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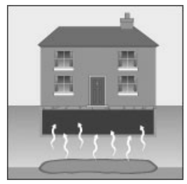
Welcome – Thanks for joining us.
ITRC's Internet-based Training Program

Vapor Intrusion Pathway: A Practical Guideline



Vapor Intrusion Pathway: A Practical Guideline (VI-1, 2007)

Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios (VI-1A, 2007)

This training is co-sponsored by the US EPA Office of Superfund Remediation and Technology Innovation

Vapor Intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals may include volatile organic compounds, select semi-volatile organic compounds, and some inorganic analytes, such as elemental mercury and hydrogen sulfide. Degradation of the indoor air quality causes a great deal of fear and anxiety among building occupants, business, and other property owners. Vapor intrusion has become a significant environmental issue for regulators, industry leaders, and concerned residents. Vapor intrusion requires three components: the source, an inhabited building, and a pathway from the source to the inhabitants.

The ITRC Vapor Intrusion Team is composed of representatives from 19 states environmental agencies, 12 environmental companies, and four federal agencies (including EPA). This team developed the ITRC Technical and Regulatory Guidance Document Vapor Intrusion Pathway: A Practical Guideline (VI-1, 2007), companion document Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios (VI-1A, 2007), and this internet-based training course to be used by regulatory agencies and practitioners alike. This training provides an overview of the vapor intrusion pathway and information on the framework (evaluation process), investigative tools, and mitigation approaches. The training uses typical scenarios to illustrate the process.

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

Training Co-Sponsored by: US EPA Office of Superfund Remediation and Technology Innovation (www.clu-in.org)

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

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ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Host organization — ECOS
- Network
  - State regulators
    - All 50 states and DC
  - Federal partners
    - DOE DOD EPA
  - ITRC Industry Affiliates Program — IAP
  - 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

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 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.

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ITRC Course Topics Planned for 2008 – More information at www.itrcweb.org

Popular courses from 2007

- Characterization, Design, Construction, and Monitoring of Bioreactor Landfills
- Direct Push Well Technology for Long-term Monitoring
- Evaluate, Optimize, or End Post-Closure Care at MSW Landfills
- Perchlorate: Overview of Issues, Status and Remedial Options
- Performance-based Environmental Management
- Planning & Promoting Ecological Re-use of Remediated Sites
- Protocol for Use of Five Passive Samplers
- Real-Time Measurement of Radionuclides in Soil
- Remediation Process Optimization Advanced Training
- Risk Assessment and Risk Management
- Vapor Intrusion Pathway: A Practical Guideline

New in 2008

- Bioremediation of DNAPLs
- Decontamination and Decommissioning of Radiologically-Contaminated Facilities
- Enhanced Attenuation: Chlorinated Solvents
- LNAPL
- Phytotechnology
- Quality Consideration for Munitions Response
- Remediation Technologies for Perchlorate Contamination
- Sensors
- Survey of Munitions Response Technologies
- More in development…

More details and schedules are available from www.itrcweb.org under “Internet-based Training.”

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Vapor Intrusion (VI) Pathway: A Practical Guideline

INTERSTATE TECHNOLOGY REGULATORY COUNCIL

Logistical Reminders

- Phone line audience
  - ✓ Keep phone on mute
  - ✓ *6 to mute, *7 to un-mute to ask question during designated periods
  - ✓ Do NOT put call on hold
- Simulcast audience
  - ✓ Use ? at the top of each slide to submit questions
- Course time = 2¼ hours

Presentation Overview

- Overview of vapor intrusion pathway
- Framework
- Questions and answers
- Investigative tools
- Mitigation
- In summary
- Links to additional resources
- Your feedback
- Questions and answers

No associated notes.

Meet the ITRC Instructors

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Bill Morris is an Environmental Scientist with the Kansas Department of Health and Environment's Bureau of Environmental Remediation in Topeka, Kansas . Bill has worked for the agency since 1995. He is the Bureau's Quality Assurance Officer and has been the Kansas point of contact for vapor intrusion since 2001. He has experience in environmental chemistry, aquatic toxicology, environmental emergency response, site remediation and residential construction practices. Bill routinely presents at conference regarding vapor intrusion and has done several classroom style trainings within the department. Bill has been active in the ITRC since 2004 when the ITRC Vapor Intrusion team was formed and is the team's co-leader team. Bill earned a bachelor's degree in zoology from Northern Arizona University in Flagstaff, Arizona in 1989.

Tom Higgins is a Hydrologist with the Minnesota Pollution Control Agency (MPCA) and serves as the MPCA's contact for vapor intrusion related issues. Tom has been a member the MPCA's Petroleum Remediation Program since 2003 working on a variety of projects including petroleum site investigation and cleanup projects as well as petroleum brownfield sites. Tom has presented materials on various topics relating to soil vapor intrusion at several conferences and has been a participant with the ITRC Vapor Intrusion team since 2005. Tom earned a bachelor's degree in biology from Minnesota State University in Mankato Minnesota in 2003 and a masters degree in environmental chemistry from the University of Minnesota in Minneapolis, Minnesota in 2006. Tom's graduate research focused on examining vapor phase diffusion rates of volatile organic compounds in Minnesota soils.

Jay Hodny is a Product Specialist with W. L. Gore & Associates, Inc., located in Elkton, Maryland. He oversees the technical, business, and administrative aspects associated with GORE™ Surveys, a passive vapor sampling service which utilizes waterproof, vapor-permeable GORE-TEX® membranes. He has been employed with Gore since 1992. Jay is a contributing author and instructor on the ITRC's Passive Sampler and Vapor Intrusion teams, and has been affiliated with the ITRC since the fall of 2004. He routinely makes presentations on the topic of passive sampling at professional conferences. In 1984, Jay earned a bachelor's degree in anthropology, with a second major in geography from the University of North Dakota in Grand Forks, ND. He then earned a master's degree in geography in 1992, and a Ph.D. in climatology in 1998, both from the University of Delaware in Newark, DE. His graduate research focused on water resources and the climatic water budget in the mid-Atlantic US. Periodically Jay teaches meteorology at the University of Delaware.

David Folkes is the President of EnviroGroup Limited, headquartered in Denver, Colorado. Dave has served as the Project Manager of one of the largest vapor intrusion sites in the country (Redfield Site) for over eight years, and has worked on over 30 other vapor intrusion projects across the U.S. His experience includes vapor intrusion screening, vapor intrusion investigations, Johnson & Ettinger modeling, indoor air testing, background source evaluation, building mitigation, and expert testimony. Dave has been a member of the ITRC Vapor Intrusion Team since its formation in 2004, and is co-chair of an ASTM work group committee that is developing standards for evaluating vapor intrusion during Phase 1 environmental site assessments. Dave is a registered professional engineer and 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.

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Vapor Intrusion

August 8, 2005

DANGER BENEATH OUR FEET

“IS MY FAMILY SAFE?”: A COMMUNITY VIEW OF VAPOR INTRUSION

“Is my family safe” from http://www.cpeo.org/pubs/CommunityView-VI2.doc

“Danger beneath our feet” from http://www.familiesagainstcancer.org/?id=235

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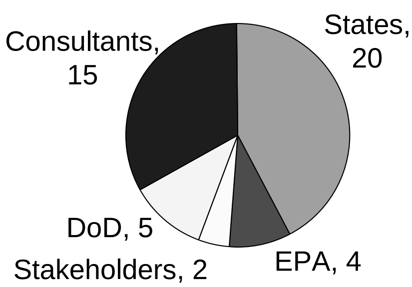
ITRC Vapor Intrusion (VI) Team

- History
- Composition
- Accomplishments
- Training
  - Existing
  - Planned



ITRC Website: www.itrcweb.org/vaporintrusion

Before we get into the training there are a few points about the team that need to be shared with the audience.

Team makeup (graph) started with a larger team, but this is the final active team member makeup.

History - formed in 2004 and finished work in 2006.

Completed most comprehensive survey of regulatory agencies regarding VI and have a website with over 40 states contacts for VI. Survey results and contact list is available from the ITRC Vapor Intrusion team's public page at http://www.itrcweb.org/vaporintrusion.

Two documents (the practical guideline and scenario document) are written for regulators, consultants and site owners.

Talk briefly about this training and if we are going to be developing classroom training.

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Scenarios

- *Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios*
  1. Gas station in residential neighborhood
  2. Drycleaner in strip mall located adjacent to neighborhood
  3. Large industrial facility with long plume under several hundred buildings
  4. Vacant lot with proposed Brownfield development over groundwater plume
  5. Vacant large commercial building with warehouse space and office space
  6. Apartment building with parking garage over groundwater plume

No associated notes.

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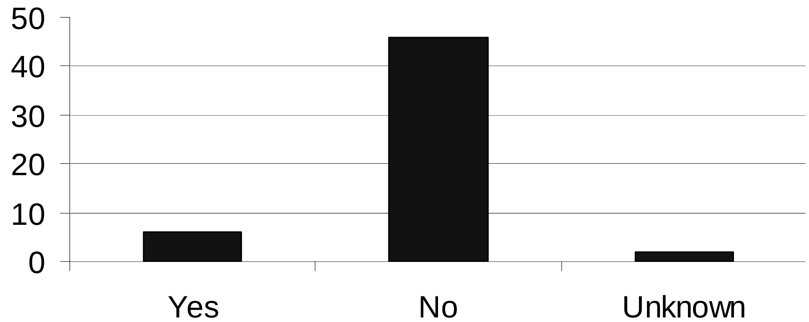
Regulatory Drivers/Oversight

- 37 of 43 states responding to the survey had no procedures for evaluating a VI Pathway
- 23 deferred to EPA guidance



Codified in law by legislation or regulation (54 respondents)

The next two slides are intended to give the audience the reasoning behind the formation of the team and also show some of the information obtained by the survey in 2004. Highlight the bullets.

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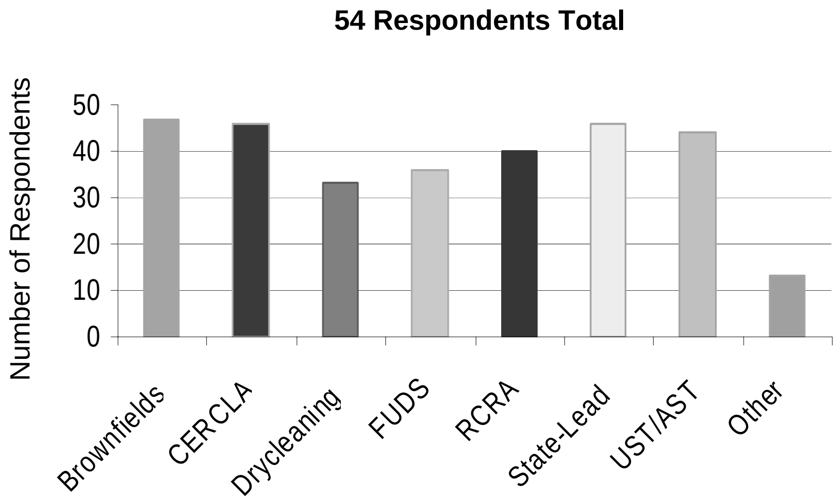
Programs Affected by Vapor Intrusion



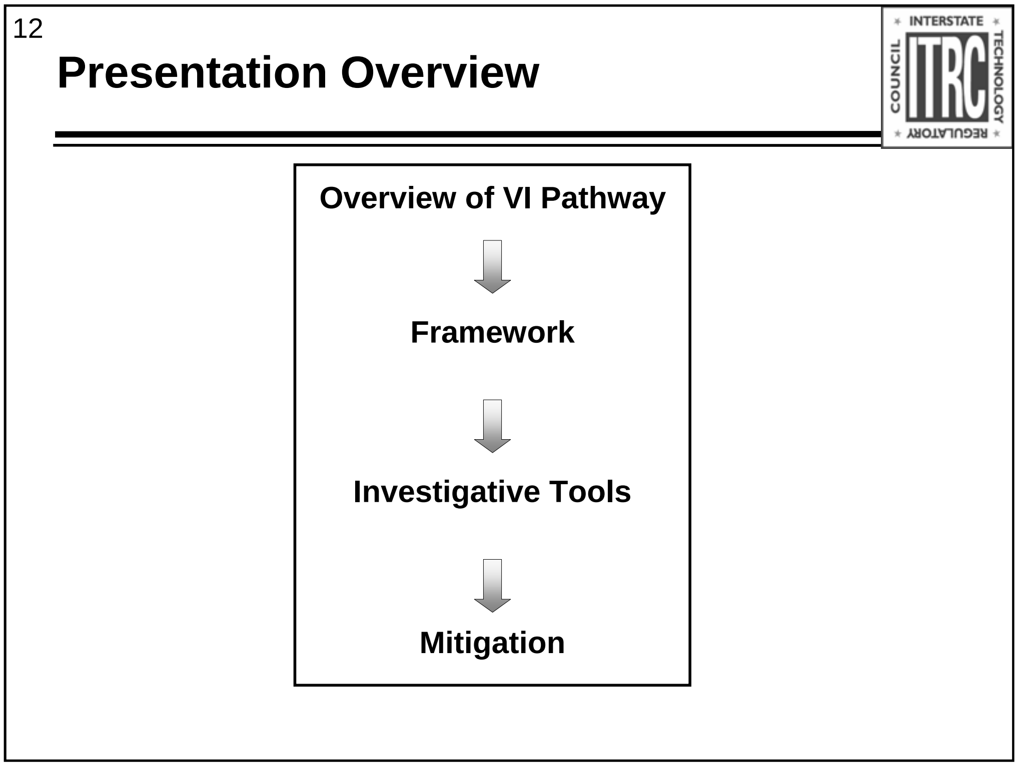
Another slide proving the importance of national guidance on the VI pathway. With this slide we can begin the training.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act (aka Superfund)

FUDS = Formerly Used Defense Sites

RCRA = Resource Conservation & Recovery Act

UST/AST = Underground Storage Tank / Aboveground Storage Tank



This training course is based on two documents:

Guidance Document is “Vapor Intrusion Pathway: A Practical Guideline” (VI-1, 2007)

Scenarios Document is “Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios” (VI-1A, 2007)

Both documents are available at the ITRC Website (www.itrcweb.org) under “Guidance Documents” and “Vapor Intrusion.”

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Overview of VI Pathway

- Definition of vapor intrusion
- Basic conceptual model
- Working principles
- Lines of evidence
- Special influences
- Community issues

Overview of VI Pathway
↓
Framework
↓
Investigative Tools
↓
Mitigation

For the first part of the training, we will layout the basics regarding vapor intrusion. Each of the items listed in the bullets is very important in a vapor intrusion investigation and the document provides information on all of these items, and there are many other things covered in the document.

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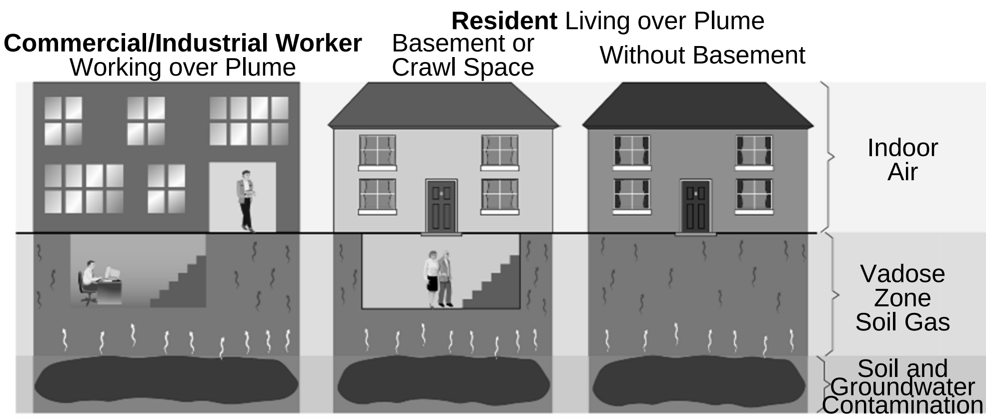
Vapor Intrusion

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



Migration of plume vapors to indoor air

So what is vapor intrusion? This is the EPA definition of vapor intrusion. For those of you that have a site with suspected or actual vapor intrusion, you can relate to how big this issue really is. The previous focus in most regulatory programs was groundwater, which is still very important, however VI can change how a site is addressed dramatically.

Possibly give an example of how it affected your state program.

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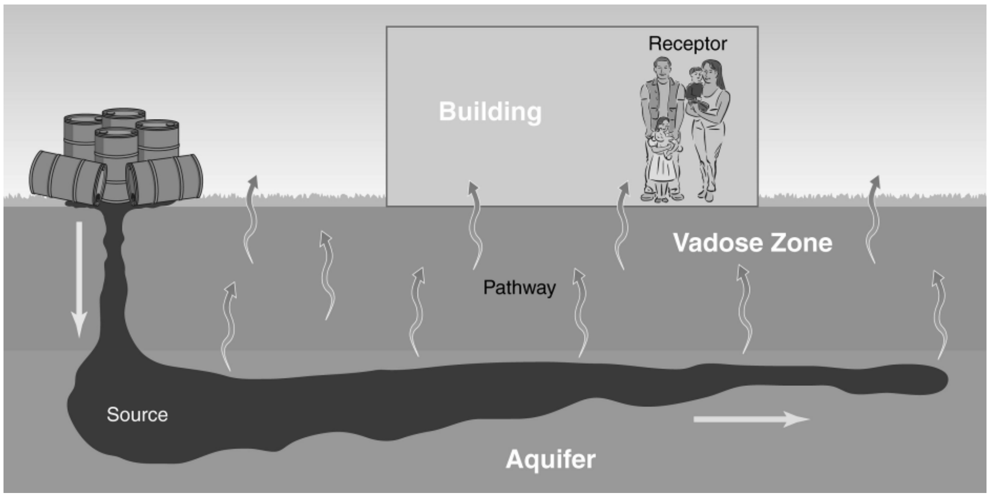
Basic Conceptual Model



For the first part of the training this is a simplified Conceptual Model. As the investigation progresses and more data is collected this model will be refined and a better understanding of the site and vapor intrusion should appear.

This model is the part that becomes much more complicated to understand.

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Working Principles

- Phased approach
  - Generic
  - Site-specific
- Iterative process
- Conceptual site model
- Use modeling, soil gas sampling, indoor air sampling, or mitigation
- Multiple lines of evidence
- Site use
  - Screening levels based on the appropriate exposure scenario
  - Residential, non-residential, occupational, etc.
- Qualified and experienced consultants
- Community outreach program

Point out these are the big picture items and there are many more things to think about during a vapor intrusion investigation. Not all of these will apply at every site, nor will they be simple to do at sites.

Use a phased approach that allows generic and site-specific

Develop an accurate site conceptual model

Based on an iterative process

Use modeling, soil gas sampling, indoor air sampling, or mitigation

Satisfy multiple lines of evidence

Consider the site use

Use screening levels that are based on the appropriate exposure scenario (e.g., residential, non-residential, occupational)

Choose only qualified and experienced consultants

Must have a community outreach program

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Special Influences

- Background contamination
- Biodegradation
- Preferential pathways
- Land use
- Undeveloped land
- Policy

Refer to Guidance Document as each of these points are discussed. These topics are also covered in the Scenario Document where appropriate

Background contaminants can affect sampling. Background refers to both indoor air background sources as well as outdoor ambient background sources. Both can have an effect on the sample results and methodologies.

Preferential pathways can make the vapor intrusion evaluation more difficult. Vapors do not have to follow the groundwater plume. They can migrate preferentially along soils with higher permeability, utility conduits, fractured bedrock, etc.

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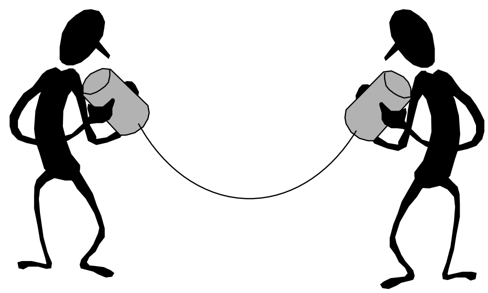
Community Issues

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



Point out that this information is located in the Guidance Document.

Last slide of the first section. Need to introduce the next trainer for the framework of the document

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Investigative Framework

- Focuses on the process
- Preliminary screening phase
  - Steps 1 – 7
- Site investigation phase
  - Steps 8 – 13

Overview of VI Pathway

↓

Framework

↓

Investigative Tools

↓

Mitigation

The Guidance Document provides a proposed vapor intrusion evaluation flowchart that is **broken into two phases**:

1. preliminary screening phase
2. site investigation phase

Please note that this is a conceptual framework. You will want to check with your regulatory agency for specific requirements; since, they may vary from the framework provided in the Guidance Document.

Each phase identified in the Guidance Document has multiple steps which I will describe in the following slides. These are steps you can take to assist in making a decision that either there is a vapor intrusion concern and mitigation is required, or there is no vapor intrusion concern and mitigation is therefore not warranted.

In the preliminary screening phase, it is assumed that a **limited amount of data** is available, and you have developed a preliminary site conceptual model.

If the data collected is indicative of worst case conditions at the site, the data **may be sufficient to make a final decision** regarding no further action or that mitigation is warranted.

If the data are **not sufficient**, then the Guidance Document recommends that you **proceed** to the site investigation phase.

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Preliminary Screening Phase (Chapter 2)

Step 1: Does the site represent an acute exposure concern?

Step 2: Are there sufficient characterization data to evaluate this pathway?

Step 3: Are any of the site contaminants of concern both volatile and toxic?

Step 4: Are buildings located in proximity to volatile chemicals in soil, soil vapor, or groundwater?

Step 5: Identify the appropriate occupant exposure scenarios and screening levels for this site

Step 6: Does the data exceed the appropriate generic screening levels?

Step 7: Does the exceedance warrant further investigation?

This slide identifies the steps of the preliminary screening phase. This phase is comprised of 7 steps.

It is assumed in the preliminary screening phase that some site data is available.

In **Step 1**, the question is whether site data are indicative of an acute exposure concern and, therefore, there is an imminent threat to public health. If that is the case, emergency response actions such as evacuation may be warranted.

In **Step 2**, the question is whether there is sufficient site characterization data to evaluate the vapor intrusion pathway.

In **Step 3**, the question is whether the site contaminants are both volatile and toxic.

In **Step 4**, the question is whether there is a potential receptor in proximity to the identified volatile impacts.

Step 5 is where you identify the appropriate screening criteria. You will want to check with your state regulators for state-specific criteria.

Step 6 is the comparison step where site data is compared to the appropriate screening criteria.

Finally in **Step 7**, assuming there is an exceedance of one or more of the screening criteria, the question is whether the exceedance may warrant further investigation or whether mitigation is warranted.

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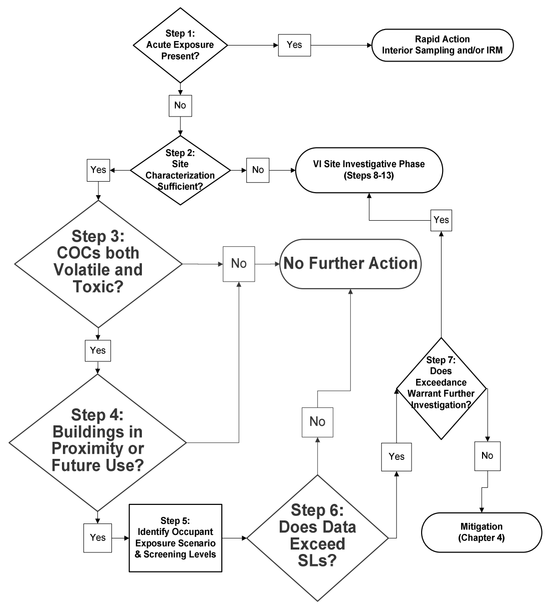
Preliminary Screening Flow Chart: Exits Points (Figure 2-2)



This slide provides the flow chart for the preliminary screening phase, which is also presented as Figure 2-2 in the Guidance Document. On this slide, the investigation exit points or decisions supporting no further action, are highlighted in red.

Assuming that there is sufficient worst case data, the exit points in the preliminary screening phase are steps 3, 4, and 6.

In **Step 3**, the question is whether site contaminants are both volatile and toxic. The Guidance Document identifies what is considered to be a volatile compound, which can include volatile organic compounds (VOCs), and also chemicals such as hydrogen sulfide, mercury, and methane. If volatiles are not present, then the vapor intrusion pathway is not complete and therefore not of concern. So no further action is warranted.

In **Step 4**, the question is there is a receptor in proximity to the volatile impacts. Check with your state regulatory agency as many states have different definitions of what is meant by proximity, and have identified setback distances for the vapor intrusion screening process. If the volatile impacts are not in proximity to the potential receptors, then again the vapor intrusion pathway is not complete and therefore not of concern. In this situation, no further action is warranted.

Step 6 is the step where you compare site data to appropriate screening criteria. If the site concentrations are lower than the appropriate state screening criteria, then the vapor intrusion pathway is complete but not significant enough to be of concern, so no further action is warranted.

The Guidance Document identifies the types of State and Federal screening criteria, how they are typically derived, and how they can be used to compare to site data. Note that screening criteria are developed using conservative assumptions, and may be considered overly protective and err on the side of indicating mitigation may be necessary when it may not.

Some States do not have screening criteria and either rely in Federal criteria or site specific

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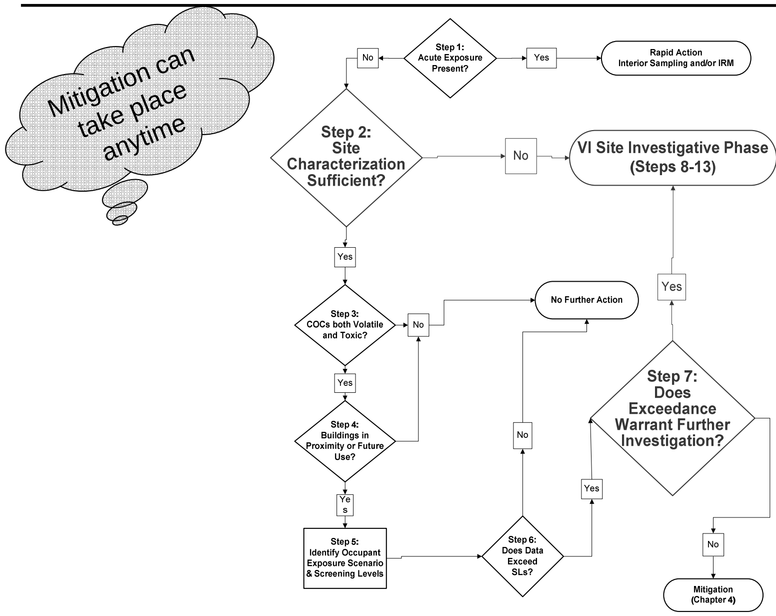
Preliminary Screening Flow Chart: Investigation Decision Steps (Figure 2-2)



This slide shows the same preliminary screening flow chart as presented in the previous slide, but instead the two investigation decision steps, Steps 2 and 7, are highlighted in red.

If the answer to Step 7, Does an exceedance warrant further investigation if YES or the answer to Step 2, Is site characterization sufficient is NO, then additional data is warranted and the evaluator would proceed to the second phase of evaluation which is steps 8 through 13.

Chapter 2 of the Guidance Document, “Vapor Intrusion Pathway: A Practical Guideline” (VI-1, 2007), provides information on how these preliminary questions can be answered.

The companion Scenario Document, “Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios” (VI-1A, 2007), provides conceptual real world examples on how these questions could be answered.   Later other presenters will use some of the scenarios in the companion document to provide examples of how to use various evaluation tools.

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Site Investigation Phase (Chapter 3)

Step 8: Choose an investigative strategy
Step 9: Design a VI investigation work plan
Step 10: Implement VI investigation work plan
Step 11: Evaluate the data
Step 12: Is additional investigation necessary?
Step 13: Is mitigation warranted?

At this phase in the vapor intrusion evaluation the determination for additional data has been made to assess the VI pathway. You are now in the site investigation phase of the evaluation process. These steps described in Chapter 3 of the Guidance Document.

In general, this phase describes how a site investigation strategy can be developed and implemented in Steps 8 through 10, and how the data can be evaluated for possible vapor intrusion concerns in Steps 11 through 13.

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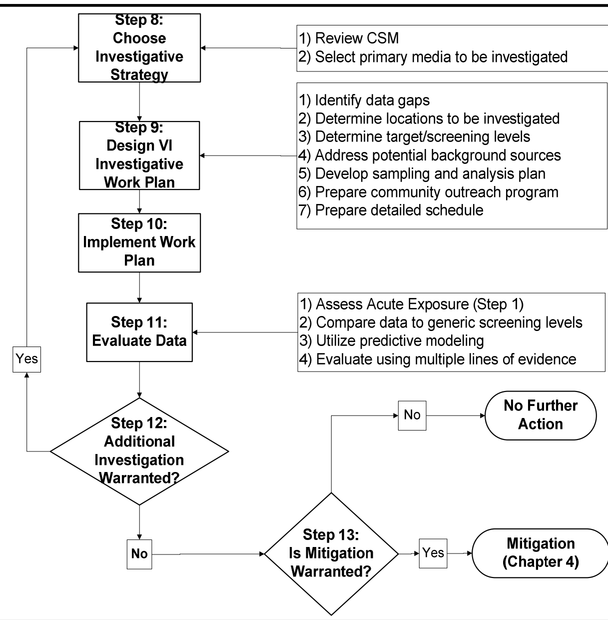
Site Investigation Flow Chart
(Figure 3-1)



This slide presents the flow chart for the site investigation phase, which is also Figure 3-1 in the Guidance Document.

Steps 8 through 10 describe the information necessary to ascertain what additional data should be collected. This decision is primarily based on data gaps identified in the site conceptual model.

Check with your regulatory agency for state specific requirements as the decision to mitigate may vary from state to state.

The data collected in this phase is typically collected from multiple locations and is comprised of various sample media. Once a site investigation strategy has been identified and implemented, step 11 describes how this data can be evaluated. This step starts with first re-asking the preliminary screening questions in steps 1 through 7. As we mentioned this is an iterative evaluation process as new or additional data is obtained. The evaluation may continue by including a more detailed evaluation if deemed necessary.

Again, at anytime within this process you can choose to mitigate, even before additional screening is conducted or additional data is collected. This process will also be an iterative process as more data is obtained and other data gaps may be discovered .

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Step 8: Choose an Investigative Strategy

Decide the media and technical approach for assessing the vapor intrusion pathway

- Interior and/or exterior sampling approach
- Characterization tools
  - Interior sampling
  - Exterior sampling
- Analyte list
- Use of supplemental data

Deciding on what media to sample and which tool to use may be difficult decisions to make (unless the regulatory agency requires a specific approach). The investigator may come back to this step several times during the process as data is evaluated.

Based on your site conceptual model, principle questions that should be asked include: What information is necessary to complete the vapor intrusion evaluation? How will the data, once obtained, be evaluated? What are the data gaps?

The investigation strategy may include the collection of both exterior and interior samples. The pros and cons, and data uses for these types of samples are described in the toolbox section of the Guidance Document.

When indoor air sampling is proposed, the evaluator must be aware of the potential confounding factors (such as background chemical sources) when interpreting indoor air data. An example indoor air sampling checklist is presented in Appendix G of the Guidance Document.

The analyte list and detection limits must also be determined. The detection limits should be at or less than the identified screening criteria.

In addition, supplemental data may be collected to provide additional lines of evidence or for use in quantitative assessments. These data types will be further

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Step 9: Design a VI Investigation Work Plan

Investigation work plan components

- Site-specific conceptual site model
- Identified data gaps
- Sampling locations
- Background
- Sampling
- Groundwater issues
- Community outreach
- Access issues
- Implementation
- Scheduling
- Impacted structures

Once the investigator has determined the media to be sampled, then a **detailed work plan** should be assembled. This slide presents a list of the typical investigation work plan components.

Information is provided in the Guidance Document regarding each of the items listed on this slide.

One of the typical components worth noting is the site-specific conceptual model. This should be a focal point for developing your work plan.

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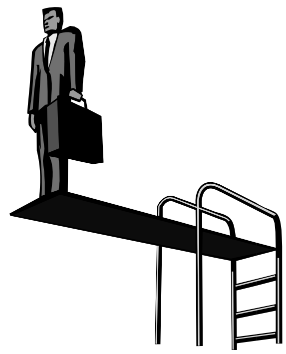
Step 10: Implement VI Investigation Work Plan

- Schedule
- Expectations of field work
  - Worst-case conditions (e.g., heating season)
  - Seasonal differences
- Flexibility and property access
- Communication



Vapor intrusion investigations will always be site specific.

For instance, the schedule for field activities may change based on a variety of factors including property accessibility and weather. This may have impacts on data interpretation, especially if seasonal data is considered necessary.

It is not recommended that soil gas samples be collected during or immediately after a rain event. Guidance as to how long to wait after a rain event is dependant on many factors including soil type and the magnitude of a precipitation event. It is recommended that you contact your state regulators for specific guidance. Decisions may also be made on a case-by-case basis.

For example, at a particular site I had to wait a little longer than what was recommended after a rain event due to the presence of puddles in areas of poor surface runoff conditions where soil gas samples were to be collected.

The collection of verification data may also be warranted to further assess unexpected data.

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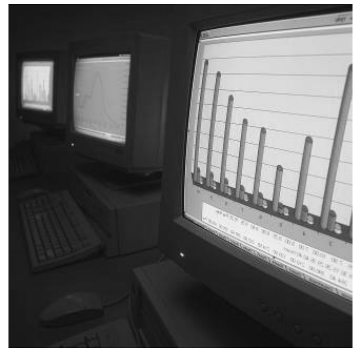
Step 11: Evaluate the Data

- Important step
  - Integrate qualitative and quantitative data
- Lines of evidence brought together
  - Revisit the preliminary screening pathway
- Can be done in conjunction with other earlier steps
- May be done several times during the vapor intrusion investigation
  - Iterative process



The goal of assessing vapor intrusion data is to make a sound defensible determination of whether or not vapor mitigation is warranted.

It is important to bring together all lines of evidence to determine whether the vapor intrusion pathway is or is not complete or potentially complete.

At each stage of assessing new data, the investigator should revisit and revise the site conceptual model as necessary and revisit the preliminary screening flowchart to assess the possibility of acute exposure.

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Step 11: Evaluate the Data (continued)

Media	Evaluation Method	Principal Issues
Groundwater	Attenuation factor or modeling based on site-specific conditions used to predict indoor air concentration	Imprecision of attenuation factors or modeling requires very conservative assumptions. Henry's law must be corrected for the aquifer temperature.
Soil vapor	Attenuation factor or modeling based on site-specific conditions used to predict indoor air concentration	Fewer pathway assumptions required than groundwater, but the accuracy and representativeness of measurements may be an issue
Sub-slab vapor	Attenuation factor estimated or measured (e.g., using radon) to predict indoor air concentration	Fewest pathway assumptions required, but intrusive and attenuation factors may still be conservative for many buildings.
Indoor air	Indoor air concentrations directly measured	Intrusive, and background sources may confound data interpretation; seasonal variations are also an issue.

Different states have different requirements regarding what media to collect and how it is interpreted. The table presented in this slide is Table 3-1 in the Guidance Document.

In general this table provides a summary of how the data from various media may be used in the evaluation of vapor intrusion, and provides pros and cons on the interpretation using these media data.

For instance, if you have only subsurface data, you can use modeling to estimate indoor air concentrations. The closer your subsurface data is to the building foundation, the fewer assumptions are made regarding vapor transport.

If, however, at this stage of evaluation you have indoor air and sub-slab samples in addition to subsurface data such as groundwater, soil, or soil gas data, the Guidance Document explains how you can use a multiple lines of evidence approach to evaluate whether vapor intrusion may be occurring.

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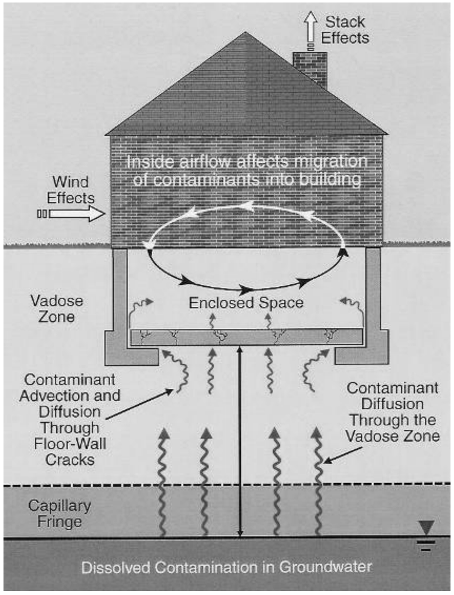
Lines of Evidence for Decision Making



- Soil gas spatial concentrations
- Groundwater spatial data
- Background sources
  - Internal
  - External
- Building construction and current condition
- Sub-slab
- Soil gas data
- Indoor air data
- Constituent ratios

Multiple lines of evidence approach can be used to evaluate whether indoor air concentrations are attributable to vapor intrusion and if so, to what level. The figure in this slide is Figure 2-1 in the Guidance Document.

The Guidance Document presents several types of evaluation approaches depending on the types of data and information that is available.

The evaluation of multiple lines of evidence forces you to look at the big picture.

The idea is to tie everything together to determine if a completed VI pathway is present and if so will mitigation be required.

A lines of evidence approach for you site may include consideration of one or more of those listed on this slide, such as the spatial distribution of subsurface impacts, or building characteristics such as air exchange rate and information regarding building pressurization.

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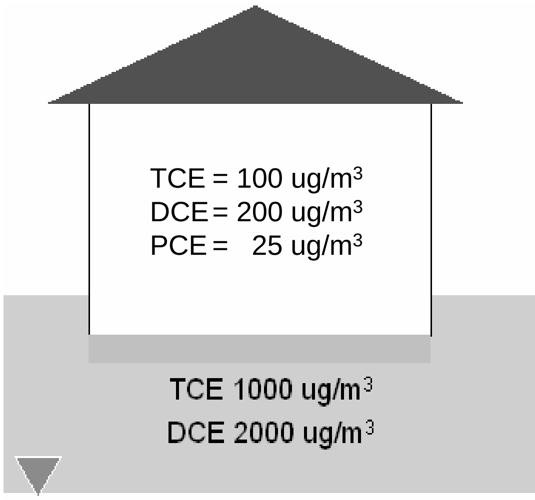
Lines of Evidence for Decision Making (continued)



- Constituent ratios can provide evidence for and against intrusion
- PCE detected indoors however not in sub-slab
- Attenuation factors can be expressed through ratio comparison

Reviewing constituent ratios is one tool that could be used is comparing the subsurface data with indoor air data to ascertain whether the measured indoor air data appears to be associated with what is being measured in the subsurface.

Constituent ratio is the ratio of the concentration of a chemical that is present in the indoor air versus subsurface soil gas. This ratio is compared to similar ratios for other chemicals that are also present in both indoor air and soil gas.

For example, when indoor air data has been collected, the measured concentrations may be attributable to background concentrations associated with ambient air or chemical products present within the house. These same chemicals may be present in the subsurface. If the measured indoor air concentrations are considered significant, one would ask whether they are due to vapor intrusion or some other source.

Please take a look at the example shown in this slide. The concentrations are arbitrary for example purposes only and the constituent ratios example may not be so simple at your site.

If chemicals in indoor air are due to vapor intrusion you would expect the ratios to be similar and within expected attenuation ranges for each of these chemicals. For instance in the example, note that the ratios for TCE and DCE in indoor air versus soil gas are similar. Also note that PCE, a potential risk driver, is not present in the subsurface, and thus it may be concluded (depending on the detection limit of the subsurface data for PCE) that the source of PCE is not from the subsurface. Or PCE may be present in the subsurface but at a significantly higher ratio than for TCE and DCE, which may be

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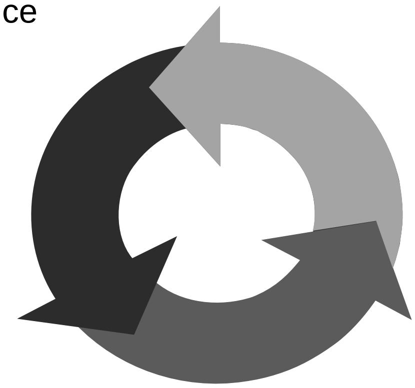
Step 12: Is Additional Investigation Necessary?

- Iterative process
- Additional data necessary
- Regulatory agency guidance
- May do additional
  - Investigation
  - Mitigation
  - Monitoring



Step 12 is a decision point to determine if the site has been adequately characterized and if risk from the vapor intrusion pathway can be assessed.

If risk cannot be determined then additional investigation may be required and the investigator would proceed back to step 8 where you would assess what types of data are needed, or if monitoring, or mitigation may be required.

Again at any time during the evaluation, a decision can be made to mitigate.

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Step 13: Is Mitigation Warranted?

- If exposure pathway complete, mitigation necessary
  - Qualitative
    - Preferential pathways
    - Poor building condition
  - Quantitative
    - Soil gas
    - Sub-slab
    - Indoor air
    - Constituent ratios
- Regulatory agency may allow monitoring vs. mitigation

After evaluating the data, determining that no additional data is necessary, and the vapor intrusion pathway is complete, you ask yourself Is Mitigation Warranted?

This is the final step in the site investigation phase. The decision to mitigate may be based on qualitative and/or quantitative information.

Check with your regulatory agency on specific details regarding the **decision to mitigate.**

Mitigation alternatives are discussed later in this presentation.

In summary, the content of Chapters 2 and 3 of the Guidance Document that include a description of the vapor intrusion evaluation framework. This framework includes two phases, the preliminary screening phase and the site investigation phase.

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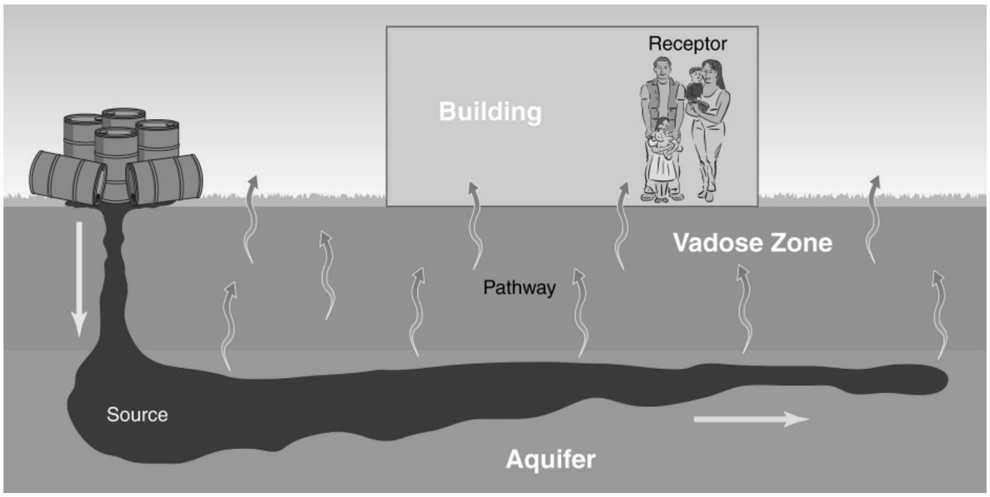
Question and Answer



No associated notes.

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Investigative Tools

- Toolbox (Appendix D)
  - Data quality objectives
  - Groundwater; soil
  - Exterior soil gas
  - Sub-slab soil gas
  - Indoor air
  - Supplemental data
- Site investigation process
  - Scenario example

Overview of VI Pathway

↓

Framework

↓

Investigative Tools

↓

Mitigation

Welcome to the Investigative Tools portion of the Guidance Document and this portion of the training.

The training up to this point has taken us through the steps involved in the Preliminary Screening Phase and into the Site Investigation phase. We are going to explore the Site Investigation phase in greater detail during this portion of the training. We are assuming that Steps 2 through 7 have been answered and **Further Investigation is warranted,** and we have now moved into Steps 8 through 13 as outlined by the previous series of slides. If at Step 13, the investigation has concluded there is a vapor intrusion problem and **Mitigation is warranted**, the Guidance Document and the next portion of the training tackles the issue of Mitigation.

This portion of the training will focus on two main areas:

1) The first area is a summary of the sampling techniques and media sampled in vapor intrusion investigations

1a) Appendix D is quite comprehensive in its discussion on the various approaches available for sampling groundwater, soil, soil gas and sub-slab soil gas, and air, and also contains discussions on the various supplemental data sampling approaches available which may provide additional information pertinent to the VI investigation.

2) The second area will look at the Site Investigation process by reviewing one of the Scenarios presented in the Scenarios Document. The Scenarios Document ties together the site investigation process discussed in the Guidance Document by looking at some probable real world vapor intrusion

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Data Quality Objectives

- Define/identify
  - Study goals
  - Contaminants of concern
  - Regulatory screening levels
- Complete
  - Pre-sampling building survey
    - Interior survey
    - Site screening
- Choose/establish
  - Sampling and analytical method
  - Number of samples
  - Reporting limits
- Collect
  - Samples
  - Quality assurance (QA) samples
- Establish
  - Validation procedures

Regarding data quality objectives.

Begin the investigation with an end in mind – that is to determine if intrusion is real and is a risk.

Data quality objectives should be defined before sampling begins, and are usually defined during the work plan preparation.

In your work plan, define and identify the study goals (site specific), and what the contaminants of concern and associated regulatory screening levels are, if known.

Complete a pre-sampling building survey. This survey may include an interior survey and/or a 'screening level' soil gas site survey, to gather information on compound presence in the vadose zone, or review of other available data such as groundwater data. In line with Chapter 2 of the Guidance Document, Preliminary Screening phase.

Choose and establish the sampling and analytical method, the number of samples, and the analytical reporting limits.

Collect the various samples following accepted sampling procedures, along with appropriate QA samples.

Establish and have in place procedures to determine data validity.

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Groundwater Sampling

- Assess available data
  - Well location and construction
  - Aquifer characteristics
  - Interpolate – flow and direction
- Gather new data
  - Well location, construction, sampling
- Consider perched water, vertical profiles
- Incorporate long-term monitoring
- Table D-1

Existing

- Can use existing groundwater data concentrations of contaminants of concern (COCs), often a good indicator of potential presence in vadose zone beneath buildings

- Review well location and construction; as you need to have well screened across water table

- This screen reveals compound presence at water table, and potential partitioning to vapor

- Review aquifer characteristics, may shed light on migration of contaminants and water level trends

- You can interpolate groundwater contaminant concentrations to regular grid if sufficient number of wells exist surrounding area of investigation, consider groundwater rate and direction of flow

New

- If you can collect groundwater data through new wells, wells should be designed, located, developed, purged and sampled to address VI issues, if allowable.

- Consider infiltration upgradient in choosing well locations

Perched water can be an issue - may only need to sample perched water

Vertical groundwater profiles can be revealing

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Soil Sampling

- Soil data generally not acceptable in VI investigations
- Existing soil data – line of evidence
  - Can “screen in” sites
  - Cannot be used alone to “screen out” sites
- Convert to soil gas concentrations
  - Partitioning equations exist
- Sampling – minimize volatile organic compound (VOC) loss

Soil (most soil data is generally not acceptable in VI investigations) “you might as well be collecting the soil from the moon”

In the absence of soil gas data, existing soil data can be used as a line of evidence

- Soil data can be used to “screen in” sites, but cannot be used alone to “screen out” sites

- Soil data may have elevated reporting limits or volatilization losses, therefore non detect (ND) in soil does not mean “no potential for VI”

- One can convert soil data to soil gas concentrations using partitioning equations. This result provides an estimate of the soil gas concentration in the vadose zone.

- If soil sampling is conducted, perform the sampling using accepted methods that minimize VOC losses

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Soil Gas Sampling

- Active methods
  - Through driven/drilled rods
  - Extraction of soil gas
- Passive methods
  - Burial of adsorbent
  - Diffusion of soil gas
- Considerations
  - Purge and sample volumes
  - Flow rate, vacuum, and leak tests
  - Sample containers
  - Temporal effects
  - Real-time sample and analysis
  - Sample density and locations
  - Hydrophobic adsorbents

- <u>Vapor data in various forms are preferred for VI investigations</u>

Vapor data provide direct measurement of contaminants of concern (COCs) in vapor, that could infiltrate or be present in a building, and enter humans.

VI risk-based levels are up to 10,000 times lower than levels collected for typical site assessment programs.

Thus, sampling techniques and analytical methods combined, are needed to achieve the increased sensitivity and lower detection limits required

- Two general approaches

<u>Active</u> – extract a volume of air from the soil environment through driven or drilled rods or tubes, analyze, report measured concentrations

<u>Passive</u> – bury an adsorbent in the soil and allow compounds diffuse to adsorbent, analyze sorbent, report a measured mass

The Appendix in the Guidance Document list several things to consider for soil gas sampling (some are listed on the slide)

The majority of these listed here pertain to active.

For passive, choosing a hydrophobic (waterproof) adsorbent is preferred – minimize water vapor uptake in the soil, instead want the uptake of the contaminants of concern.

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Sub-slab Soil Gas Sampling

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

Active sampling

Passive sampler insertion

Sub-slab vapor sampling

- May represent the soil gas and contaminants of concern most likely to enter a structure.

- May also detect chemicals originating with the building.

- May collect indoor air samples concurrently for comparison to the sub-slab soil gas data.

- Sub-slab soil gas can be collected at slab base or at depth into soil beneath slab or both.

- The sample points can be temporary or permanent. Permanent points are convenient for repeat sampling, but the sample point should be flush mounted and sealable to minimize potential for damage, prevent vapor infiltration, maintain cosmetic appearance and room functionality in family homes. Temporary points need to be sealed effectively to prevent infiltration of vapor, water, etc.

- Both active and passive sampling approaches can be used to sample and monitor sub-slab soil gas.

- Active research going on to determine conditions under which near slab

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Indoor Air Sampling

- Generally performed after subsurface sampling
- Pre-sampling building survey
  - Appendix G
- Focus on contaminants of concern (COCs)
- Length of sampling time
- Analytical methods
- Active and passive methods
- Locations
  - Crawlspace samples
  - Ambient samples

Examples of sampling canisters (shown with sporting equipment to illustrate size)

Indoor air sampling

- Generally performed after subsurface sampling completed but can be done concurrently.

Exceptions: in cases of emergencies due to spills, concentrations reaching explosive limits, if the water table is intersecting the basement or slab, LNAPL is present of suspected to be present beneath the building

- Conduct building survey

•Document occupant behaviors, e.g., lawn mower stored in basement, smoking

•Document potential sources and chemicals present, e.g., lawn mower, paints

•Appendix G is a useful Indoor Air Questionnaire for conducting a pre-sampling survey

- Focus on contaminants of concern (COCs) found in elevated levels during the soil gas and/or sub-slab soil gas investigation.

- Length of time sampling is important to capture a time-integrated sample

- Analytical methods require reporting limits lower than target concentrations

- Active and passive methods

•Canisters and adsorbents

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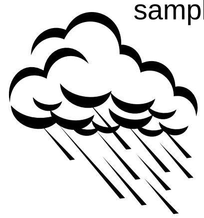
Supplemental Tools/Data

- Emission flux chambers
- Tracers – attenuation
- Differential pressure measurements
- Real-time and continuous analyzers
- Forensics
- Soil properties
- Meteorological data

- Tables D-3, -4, and -5
  - Additional toolbox information in summary form
- Appendix E
  - Quality assurance/ quality control (QA/QC) considerations with active, passive, and flux chamber sampling



Supplemental Tools - lots of them are discussed in Appendix D of the Guidance Document and provide additional datasets that can aid the VI investigation.

Flux chambers: surface placed enclosures that can measure flux of contaminants of concern (COCs) from subsurface

Tracers: measure natural or induced tracer in sub-slab and indoor air, compute attenuation factors; help determine room ventilation rate

Differential pressure measurements: measure and compare sub slab, interior and exterior pressures and manipulate pressure to see effects on vapor migration from/to subsurface

Real-time and continuous analyzers: allows for more detailed trend analysis, record background data, and correlate to other variables. For example, air pressure changes over time correlated to changing sub-slab vapor concentrations.

Forensics: chemical fingerprinting of source; contaminant ratios; chromatographic fingerprinting; isotopes; multi-variate statistical techniques

Soil properties: measured properties are better than estimated values, and are therefore better inputs to VI models than those estimated

Meteorological data – weather: rain infiltration, wind speed, air pressure and their effects on the vapor migration and intrusion process

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Vapor Intrusion Scenarios

- Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios

1. Gas station in residential neighborhood
2. Drycleaner in strip mall located adjacent to neighborhood
3. Large industrial facility with long plume under several hundred buildings
4. Vacant lot with proposed Brownfield development over groundwater plume
5. Vacant large commercial building with warehouse space and office space
6. Apartment building with parking garage over groundwater plume

We are going to show an example of how the Scenario Document is put together and follows the steps in the Guidance Document.

Guidance Document = Vapor Intrusion Pathway: A Practical Guideline (VI-1, 2007)

Scenarios Document = Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios (VI-1A, 2007)

Both available from the ITRC Website (www.itrcweb.org) under “Guidance Document” and “Vapor Intrusion.”

Here are each of the scenarios. They were developed by the team and represent some of the typical investigation experiences we have had.

For the following slides, we will be using Scenario 3, the large industrial facility with a long contaminant plume, as an example which ties together the site investigative process defined in the Guidance Document to a probable real world investigation.

The Scenarios Document also discusses the selection and practical application of the tools in the Appendix D -Toolbox in each of the scenarios, and the reasons for their selection and use.

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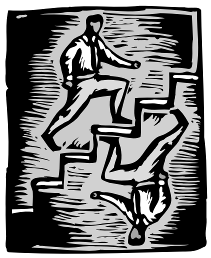
Scenario Progression

Follows stepwise approach from Guidance Document

- Site description (the situation, conceptual site model)
- VI investigative process (Steps 8 through 13)
- What was unique about the scenario?
  - Key issues
  - Lessons learned
- Next steps



- ✓ Step 8: Choose an investigative strategy
- ✓ Step 9: Design a VI investigation work plan
- ✓ Step 10: Implement VI investigation work plan
- ✓ Step 11: Evaluate the data
- ✓ Step 12: Is additional investigation necessary?
- ✓ Step 13: Is mitigation warranted?

Scenario Progression

When you read each of the scenarios in the Scenario Document you will see that each one follows a stepwise investigative approach of the Site Investigation process explicitly. The dialogue in each scenario is not meant to be “marching orders” or a “how-to” conduct a vapor intrusion investigation, or that the ITRC VI team recommends one conducts a vapor intrusion investigation. Rather, each one is based on probable real world situations, and describe how the issues were tackled and the questions answered. The dialogue may fit your investigation, but will likely need to be modified for your specific site.

The scenarios include discussions on the VI concern, site description, site background which may include site geology, kinds of contaminants present, documented releases, etc., all of which help define the conceptual site model.

The scenarios go through Steps 8 through 13 explicitly.

The discussions include the thought process around the tools selected to conduct the investigation.

Each scenario highlights key issues identified and dealt with during the investigation.

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Scenario: Site Description

- Scenario 3
- Groundwater
  - 15-30 feet bgs
  - Chlorinated compounds
  - Plume - miles long
- Lithology
  - Alluvial soil
  - Clay layer 3-5 feet bgs
- Hundreds of structures
  - Basements, crawlspaces, slabs
- Groundwater “hot spot” concentrations 100x screening levels
- Similar to Redfield site

Solvent contamination and adjoining mixed-use neighborhood

For Scenario #3:

The situation at the site is described, available data are summarized, and a conceptual site model developed.

- Here we have groundwater depth measured, chlorinated contaminants of concern known to be present, and the extent of the contaminant plume identified.

- Site soil information was available.

- Cultural component includes hundreds of structures in a mixed zone of commercial businesses, homes, daycares, schools.

- Groundwater concentrations defined a “hot spot” that had concentrations that were 100 times greater than the allowable groundwater screening levels.

- This scenario is similar to the Redfield investigation in Colorado

bgs = below ground surface (depth below the ground surface)

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Scenario: VI Investigation

- Follows progressive and iterative process
- Steps 8 through 13 are discussed
- Scenario 3
  - Utilized a “hot spot” approach for initial investigation
  - “Step-out” two buildings at a time (based on results)
  - Decision points determined in work plan
  - Redfield site investigation similar

The Site Investigation process discussed in each scenario follows a progressive and iterative process. Decisions and the rationale behind the decisions at each step are discussed. Further, in this slide and in the next slide, the decision and rationale for choosing a specific sampling procedure or tool are discussed, and include sampling alternatives and their respective pros and cons.

For Scenario #3:

The decision was to focus on the groundwater “hot spot” and the buildings in closed proximity, then,

Step out two buildings at a time, sample and evaluate the data, and decide if the two building step out continues.

This Site Investigative approach is similar to the Redfield Colorado site investigation.

Scenario: VI Investigation (continued)

Alternatives	Pros	Cons
Investigate entire area where groundwater > screening levels to reduce area of VI concern	Ability to evaluate an entire site ensures that all areas and conditions are considered (most conservative approach)	Very costly May by unnecessary if determined no VI hot spot
Statistical selection of structures within contamination area	Gives a representative mix of sampling locations Provides broader coverage than just hotspots	Can be costly if sample size needs to meet data quality objectives (large sampling size)
Modeling groundwater data to limit area of VI concern (regulatory agency does not allow modeling)	Inexpensive Can be done with existing data if of sufficient quality and detail	Although costs can be reduced, it does not necessarily reduce size of investigation Conservative assumptions should be used due to model imprecision and uncertainty
Focus area on hottest part of plume	Saves cost Minimizes disturbance to residents	May miss some impacted receptors Not-included residences may get concerned

Here is the Alternatives, Pros, and Cons table from Scenario #3.

A reasonable spectrum of sampling options, in the first column, are presented in the table, along with their associated pros and cons.

For example, one alternative would be to investigate the entire area where groundwater concentrations exceeded the groundwater screening levels. Pro – comprehensive investigation, Con – expensive.

In Scenario #3, the alternative chosen was to focus first on the area of the hottest part of the groundwater plume and then step out from there. Pro – less cost, less disturbance, Con – some impacted receptors may be missed.

Each scenario has a similar table.

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Scenario: Key Issues and Lessons Learned

What was unique about this scenario?

- Public communications and outreach are essential
- Worst case building selection is challenging
- Wider variations should be expected
  - Geology
  - Aquifer characteristics
  - Building conditions
  - Background sources
- Managing resources are difficult
- Logistics can be overwhelming
- Expect surprises

In addition to following the investigation steps 8 – 13 through to the end, and concluding whether mitigation and monitoring are required, or VI is not a problem, each scenario highlights some of the Key Issues and Lessons learned – or in other words, what is unique about the scenario.

For Scenario #3, it was clear

1) Community involvement and outreach was essential to work through the investigation successfully.

2) The selection of the worst case building is challenging when one has to consider all of the variables.

3) For sites covering large areas, expect significant spatial variability, including geological variability, varying building conditions, and other confounding sources.

4) Managing resources are difficult

5) Logistics for a site this size, possibly any site depending on the complexity, can be overwhelming, but you have to press on.

6) Expect surprises, each site, each situation is unique.

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Scenario: Next Steps

- Work plan that details next steps
- Source control remedy may be implemented
- Groundwater and soil gas monitoring
  - Groundwater movement – future impacted buildings
  - Vapor data – attenuation factors
- Mitigation system inspection, testing, and maintenance
- Ongoing community involvement

Each scenario finishes with a section that discusses Step 13 – Is mitigation warranted?, and what are the next steps in the overall investigation process.

For Scenario #3:

The work plan details the next steps.

Source control remedy may be implemented to reduce overall subsurface vapor concentrations.

•This remedy would be coordinated with the vapor intrusion investigation if adopted.

Monitoring of the groundwater and soil gas ongoing.

•Groundwater movement could take the contaminant plum under buildings not currently impacted by VI

•Monitoring of soil gas can help determine attenuation factors which may a useful screening tool to identify other vapor intrusion trouble spots.

Mitigation system inspection, testing, and maintenance required.

Ongoing community involvement is required.

Conclusion:

During this portion of the training, we went into greater detail on the Site Investigation phase of the Guidance Document following its introduction earlier. The topics discussed here included the tools and media sampled as summarized in Appendix D of the Guidance. Then we explored the Site Investigative process further by reviewing Scenario 3 from the Scenarios Document in the context of a VI Site Investigation.

If the vapor intrusion investigation concludes that intrusion exists and is a

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Mitigation

- General approaches to mitigation
- Building control options
- Factors affecting technology selection
- Design and installation issues
- Performance monitoring
- Closure

Overview of VI Pathway

↓

Framework

↓

Investigative Tools

↓

Mitigation

Provide overview of the last portion of the training. Final chapter of the Guidance Document.

Fairly comprehensive.

Point out that mitigation is usually the last thing done in the vapor intrusion pathway, however, can be done earlier in the process or monitoring may be an alternative and the state regulatory agency should provide direction.

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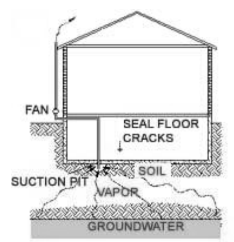
General Approaches

1. Site remediation 
2. Institutional control 
3. Building control 

These are the three general approaches to address vapor intrusion at a given site or structure.

I will talk about each of these in a little more detail

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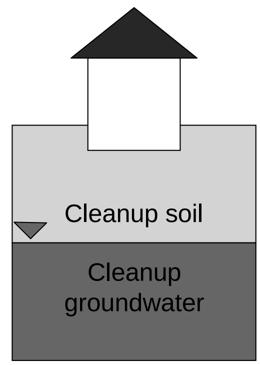
General Approach – Site Remediation

- Soil excavation
- Permeable reactive barriers
- Air sparging and soil vapor extraction
- In situ chemical oxidation
- Groundwater pump and treat
- More…

ITRC offers Guidance Documents and Internet-based training classes on a wide variety of remediation tools and approaches
Visit www.itrcweb.org for details



First is to perform site remediation (not in the scope of our Guidance Document)

•site remediation is often required for other reasons

•this approach involves actually removing the source of vapors from the subsurface

•however, usually takes too long to control exposure to building occupants

•therefore, site remediation is usually combined with the other approaches (I'll address next)

Note that ITRC offers guidance for many site remediation technologies.

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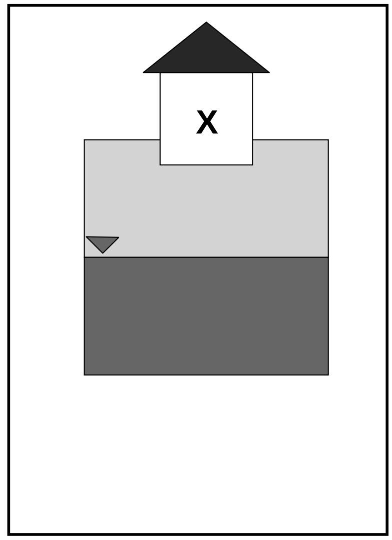
General Approach – Institutional Controls

- Deed restriction
- Restrictive covenant
- Land use control
  - ITRC Brownfields Team



2nd approach is the use of institutional controls.

•can include prevention of building construction in certain areas, or requirements for vapor intrusion controls in new buildings

•can be difficult to implement in manner that can be relied on over the long term

•may require additional monitoring (analytically and clerically)

•usually used in conjunction with other technologies or as a long term remedy

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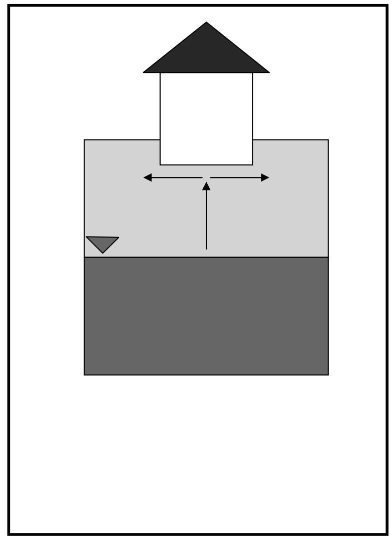
General Approach – Building Controls

- Passive barriers
- Sub-slab depressurization
- Sub-membrane depressurization
- Passive venting
- Sub-slab pressurization
- Indoor air treatment
- Building pressurization



Lastly, building controls (includes both current and future buildings).

•focus of the Guidance Document

•additional information on several of the technologies will be presented next

•building controls are the most widely used to interrupt the VI pathway

•easy to design and install (quick) and very effective

The two of the technologies that we will discuss are highlighted.

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Building Control Options – Examples from Table 4-1 in Guidance Document

Technology	Typical Applications	Challenges	Range of Installed Costs
Passive Barriers	New construction; crawl spaces; often combined with passive or active venting, sealing openings in the slab, drains, etc.	Preventing tears, holes; may not suffice as a stand-alone technology; some states do not accept. Ensuring caulking seals cracks in floors, etc.	$0.50-$5/ft^2 ; thinner, less expensive barriers likely to be inadequate
Passive Venting	New construction; low vapor flux sites; should be convertible to active system if necessary	Relies on convective flow of air due to wind and heat stack effects; air flows, suction typically far less than achieved by fans	$0.75-$5/ft^2
Sub-Slab Depressuri-zation (SSD)	New and existing structures; sumps, drain tiles, and block wall foundations may also be depressurized if present	Low permeability and wet soils may limit performance; otherwise, highly effective systems	$1-$5/ft^2; residential systems typically in the $1-2/ft^2 range
Sub-Membrane Depressuri-zation (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/ft^2; residential systems typically $1.50-2/ft^2 range

This slide is an example of one of the tables from Chapter 4 (Table 4.1) of the Guidance Document

Table includes the technology, its typical application, challenges and costs associated with its use.

Based on the teams experience, the technologies in maroon are the two that are the most widely used at VI sites.

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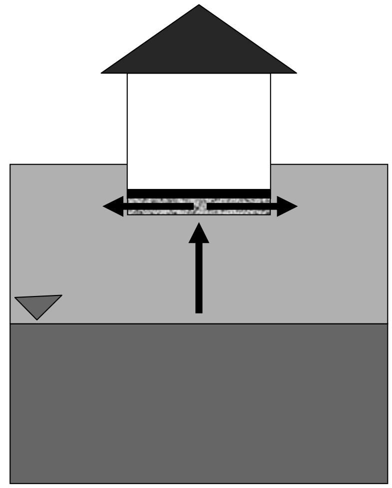
Key Elements of Passive Barrier Systems

- Generally not applicable to existing structures
  - Except crawl spaces
- Should be combined with passive venting system
- Liner material must be thick enough to survive construction
- Good construction quality control important
- Allow for addition of fan, if needed
- Test after installation
  - System integrity
  - Performance
- Do not expect performance equivalent to active systems



The first technology I will be talking about is Passive Barriers

is usually requested as the mitigation technology

bullets very important if this technology is chosen

may have to revisit if not completely successful

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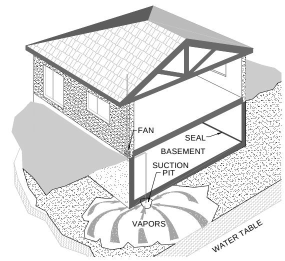
Sub-slab (Active) Depressurization (SSDs)

- Most widely applied and successful building control
- May be combined with drain tile or block wall depressurization
- $1500 to $3000 to install



Advantages	Disadvantages
Successful track record of performance, 90 to 99% reductions typical, 99.5% or greater reductions possible with well designed systems	Requires periodic maintenance
Adaptable technology, applicable to a wide variety of site conditions and geology	Wet and low permeability soils retard vapor movement
Can be applied to new and existing structures	Building-specific conditions may limit options for suction pit, riser pipe, and fan locations

The next technology discussed are SSDs

- most used and most successful
- technology taken from radon industry (both are gases intruding)
- usually the cheapest and quickest to install
- costs are in general, explosion proof fans tend to be higher in cost
- usually requires follow up samples several weeks after installation to ensure effectiveness
- life expectancy is 7-15 years, based on likely fan life – systems can operate indefinitely if fans are replaced when needed

Again refer to Guidance Document, much more detail on these types of systems

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Sub-slab (Active) Depressurization – Key Elements

- Simple technology
- Used in radon industry for years
- One or two suction points for most houses
- Can be fast tracked
- Easy to modify for site-specific situations
- Can be combined with other technologies (e.g. membranes)

The Guidance Document provides useful design details, such as the number of suction points that might be needed

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Factors Affecting Control Technology Selection

- New vs. existing building
- Building use
- Foundation type and condition
- Soil conditions
- High water table conditions
- Chemical of concern

Spray on barrier being applied during construction. Photograph courtesy of LBI Technologies, Inc.

Now that we have talked about a couple of the technologies, let's talk about some of the factors that influence the decision on which technology is chosen.

regulatory agency/potentially responsible party (PRP) preference

goals

give real world examples of: soil conditions, chemicals of concern, etc.

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Design and Installation

- Design approach
  - Traditional and fast-track options
- Owner tenant preferences may affect locations
- Pre-mitigation diagnostic tests (optional)
- Post-mitigation diagnostic test and system modifications (recommended)
- Access and scheduling
- Lead-based paint and asbestos
- Heating, ventilation, air-conditioning systems
- Operation, maintenance, and monitoring

Active sub-slab depressurization (SSD) system

Now that a technology has been selected, let’s look at some of the issues that you may encounter during the design and installation of the system.

not a complete list

refer to the Guidance Document for additional information

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Operation, Maintenance, and Monitoring

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

The Guidance Document includes a section on operation, maintenance, and monitoring of building controls, specifically depressurization systems.

Operation issues include electrical costs (typically less than $100 per fan annually) and the potential need for emission controls (varies by jurisdiction)

Maintenance requirements are usually minimal, but fans may need replacement.

Monitoring requirements may include indoor air tests, pressure tests, and/or inspections, depending on agency requirements.

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Closure

- When long term cleanup objectives are met
  - Building mitigation will no longer be required
  - Institutional controls can be retired/removed
- Consider how decisions to stop mitigation will be made at the beginning of program
- Collect sufficient information during operations and maintenance (O&M) to make closure decisions
  - Develop correlations between subsurface media concentrations and indoor air concentrations

The Guidance Document provides suggestions on closure of systems

Need to think about this at the beginning of the program, so that the right data can be collected to support closure.

Confirmation tests may be conducted after systems are shut off, to confirm they are no longer required.

Correlations between indoor air and subsurface media concentrations may be useful to trigger confirmation tests

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In Summary

- ITRC and the Vapor Intrusion team
- Practical guideline
- Process
- Tools and scenarios
- Mitigation

Overview of VI Pathway

↓

Framework

↓

Investigative Tools

↓

Mitigation

No associated notes.

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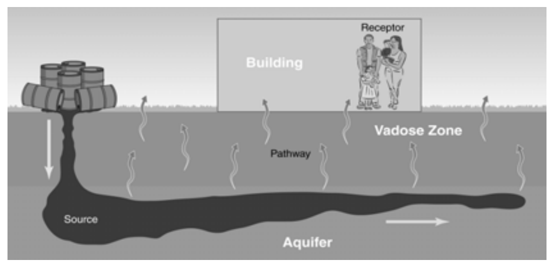
ITRC VI Classroom Training

- ITRC will be offering 2-day classroom training on the VI pathway that will include
  - Interactive presentations
  - Hands-on exhibits
  - Informative handouts
  - Problem sets

First session:
Portland, Oregon
October 2008



When available, more information will be available at www.itrcweb.org under "Classroom Training"

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Thank You for Participating

- Links to additional resources at
  - http://clu-in.org/conf/itrc/vipathway/resource.cfm
- 2nd question and answer session

Crawlspace mitigation using sub-membrane depressurization (SMD)

Passive sump mitigation system

Links to additional resources:

http://clu-in.org/conf/itrc/vipathway/resource.cfm

Your feedback is important – please fill out the form at:

http://clu-in.org/conf/itrc/vipathway/

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

✓Be an official state member by appointing a POC (State Point of Contact)