extensive and below the building, so excavation and/or remediation, while likely required in any case, might not control vapors quickly enough. Not an emergency situation given the concentrations, but mitigation with a requirement to continue mitigation O&M until source cleanup is achieved would be reasonable. Building positive pressure is not typically a good approach for residential buildings (a commercial building would not require mitigation). Sealing cracks is seldom sufficient. Source remediation should also consider the potential for generating more vapors (e.g., sparging).



Which control strategy is likely to be most suitable for Example 2? Select up to 3 options.

Emergency evacuation of building

Remediation: Excavate & remove source

Remediation: Source remediation (MPE, bio, etc.)

Remediation: Utility trench dam

Mitigation: Sub-slab depressurization

Mitigation: Building positive pressure

Mitigation: Sealing cracks (only)

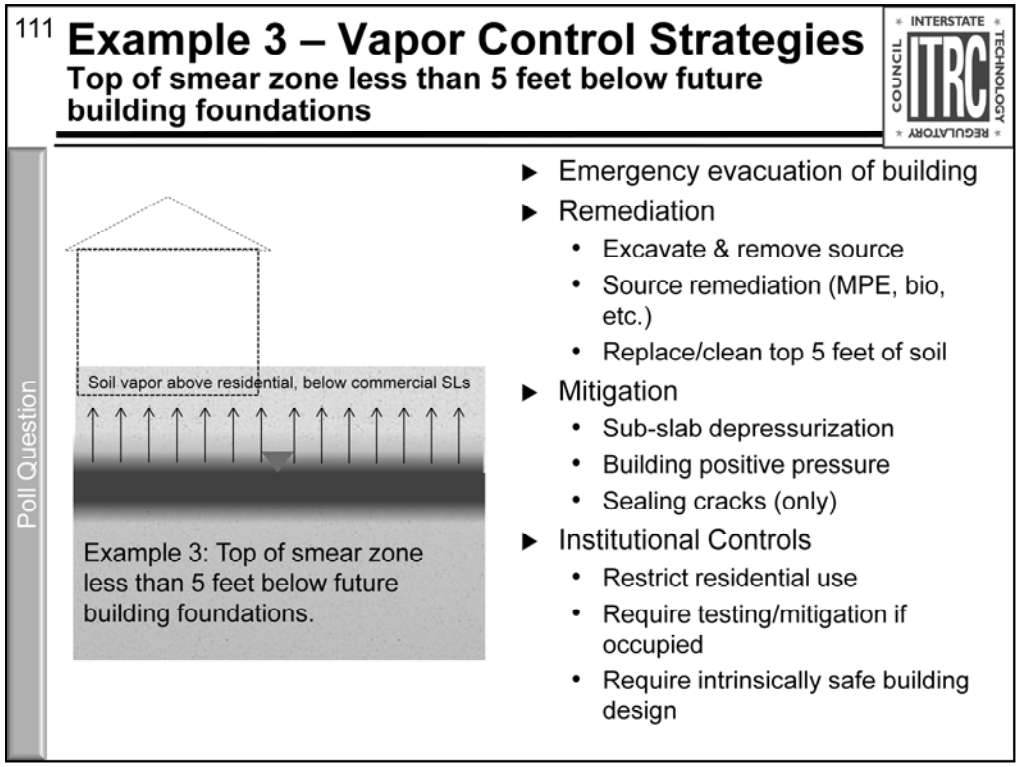
Institutional Controls: Restrict residential use

Institutional Controls: Require testing/mitigation if occupied

Institutional Controls: Require continued O&M of mitigation

Discuss what doesn't make sense in this situation, then pro's and con's of the remaining options.

In this case, the contamination is extensive and below the building, so excavation and/or remediation, while likely required in any case, might not control vapors quickly enough. Not an emergency situation given the concentrations, but mitigation with a requirement to continue mitigation O&M until source cleanup is achieved would be reasonable. Building positive pressure is not typically a good approach for residential buildings (a commercial building would not require mitigation). Sealing cracks is seldom sufficient. Source remediation should also consider the potential for generating more vapors (e.g., sparging).



Note, choices slightly different for this scenario.

Which control strategy is likely to be most suitable for Example 3? Select up to 3 options.

Emergency evacuation of building

Remediation: Excavate & remove source

Remediation: Source remediation (MPE, bio, etc.)

Remediation: Replace/clean top 5 feet of soil

Mitigation: Sub-slab depressurization

Mitigation: Building positive pressure

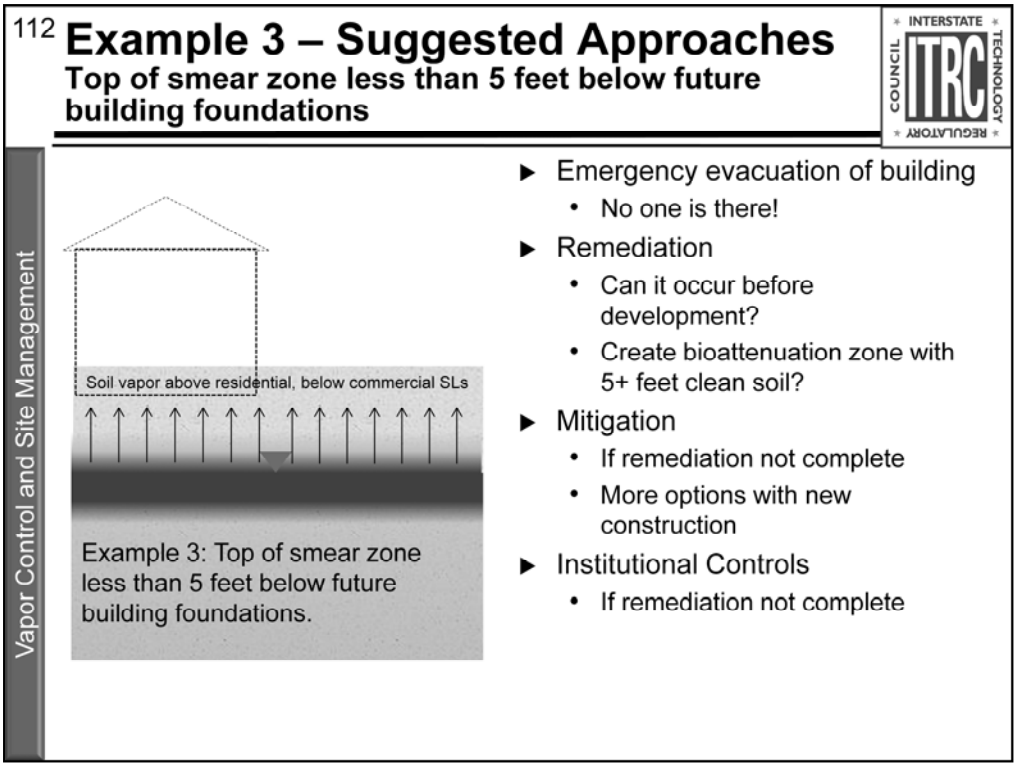
Mitigation: Sealing cracks (only)

Institutional Controls: Restrict residential use

Institutional Controls: Require testing/mitigation if occupied

Institutional Controls: Require intrinsically safe building design

In this case, remediation might be feasible before development. Alternatively, cleaning up the upper 5 feet might be sufficient to allow development without VI concerns (while long term remediation including MNA continues). Ics requiring evaluation and/or mitigation at the time of development might be required.



Note, choices slightly different for this scenario.

Which control strategy is likely to be most suitable for Example 3? Select up to 3 options.

Evacuate

Remediation: Excavate & remove source

Remediation: Source remediation (MPE, bio, etc.)

Remediation: Replace/clean top 5 feet of soil

Mitigation: Sub-slab depressurization

Mitigation: Building positive pressure

Mitigation: Sealing cracks (only)

Institutional Controls: Restrict residential use

Institutional Controls: Require testing/mitigation if occupied

Institutional Controls: Require intrinsically safe building design

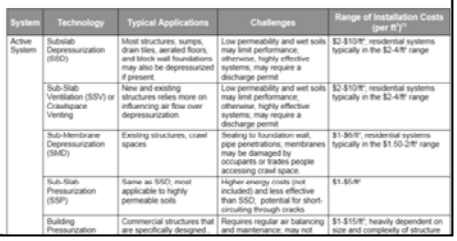
In this case, remediation might be feasible before development. Alternatively, cleaning up the upper 5 feet might be sufficient to allow development without VI concerns (while long term remediation including MNA continues). Ics requiring evaluation and/or mitigation at the time of development might be required.

113

PVI Mitigation Resources

Vapor Control and Site Management

- Chapter 6 (Vapor Control and Site Management)
  - Overview of strategies
  - Factors unique to PVI mitigation
- Appendix J (Vapor Intrusion Control)
  - Detailed information on methods, selection factors, design, O&M, closure strategies
  - Table J-1 – Summary of Mitigation Methods
    - Technology
    - Typical applications
    - Challenges
    - Range of installation costs

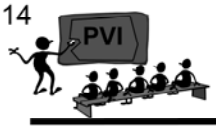


System	Technology	Typical Applications	Challenges	Range of Installation Costs (per ft²)
Active System	Subslab Depressurization (SSD)	Most structures; sumps, drain tiles, aerated floors, and block wall foundations may also be depressurized if present	Low permeability and wet soils may limit performance; otherwise, highly effective systems; may require a discharge permit	$2-$10/ft²; residential systems typically in the $2-4/ft² range
	Sub-Slab Ventilation (SSV) or Crawlspace Venting	New and existing structures relies more on influencing air flow over depressurization.	Low permeability and wet soils may limit performance; otherwise, highly effective systems, may require a discharge permit	$2-$10/ft²; residential systems typically in the $2-4/ft² range
	Sub-Membrane Depressurization (SMD)	Existing structures, crawl spaces	Sealing to foundation wall, pipe penetrations; membranes may be damaged by occupants or trades people accessing crawl space.	$1-$6/ft²; residential systems typically in the $1.50-2/ft² range
	Sub-Slab Pressurization (SSP)	Same as SSD; most applicable to highly permeable soils	Higher energy costs (not included) and less effective than SSD; potential for short-circuiting through cracks	$1-$5/ft²
	Building Pressurization	Commercial structures that are specifically designed	Requires regular air balancing and maintenance; may not	$1-$15/ft²; heavily dependent on size and complexity of structure

ITRC PVI-1, 2014: Chapter 6 and Appendix J

No associated notes.

114



Community Engagement
How is a PVI Problem Fixed? Will it Ever be Over?

Community Engagement

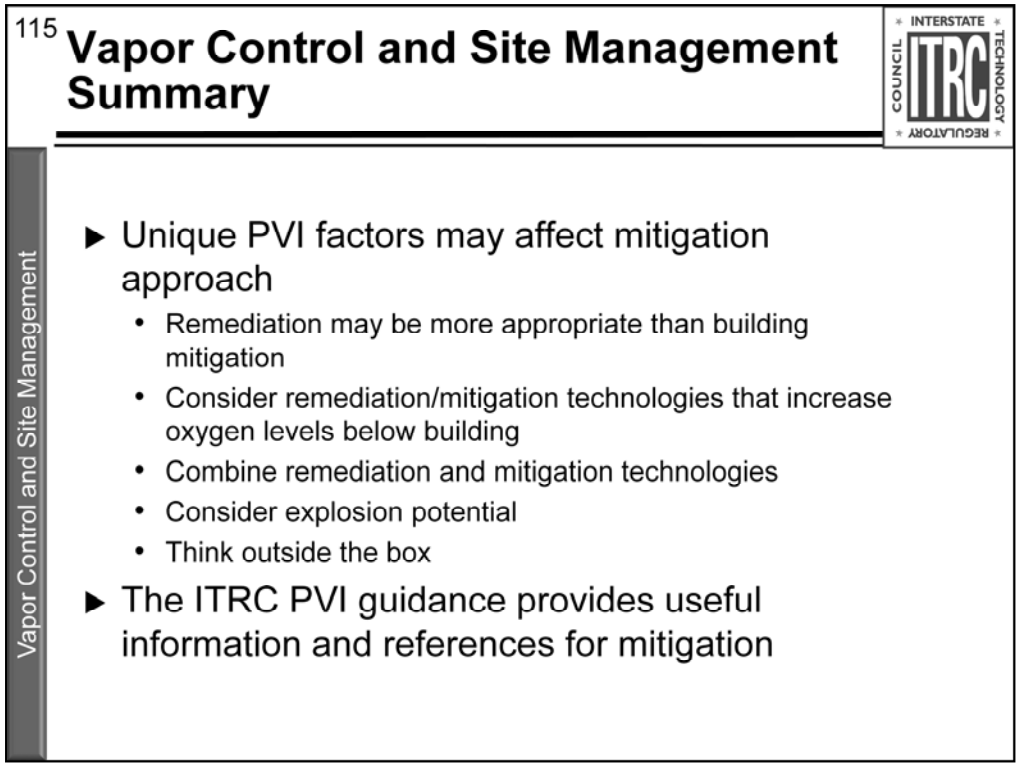
- What are some commonly used vapor control methods?
- How do I operate a vapor control system?
- How long will it take to get rid of the petroleum vapor intrusion problem?
- So, I may have a vapor control system in my home for years?
- How will I know how long it will take for clean-up and vapor control?

Petroleum Vapor Intrusion: Frequently Asked Questions
How is a Petroleum Vapor Intrusion Problem Fixed?
(PVI FAQ Sheet 3)

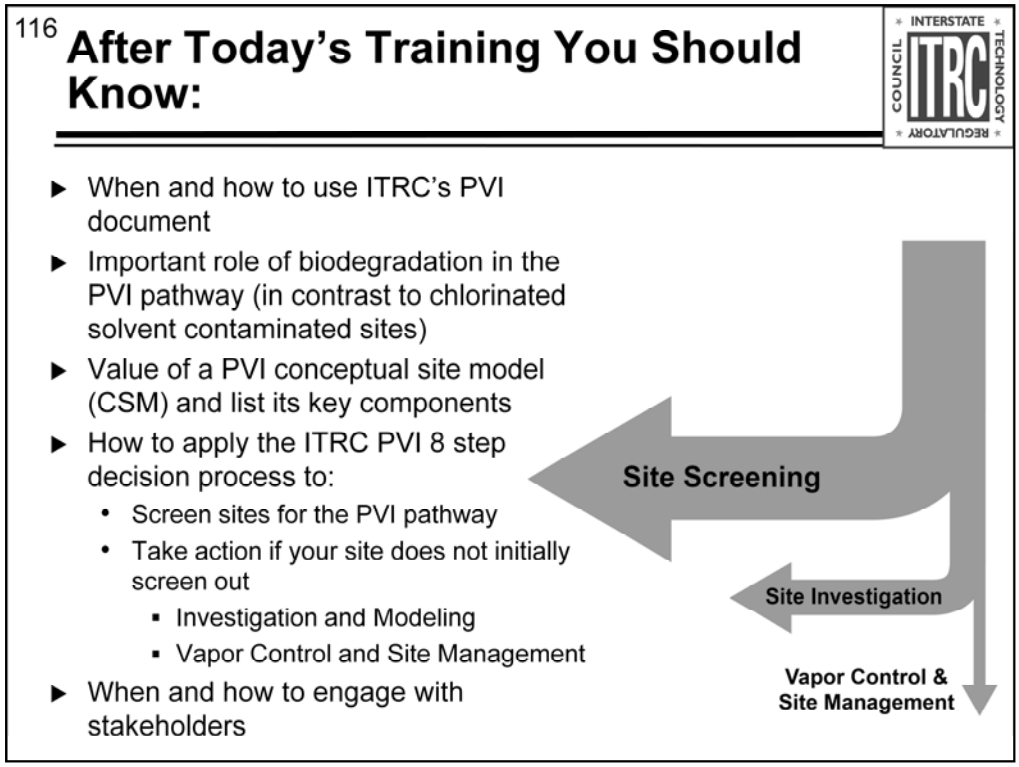
Petroleum Vapor Intrusion: Frequently Asked Questions
Is a Petroleum Vapor Intrusion Problem Ever Over?
(PVI FAQ Sheet 4)

ITRC PVI-1, 2014: Appendix K – Frequently Asked Questions Fact Sheets

No associated notes.



No associated notes.



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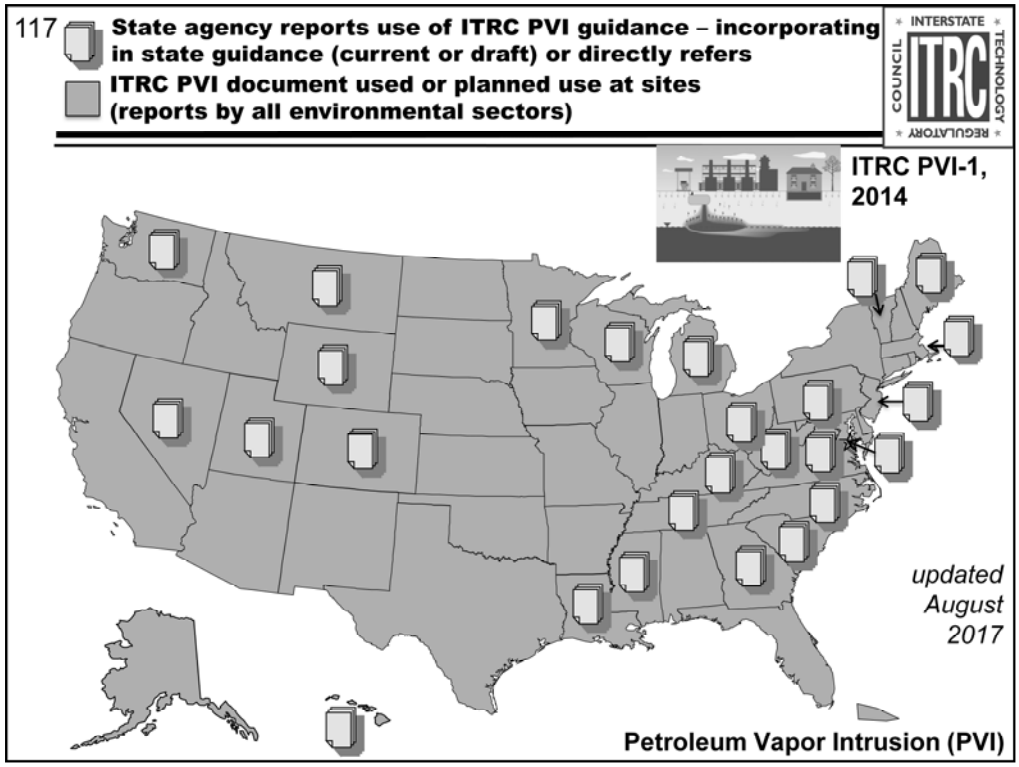
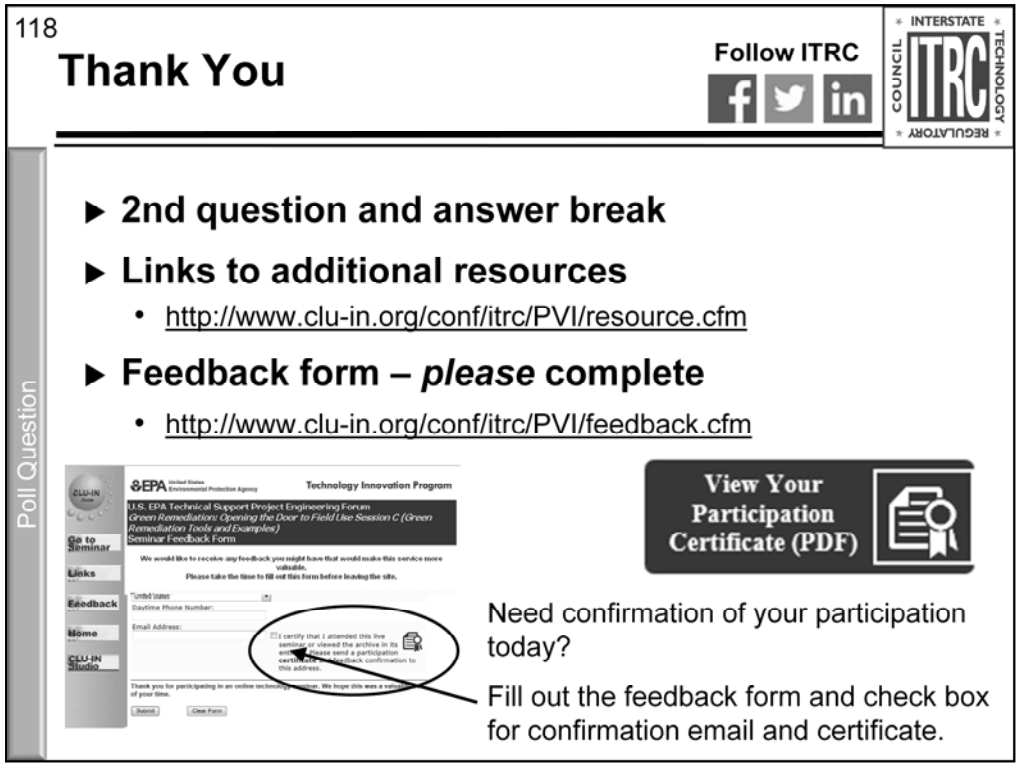


Map document icons reflect responses from states during readiness assessment to help determine potential 2017 host state locations for PVI classroom training:

Question: How is your state using the ITRC Petroleum Vapor Intrusion (PVI) guidance document?

- We have incorporated (or are in the process of incorporating) the ITRC PVI document into our state guidance to support evaluation of the PVI pathway.

- We refer directly to the ITRC PVI document and encourage its use at sites in our state.



Links to additional resources:
http://www.clu-in.org/conf/itrc/PVI/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/PVI

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities

✓Use ITRC products and attend training courses

✓Submit proposals for new technical teams and projects