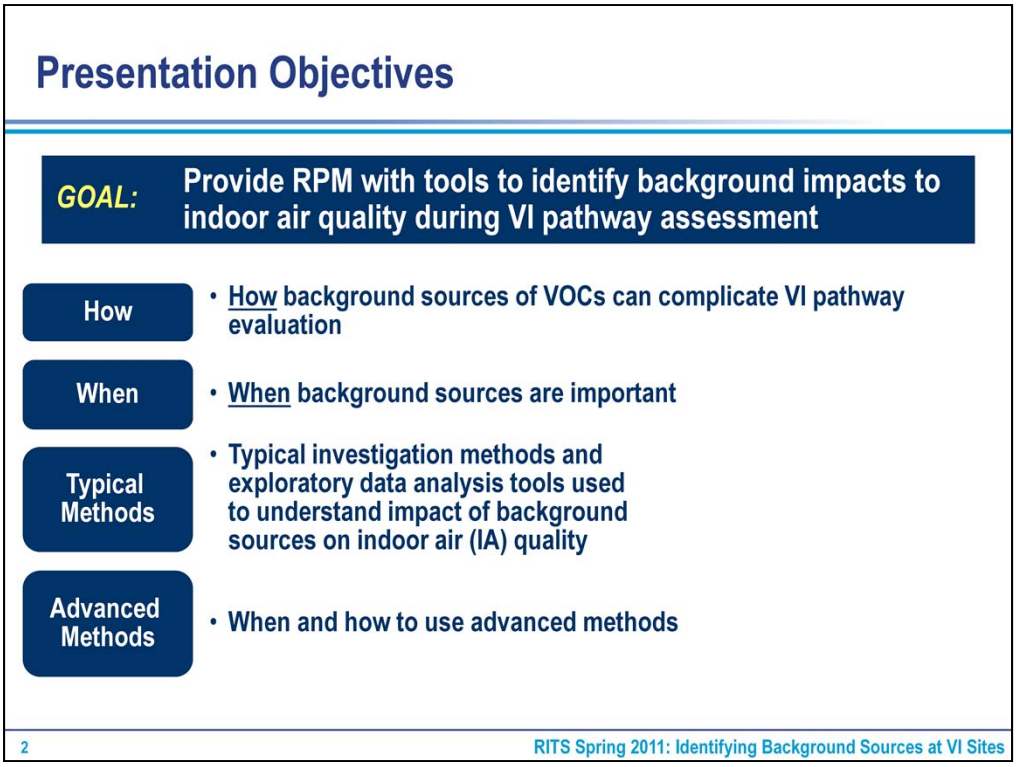
- Introduction Slide
- When vapor intrusion investigation requires indoor air sampling, consideration of potential background sources is critical to avoid false conclusions regarding vapor intrusion impacts on indoor air quality



- Background sources of VOCs complicate the VI pathway evaluation because they are very common in ambient (e.g., industrial and vehicle emissions) and indoor air (e.g., consumer and industrial products), often at concentrations that exceed risk-based screening levels.
- Consideration of background sources is always important when indoor air sampling is included as part of the VI investigation.
- In a majority of cases (~80%) typical sampling methods (e.g., summa canisters) provides sufficient data to understand background sources using exploratory data analysis tools that we will present in this presentation and are also included in the VI Assessment Toolkit that was presented this morning.
- When the data is inconclusive, advanced methods should be considered (e.g., real-time data collection).

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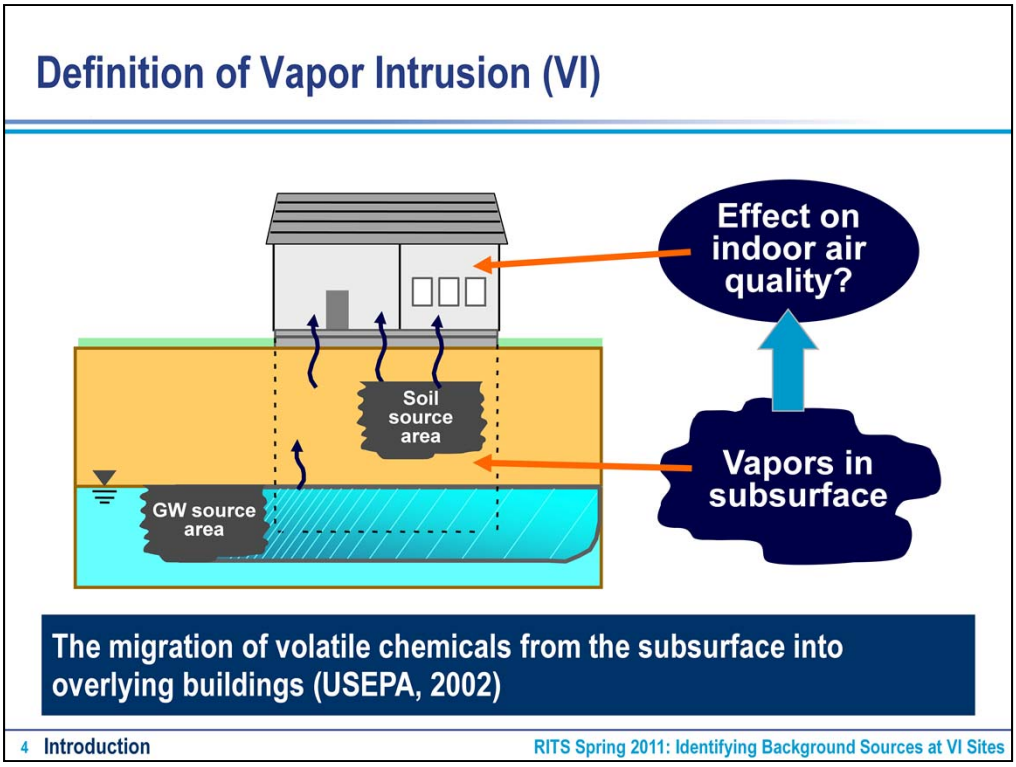
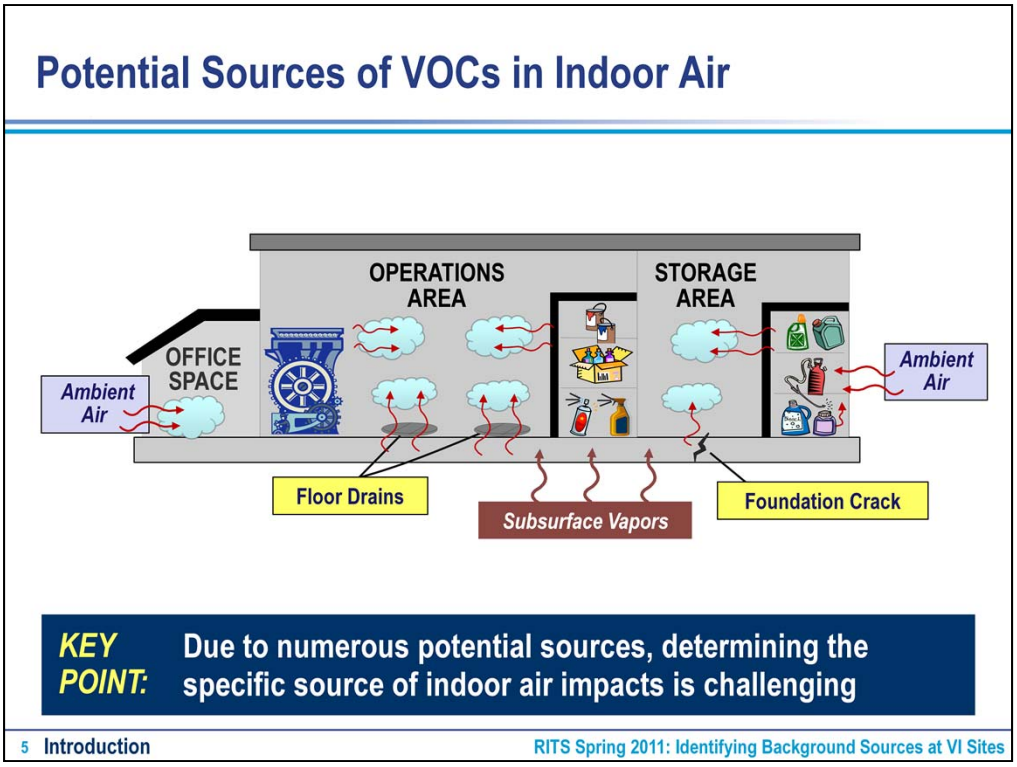


- Vapor intrusion is a potential exposure pathway that is still relatively new but is increasingly becoming a pathway of concern among stakeholders.
- Understanding of and evaluation methods for VI are still evolving.



- VOC impacts to indoor air quality can come from a number of different sources as shown on the slide, greatly complicating interpretation of indoor air concentration results.

VI Guidance Documents: Navy, DoD

- Navy VI Policy (2008)
- DoD Vapor Intrusion Handbook (DoD, 2009)
  >> Primary Guide for VI Assessment at Navy (DoD) Sites
- Navy Vapor Intrusion Assessment Tool (password protected during beta testing, Beta Tester POC for each FEC will be identified)
- Guidance for Environmental Background Analysis (NAVFAC, 2010)
  >> Primary Navy Guide for Evaluating Background (Focus of This Presentation!)
- Vapor Intrusion Web Site
- Review of Best Practices, Knowledge and Data Gaps, and Research Opportunities of the U.S. Department of Navy Vapor Intrusion Focus Areas. (DON, 2009)

6 Introduction RITS Spring 2011: Identifying Background Sources at VI Sites

- Slide designed as a resource from this presentation for information regarding Navy's policy on vapor intrusion.
- Note the background guidance that is the focus of this presentation.

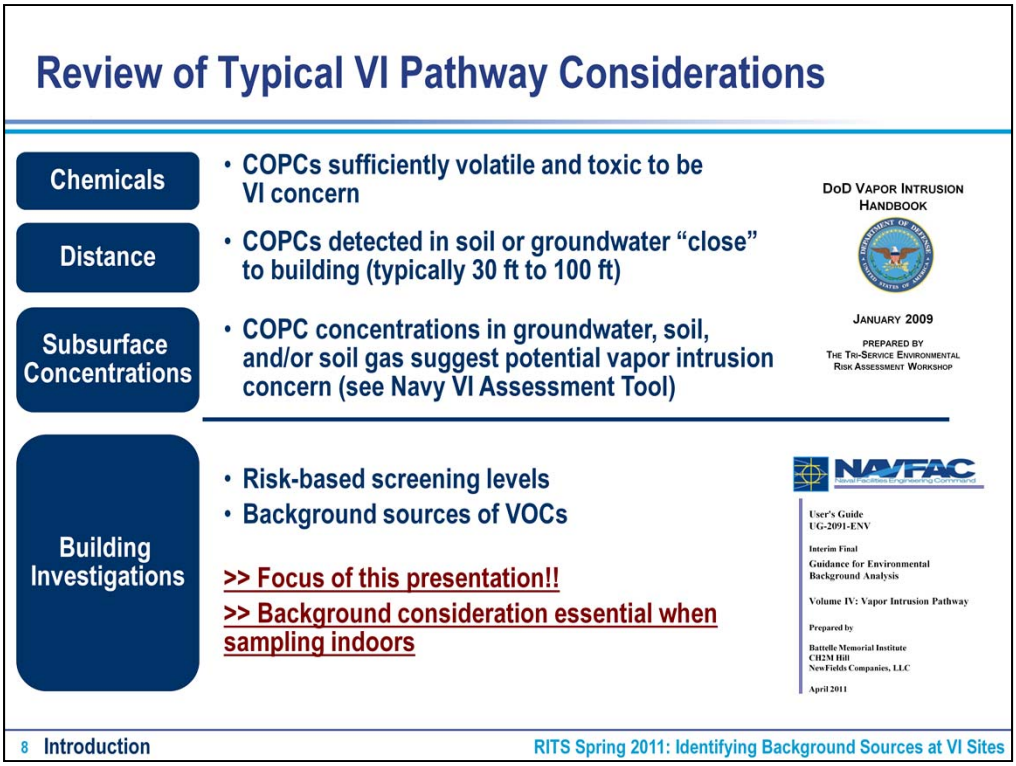
VI Guidance Documents: USEPA, State, Other

- **Vapor Intrusion Pathway: A Practical Guideline (ITRC, 2007)**
- **OSWER Draft Guidance For Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (US EPA, 2002):** ***To be updated in 2012***
- **State VI Guidance**

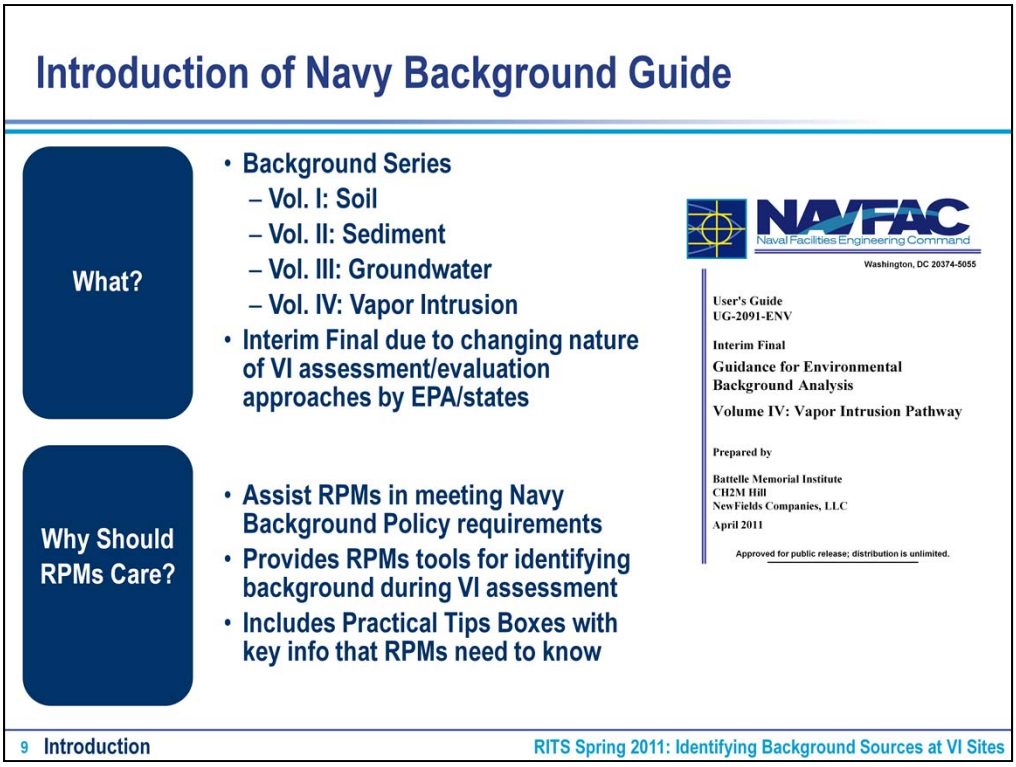
OSWER = Office of Solid Waste and Emergency Response

7 RITS Spring 2011: Identifying Background Sources at VI Sites

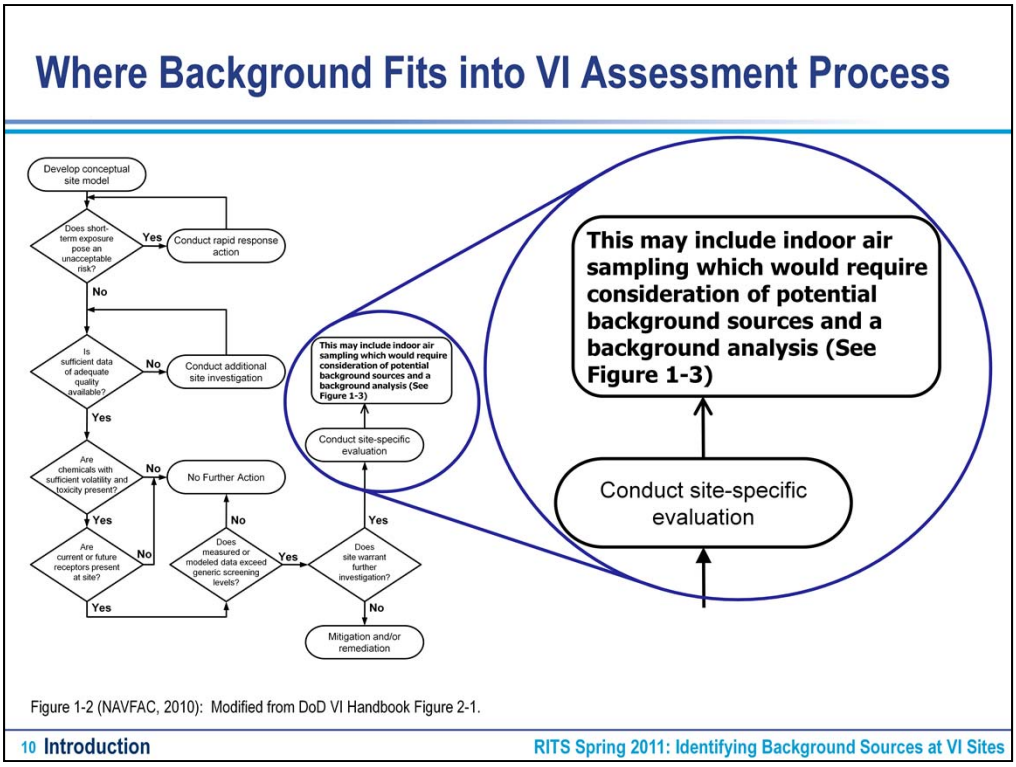
- Slide designed as a resource from this presentation for information regarding USEPA and State vapor intrusion guidance.
- Note that USEPA will issue an update to the 2002 draft guidance and EPA has indicated that there will be more emphasis on sampling of indoor air vs. soil gas and groundwater screening.



- Initial screening for chemicals of concern and receptors, based on the site conceptual model (e.g., soil and groundwater data), should be completed prior to sampling indoor air. Not discussed in this presentation but note DoD VI handbook and Navy VI Assessment Tool.
- Once a building investigation is determined to be necessary, consideration of background sources is essential for a successful investigation and evaluation.



- Introduce the Navy Background Guidance, 4th in a series on evaluation of background.



- Flow chart modified from the DoD VI handbook shows where consideration of background fits within the VI assessment process.
- When conducting a site-specific evaluation, that may include indoor air sampling, consideration of background becomes an important element of the assessment process moving forward.

Navy VI Background Analysis Process

Vapor Intrusion Pathway Background Analysis: Building Multiple Lines of Evidence

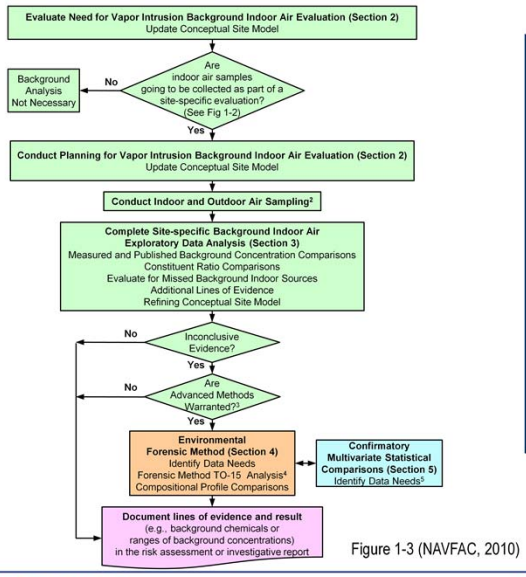


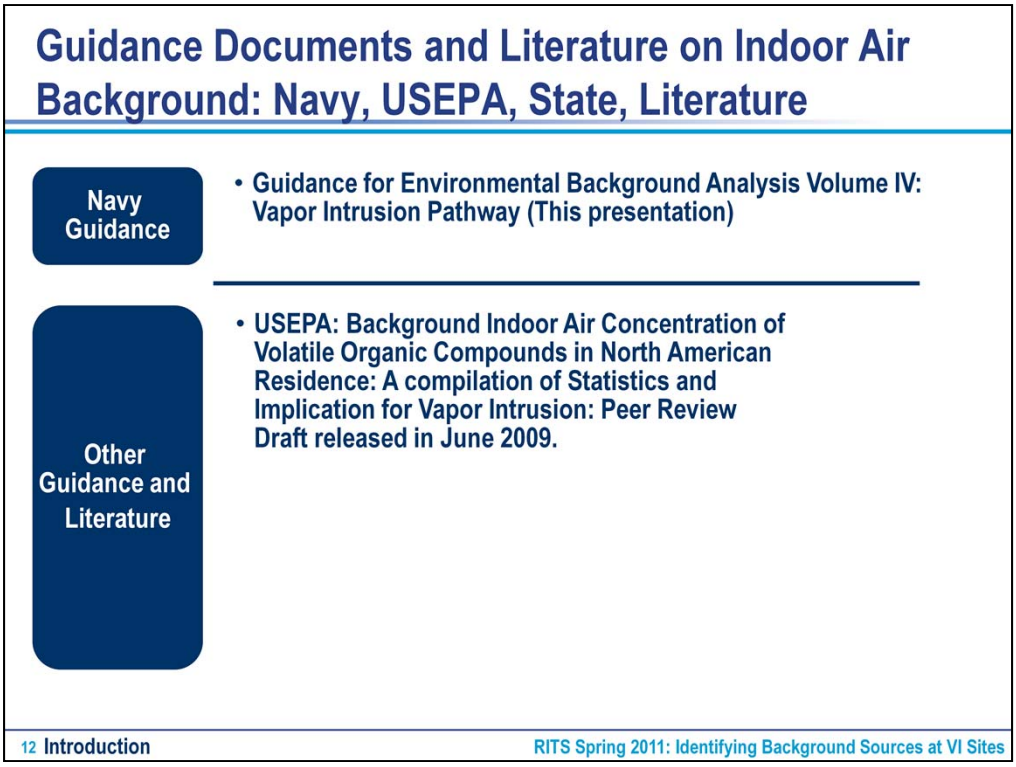
Figure 1-3 (NAVFAC, 2010)

KEY STEPS:

- **Plan!**
- **Collect Data**
- **Exploratory Data Analysis**
- **Strength of Evidence**
- **Advanced Methods (if needed)**
- **Document Results and Findings**

11 **Introduction** RITS Spring 2011: Identifying Background Sources at VI Sites

- VI Background Analysis Process from the Background Guide
- Walk through each of the key steps



- Resource slide regarding background sources, note that most guidance documents from ITRC, EPA, States all take into account the importance of the consideration of background sources of VOC impacts to indoor air quality.

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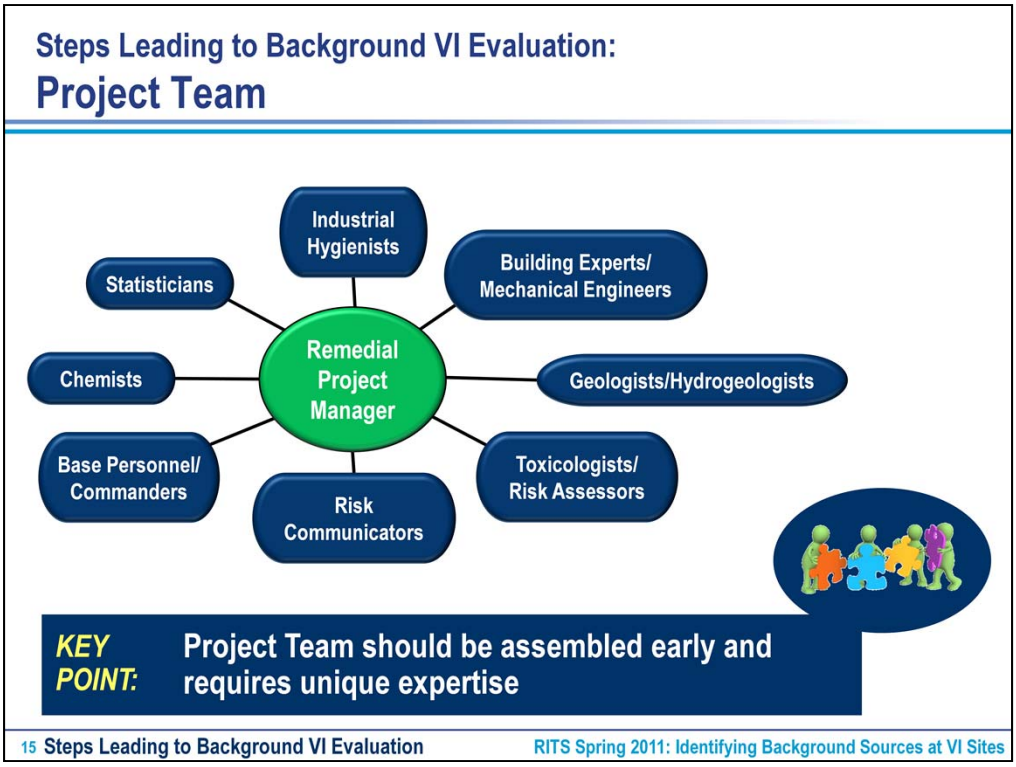
Steps Leading to Background VI Evaluation

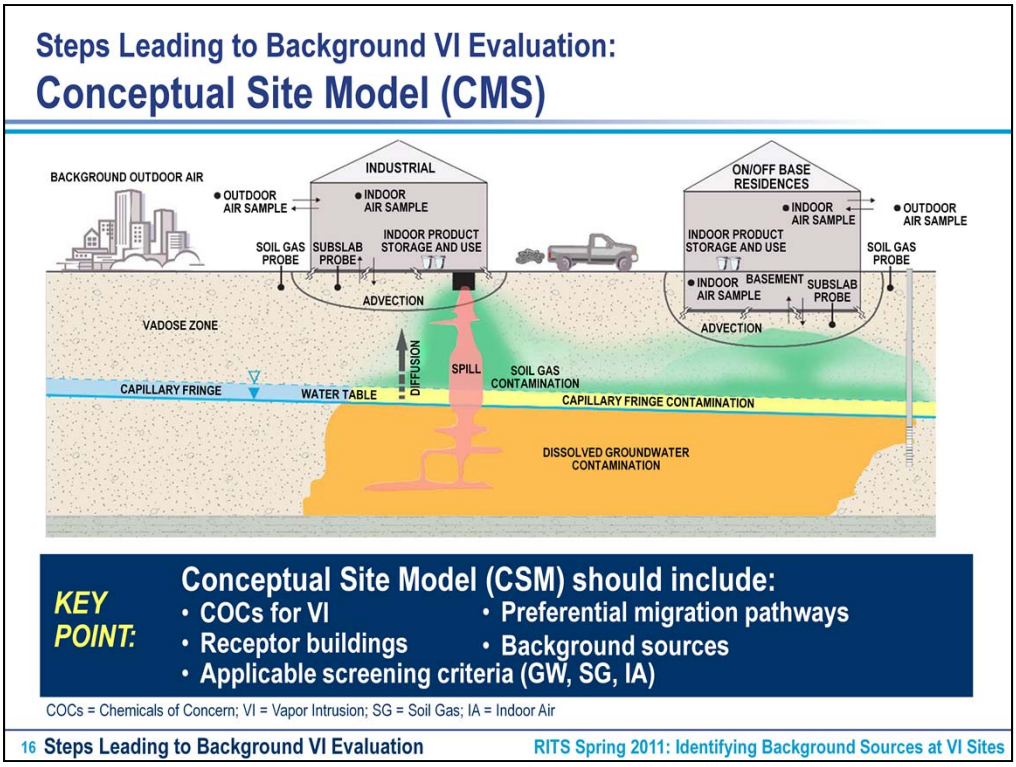
- **Project Team** *(NAVFAC, 2010; Section 2.1.1)*
- **Conceptual Site Model** *(NAVFAC, 2010; Section 2.1.2)*
- **Background Sources of VOCs** *(NAVFAC, 2010; Section 3.4)*

14 Steps Leading to Background VI Evaluation RITS Spring 2011: Identifying Background Sources at VI Sites

- Introduction slide with the concepts to be presented in this section of the presentation and the corresponding Section of the NAVFAC Background VI Guidance.



- The proper project team leads to ultimate success.
- Make sure that you have all the tools you will need to build the vapor intrusion story.
- Some team members, such as Industrial Hygienists and Building Experts, are likely not part of a normal project team.



- Use existing knowledge of the site from standard investigation data/information to develop a preliminary vapor intrusion conceptual model for use in design of vapor intrusion investigation.
- Preferential migration pathways may include, sewer lines, sumps, dry wells, elevator pits, etc.
- Begin to consider the potential indoor sources based on building use and location (i.e., proximity to ambient sources).

Background Sources of VOCs: Ambient and Indoor

Key Sources of VOCs in Indoor Air

- Ambient air
- Vehicles, gasoline
- Paints, adhesives
- Cleaning agents
- Insecticides
- Tobacco smoke
- Cosmetics, etc.

REFERENCES:
- USEPA, 1991, "Building Air Quality Guide"
- OSHA, 1999, "Tech Manual for Indoor Air Inv."

17 Steps Leading to Background VI Evaluation — RITS Spring 2011: Identifying Background Sources at VI Sites

- Indoor sources of the same VOCs potentially associated with vapor intrusion from subsurface sources are commonly present in structures.
- The presence of these VOCs from background sources complicates the evaluation of the vapor intrusion.
- It is critical to recognize the potential contributions to indoor air quality from background sources when planning for a vapor intrusion investigation and evaluating results.

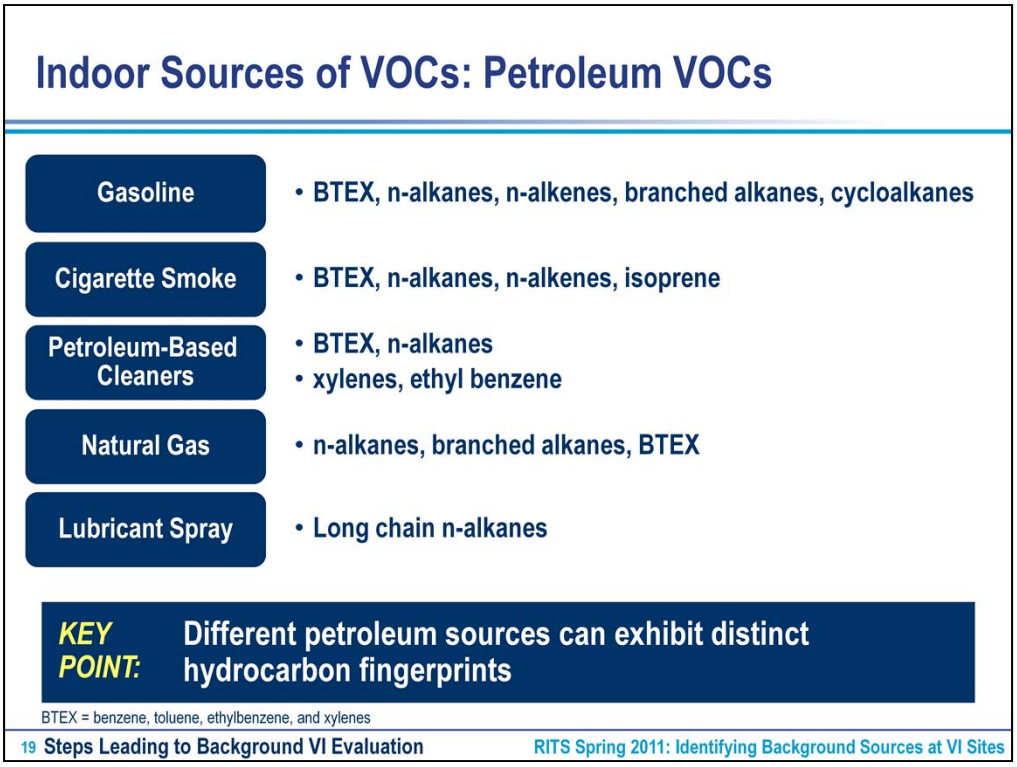
Indoor Sources of VOCs: Chlorinated VOCs

Gun Cleaner: $19.95	Pepper Spray: $3.99	Hobby Glue: $4.95	Bleach Cleaner: $3.95	Plastic: $4.95
>90% TCE	>90% TCE	>90% PCE	Carbon Tet. 1,1-DCE	1,2-DCA

KEY POINT: **TCE, PCE, etc., are legal and are still used in a wide range of consumer products currently available for purchase**

PCE = Tetrachloroethene; TCE = Trichloroethene; 1,1-DCE = 1,1-Dichloroethene; 1,2-DCA = 1,2-Dichloroethane

- VOCs not always listed on product label (e.g., pepper spray, TCE is the carrier solvent used to dissolve the pepper).
- Carbon Tetrachloride and 1,1-DCE are a results of a reaction with the bleach while in the container, relatively low concentrations but may still be detectable.
- Increase in the occurrence (both in concentration and frequency) of 1,1-DCA in indoor air since early 2000's due to manufacturing of molded plastics in China.



- Many potential background sources of petroleum VOCs.
- The distinct hydrocarbon fingerprint of certain known indoor sources can be used to distinguish between indoor source and vapor intrusion.

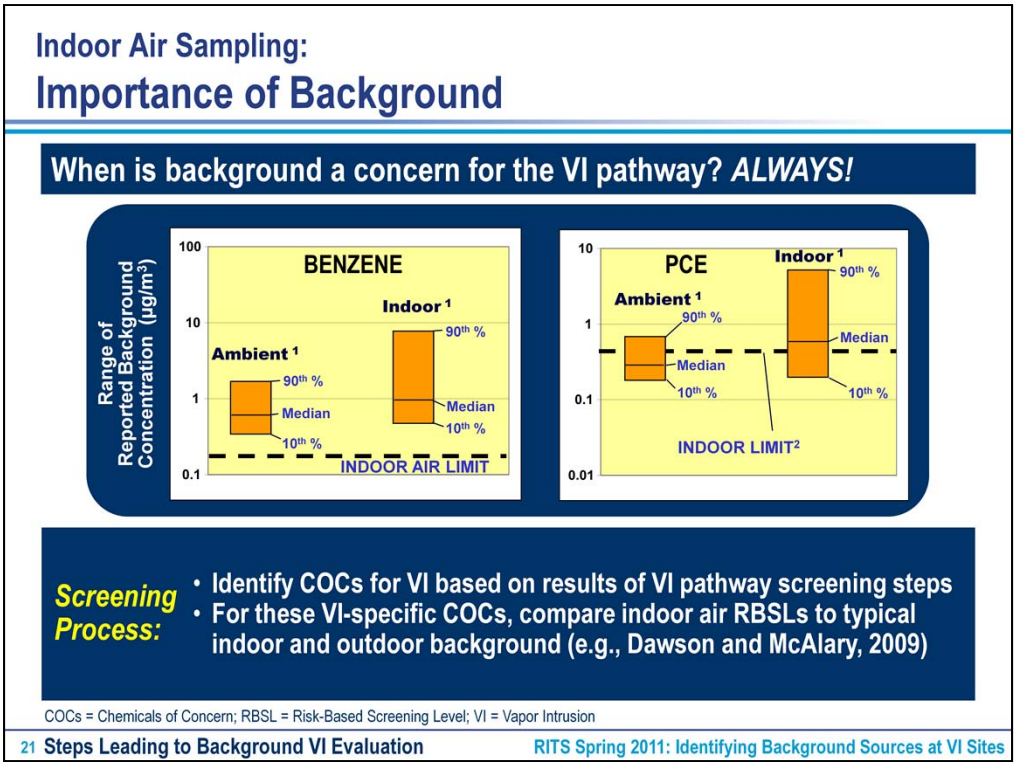
Indoor Sources of VOCs: Naphthalene

Combustion
- Industrial
- Cigarette Smoke
- Vehicle Emissions

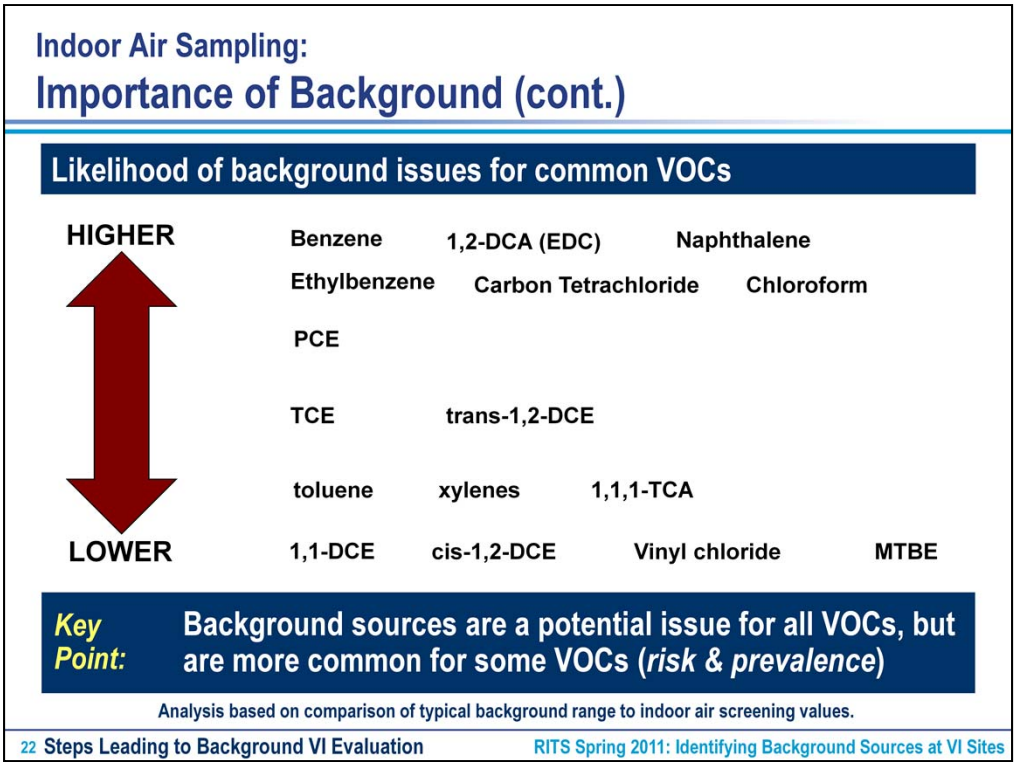
Off-Gassing
- Deodorizers
- Repellents (e.g., moth balls)
- Fumigants

Chemical Production Intermediate
- Phthalic Anhydride (used in production of plasticizers)
- Surfactants
- Pesticides

BTEX = benzene, toluene, ethylbenzene, and xylenes



- When is background a concern for VI pathway? Always!
- Want to know ahead of time the magnitude of potential background issues prior to sampling indoors.
- For many VOCs common background concentrations exceed the RBSLs, for these COCs proper consideration of background sources and collection of sufficient data to evaluate the multiple lines of evidence is critical to avoid false conclusions regarding vapor intrusion



- Likelihood of background issues is highest to those VOCs with low risk-based screening levels and high prevalence in industrial, commercial, and residential consumer products.
- Example: Toluene and Xylenes are almost always detected in indoor air due to background sources but screening level is high for these compounds so background less likely to cause exceedance.
- Example: cis-1,2-DCE not likely to be found in consumer products.

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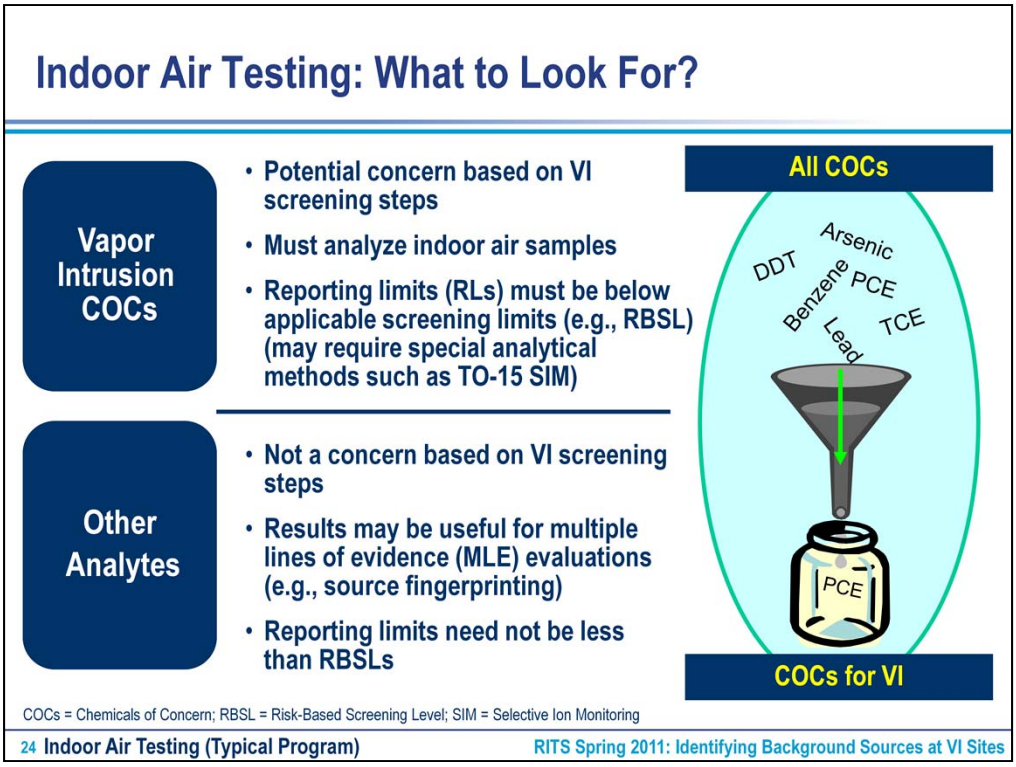
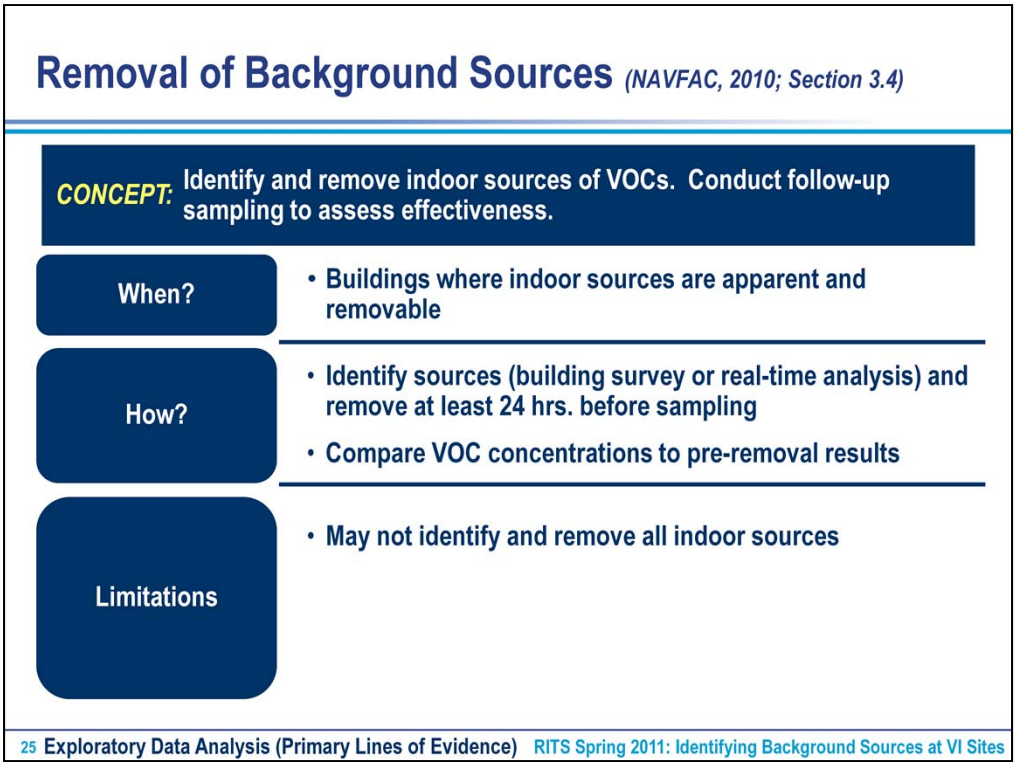
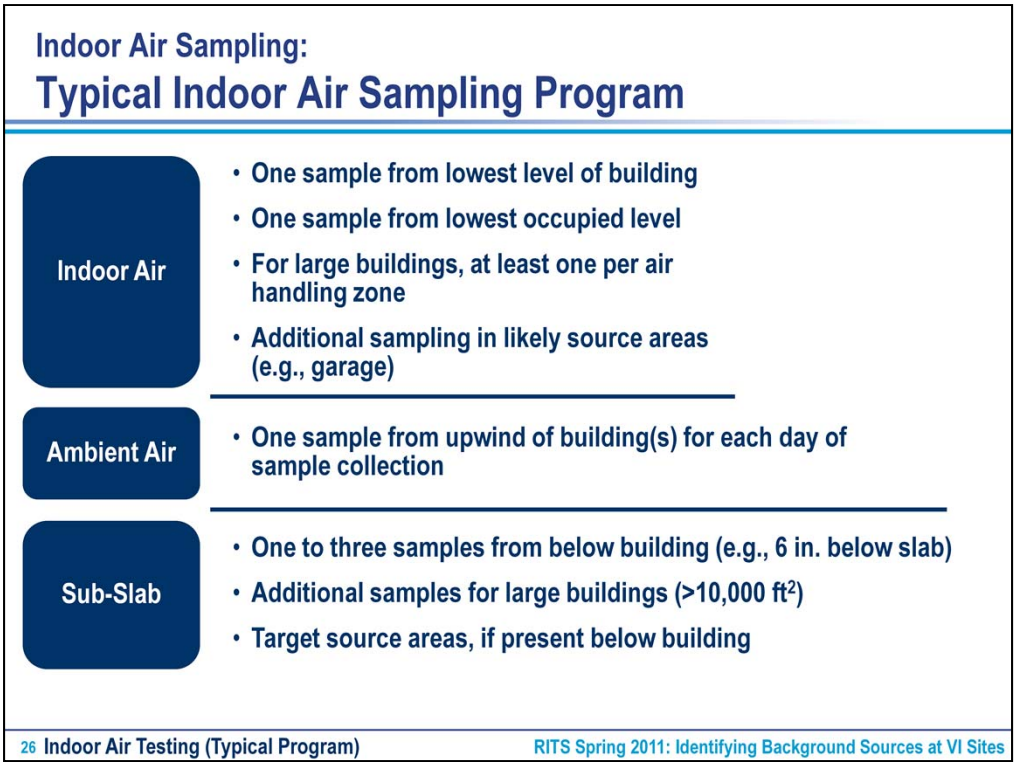


- COCs of potential vapor intrusion concern based on screening process: presence in subsurface source close to receptor (e.g., within 100-ft).
- Be sure to coordinate with the laboratory regarding detection limit requirements for all potential VI COCs.
- Be sure to separate the decision logic between VI COCs and additional analytes (other VOCs for source comparison, fixed gases, radon) that may be useful in distinguishing between VI and and other sources.
- Potential ways to use additional analytes not potentially associated with VI are discussed in more detail later in this presentation.



- Attempt to remove indoor sources prior to indoor air testing can lead to a false sense of security regarding the need to collect sufficient data for lines of evidence evaluation.
- Products can be difficult to find visually (e.g., hobby glue in master bedroom closet) and homeowners often forget where the have chemical products stored (I can't find my keys half the time).
- If you state that you removed all indoor sources prior to sampling, any exceedance may be viewed in vapor intrusion.



- Point to summa canister and define this as the typical method for vapor sampling, regulated to collect 24-hr sample (residential) or 8-hr (commercial), ship to laboratory for off-site analysis.
- Define sub-slab sample, drill through slab and install sampling point directly below the foundation, be sure that it is properly sealed, tracer tests can be conducted to verify (e.g., helium in shroud over sampling point.
- Data from a typical indoor air sampling program can be used for exploratory data analysis (as we will discuss later), using a weight-of-evidence approach.
- In many cases, this data will be sufficient to determine the likely source of indoor air impacts (if any).

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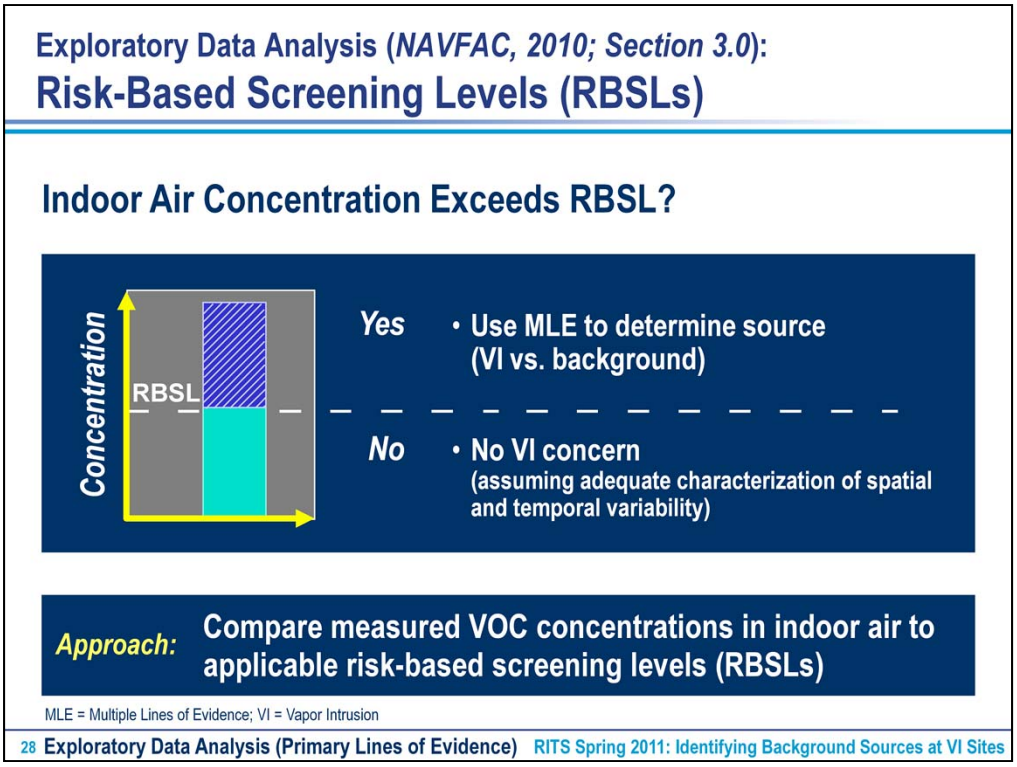
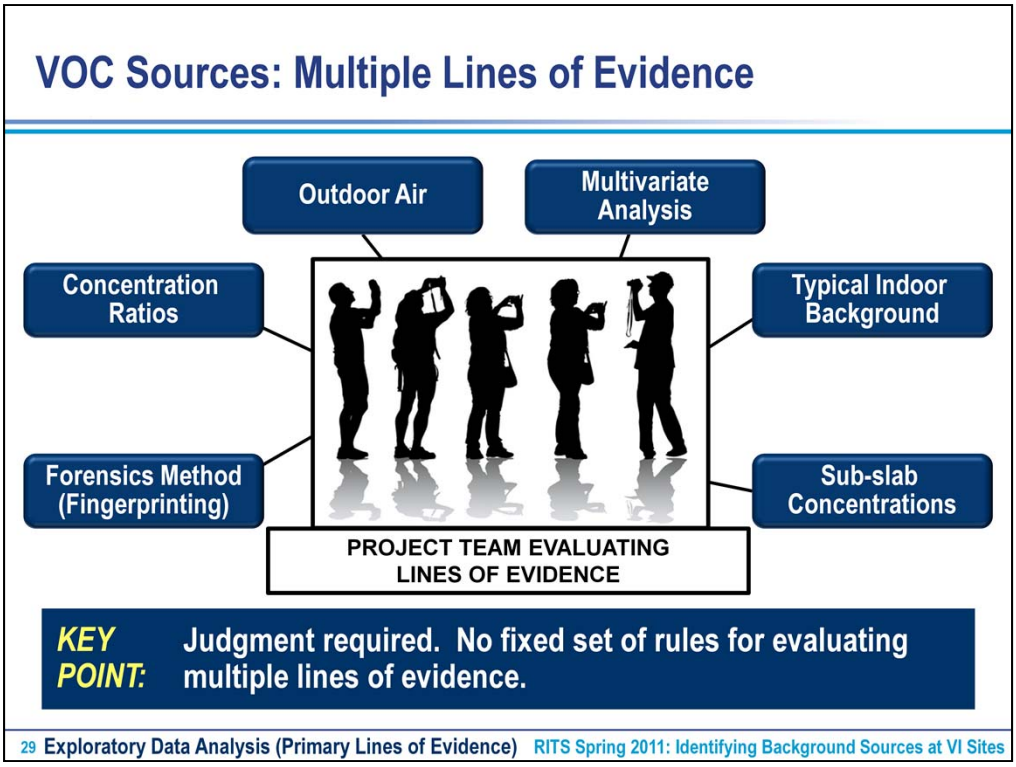
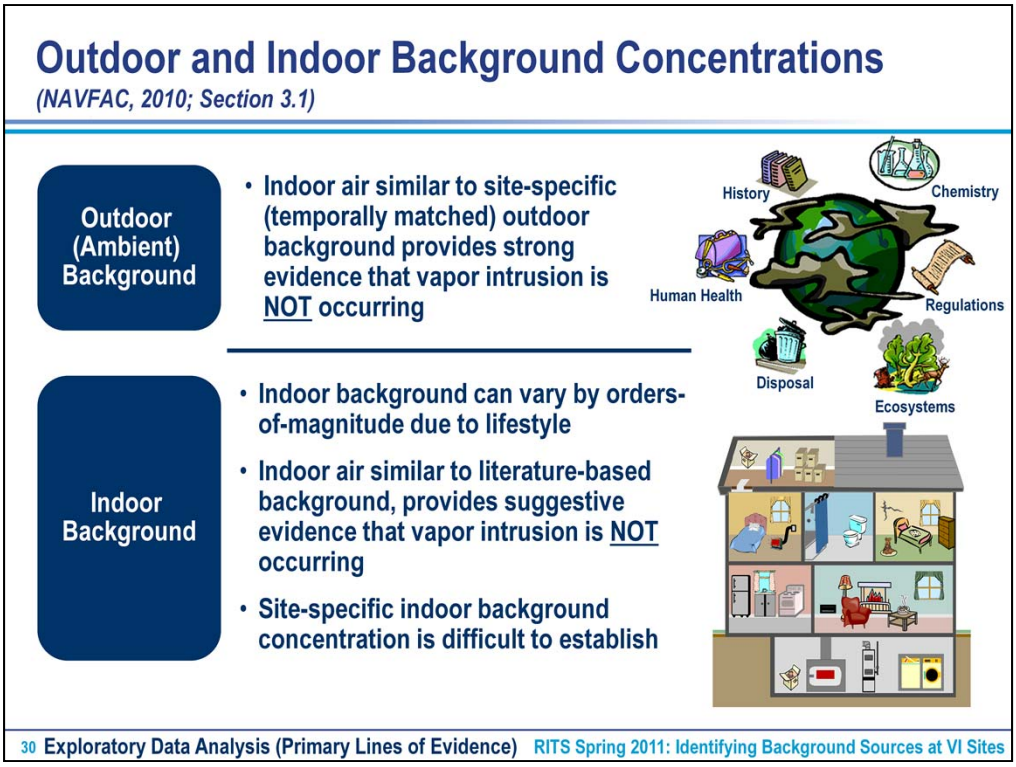


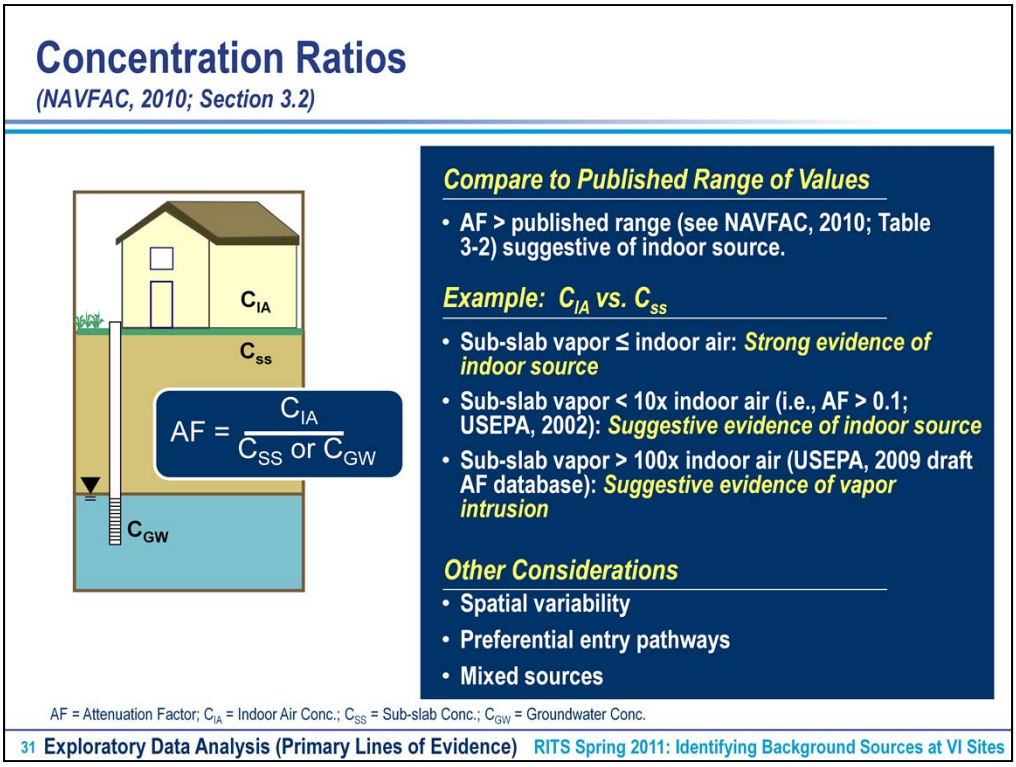
- First question is, Do we have an exceedance of screening criteria?
- Below the RBSL, no need to do further analysis.
- Above the RBSL, use exploratory analysis to determine source(s) of indoor air impacts.
- In some cases with indoor air above the RBSL, more advanced methods of evaluation may be necessary and we will discuss some of these in detail later in this presentation.



- The applicable lines of evidence should be considered as a whole to make a determination based an overall “weight-of-evidence”. The lines of evidence are well established but judgment is required to properly evaluate.
- Requires knowledge of the site conceptual model (i.e., know the COCs, potential migration pathways, observed indoor sources, etc.).



- Advanced methods are available to indentify the presence of indoor sources if not obvious based on data (e.g., distribution).
- Indoor background concentrations are site-specific based on use and storage chemical products, attached garage, smoking, etc. Therefore, establishing a background concentration is difficult.



- The higher the sub-slab concentrations are relative to indoor air, the more concern there is that vapor intrusion may be occurring.
- Even if the ratio's are high, that does not mean that vapor intrusion is occurring.
- Spatial variability within the structure can be very useful in identifying the potential source.
- Preferential pathways (e.g., sumps, drains, large cracks) can be identified, an advanced method discussed later in this presentation (even when no VOCs, radon can be used to find entry points).
- Mixed sources such as natural gas leaks, drains and sewer lines, etc. can cause elevated sub-slab concentrations not associated with affected environmental media.

Constituent Ratio Comparisons *(NAVFAC, 2010; Section 3.3)*

CONCEPT: **VOCs originating from the same subsurface source should enter building at similar rate (i.e., attenuation factors should be similar)**

When?

- **For sites where subsurface source has multiple COCs for vapor intrusion**
- **Can also use radon as subsurface tracer**

How?

- **Compare COCs ratios in subsurface sample to COC ratios in indoor air sample**
- **If ratios are different, evidence of indoor source for one or more of the COCs**

How to Improve?

- **Collect a sufficient number of representative samples**
- **Develop DQOs, laboratory procedures, and data reduction schemes to ensure appropriate quantitation limits**

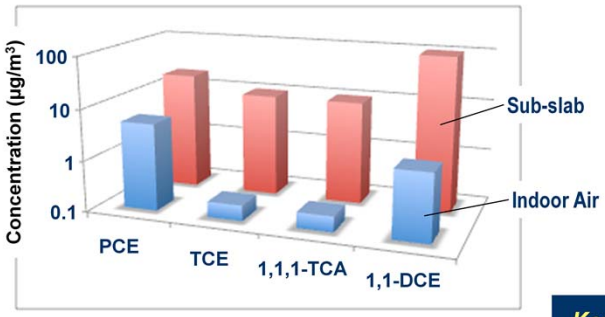
COCs = Chemicals of Concern; DQOs = Data Quality Objectives

32 **Exploratory Data Analysis (Primary Lines of Evidence)** RITS Spring 2011: Identifying Background Sources at VI Sites

- How to improve? Make sure you have enough samples for comparison and that they are representative based on what we discussed earlier.
- If using this method, the reporting limits for some COCs with high RBSLs may need to be adjusted to ensure that they are detected and the ratios are useful.

Constituent Ratio Comparisons (cont.)

(NAVFAC, 2010; Section 3.3)



Chemical	AF (IA/SS)	IA >RSL?
PCE	0.5	Yes
TCE	0.011	No
1,1,1-TCA	0.015	No
1,1-DCE	0.008	No

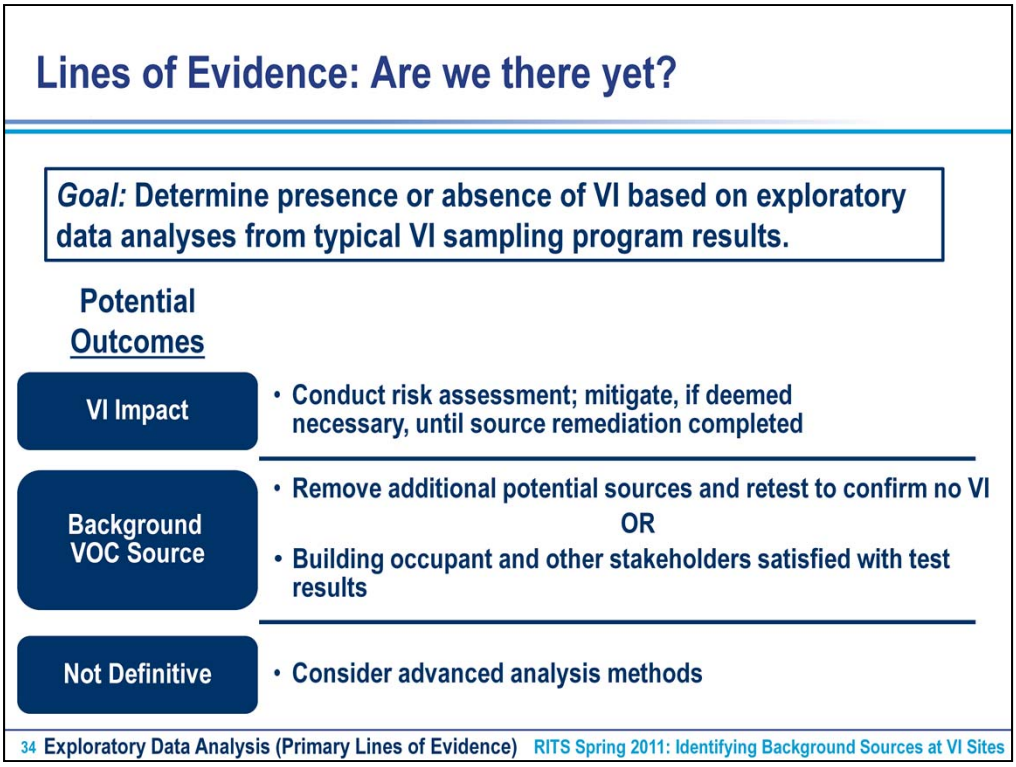
Key Findings:

- **PCE is the only COC that exceeds RBSL in indoor air**
- **Ratio analysis indicates indoor source of PCE**

COCs = Chemicals of Concern; AF = Attenuation Factor; IA = Indoor Air; SS = Sub-slab; RBSL = Risk-Based Screening Level

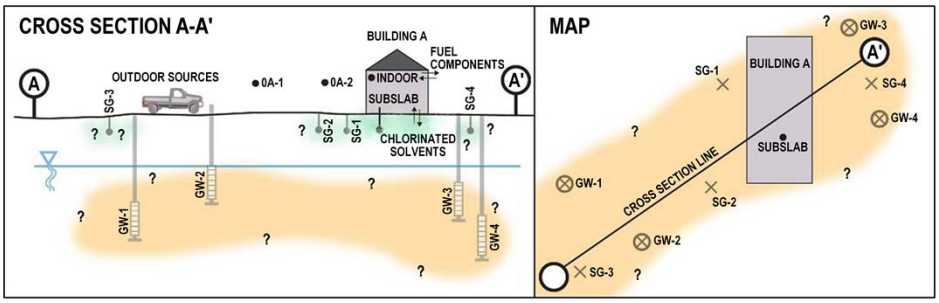
33 **Exploratory Data Analysis (Primary Lines of Evidence)** RITS Spring 2011: Identifying Background Sources at VI Sites

- While the calculated attenuation factor (indoor air/ sub-slab) for TCE, 1,1,1-TCA, and 1,1-DCE are similar, PCE is over 40x higher, indicating an indoor source is impacting indoor air quality.
- Since PCE is the only COC above the RBSL, this indoor source may be the main contributor causing exceedance.



- A determination should be made based on the “weight-of-evidence”.
- How strong a case that needs to be made depends on a number of factors, including satisfaction of stakeholders.
- Is there time to do more advanced analysis and collect more data and is there evidence that additional data may be of use.
- ***Example:*** Data suggests a potential source in main living area but lines of evidence is not definitive, indoor survey with HAPSITE could be used to find the specific source, also may do fingerprinting, stable isotope analysis to distinguish between sources.

Refining the CSM



KEY POINT:
- Update CSM to reflect all available information
- Consider innovative investigation methods more likely to provide definitive results

35 Exploratory Data Analysis (Primary Lines of Evidence) RITS Spring 2011: Identifying Background Sources at VI Sites

- Now that we have more data, we can refine the conceptual site model to better understand the vapor intrusion pathway.
- This could lead to collection of additional data and/or the use of more advanced methods, as we will discuss next.

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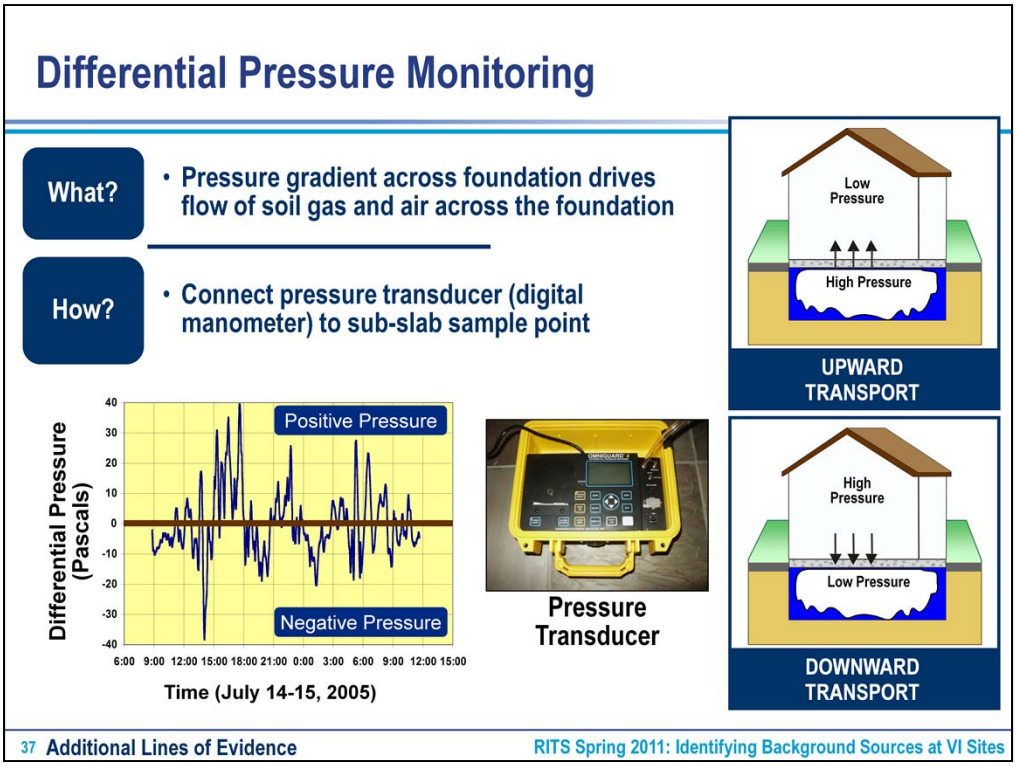


- Pressure monitoring can be used to determine if vapor intrusion could be occurring based on the air flow direction across the foundation.
- Positive downward pressure can cause the transport of VOCs from indoor sources into the sub-slab.
- Direction of flow can change over time, also resulting in VOCs moving from the indoors to the sub-slab.

Building Pressure Cycling (BPC)

What?

- Use controlled ***NEGATIVE*** building pressure to ***MAXIMIZE*** VI
- Use controlled ***POSITIVE*** building pressure to ***TURN OFF*** VI

When?

- To confirm impact of non-removable or unidentified indoor source on indoor air quality
- To reduce temporal variability associated with normal fluctuations in building pressure (i.e., to ensure potential for VI during scheduled sampling event)
- To maximize vapor intrusion during on-site analysis program

38 Additional Lines of Evidence — RITS Spring 2011: Identifying Background Sources at VI Sites

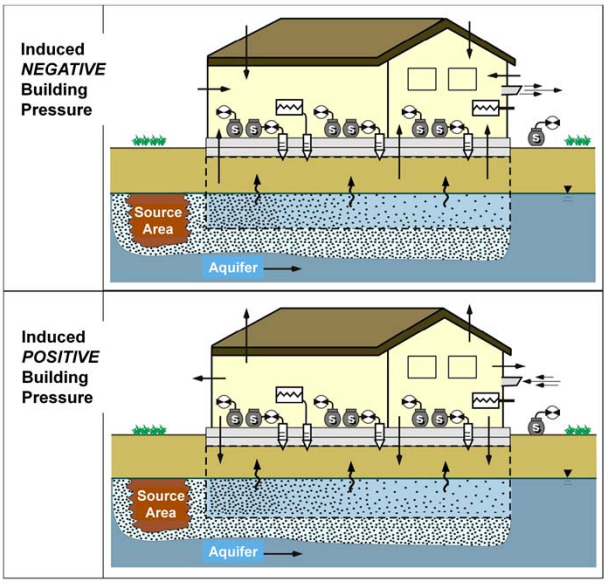
- Maximizing VI by introducing a negative building pressure can reduce the potential need for multiple sampling events and reduce stakeholder concerns regarding temporal variability.
- Maximizing VI in conjunction with on-site analysis can assist in identifying entry points such as crack, drains, sumps, etc.

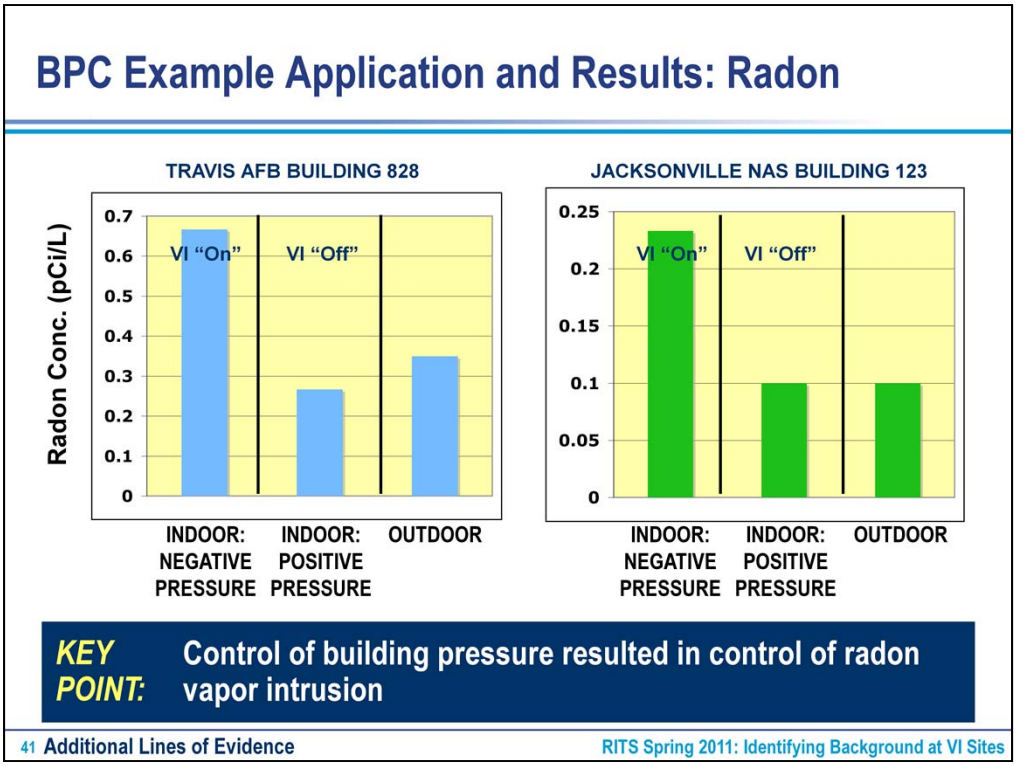
Overview of Building Pressure Cycling

How?

- Use fan or building HVAC system to control building pressure
- Measure radon and VOC concentrations in indoor air and ambient air under baseline, negative pressure, and/or positive pressure conditions
- Radon is a tracer for soil gas and serves to confirm effectiveness of building pressure control
- Limitation: not effective for very large and very leaky buildings
  (e.g., older buildings on Navy bases)

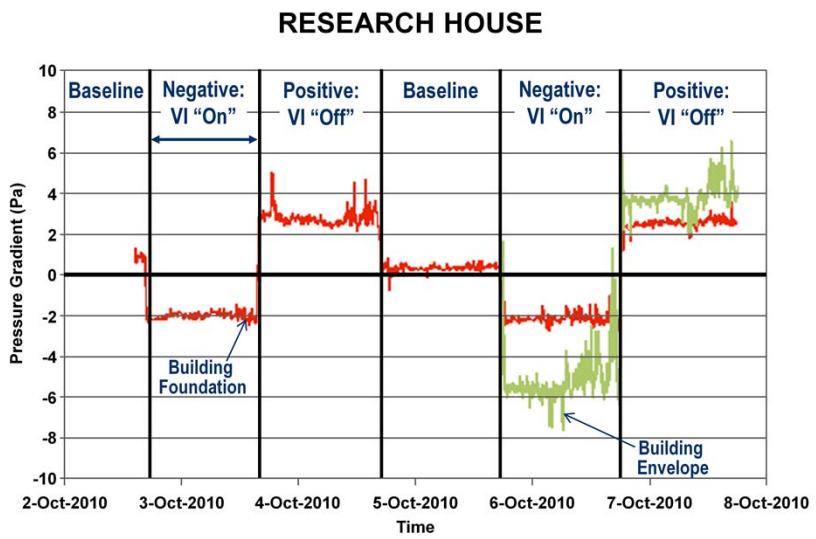
Overview of Building Pressure Cycling (cont.)





- The natural soil gas tracer radon was used at these two site to show the effectiveness of building pressure cycling to turn on and off the effects of vapor intrusion.

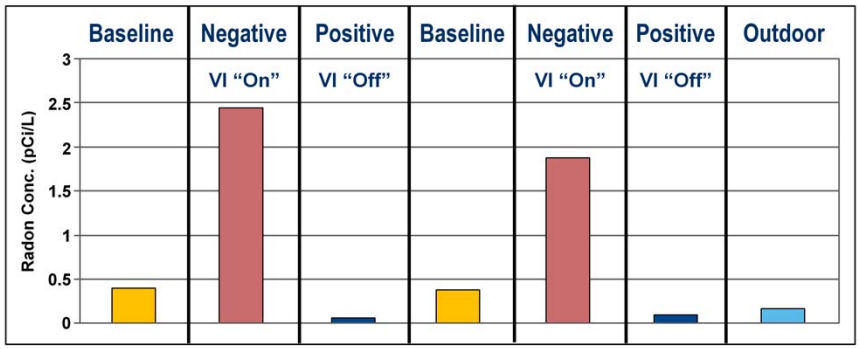
BPC Example Application and Results: Research House



42 Additional Lines of Evidence RITS Spring 2011: Identifying Background Sources at VI Sites

- Use of pressure gradient measurements to show the effectiveness of building pressure cycling, prior to conducting a both radon and VOC sampling.
- Slight positive pressure during baseline may be enough to mostly suppress vapor intrusion.

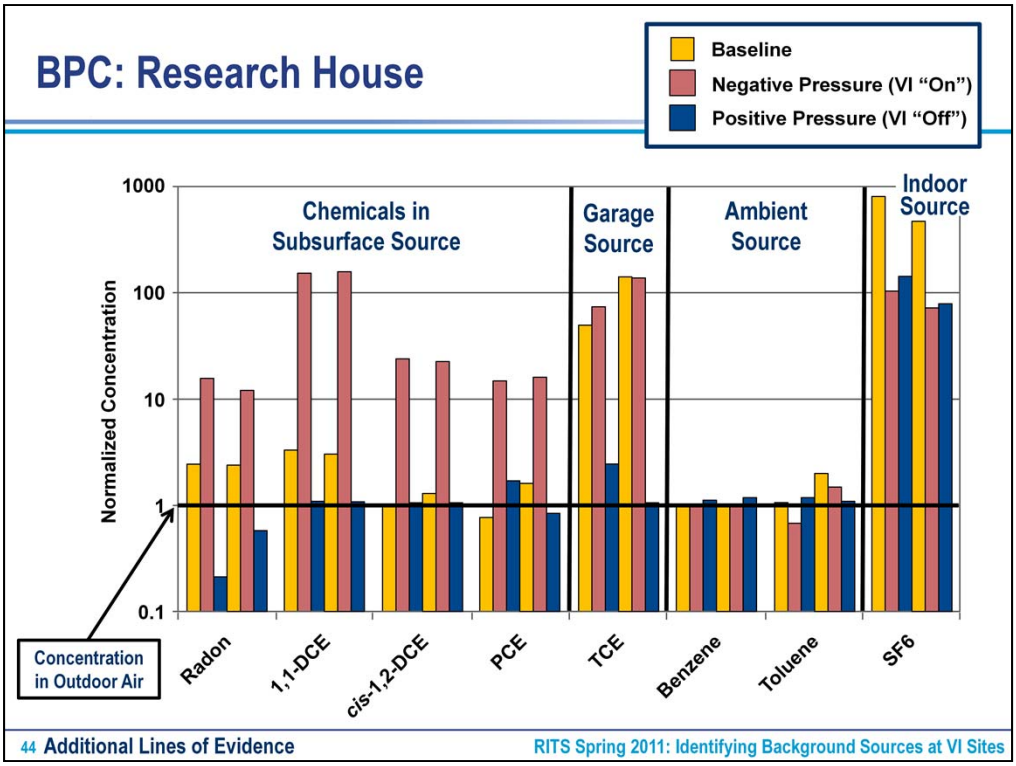
BPC Application and Results: Research House (cont.)



KEY POINT: Control of building pressure resulted in control of radon vapor intrusion

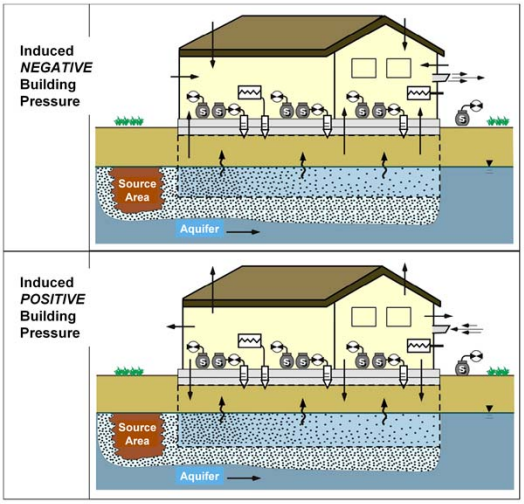
43 Additional Lines of Evidence — RITS Spring 2011: Identifying Background Sources at VI Sites

- The results of sampling for the natural soil gas tracer radon showed that the building pressure cycling was effective in turning VI of and on, as would be expected from the results of the pressure gradient measurements presented in the previous slide.
- Results of the baseline sampling shows only minor levels of radon above outdoor conditions due to positive pressure under baseline conditions.



- Results for chemicals in the subsurface source showed that under negative pressure (i.e., VI "on") concentrations much higher than baseline and with VI "off" indicating that pressure cycling clearly made for "worst" case VI scenario.
- TCE was stored in the garage by accident (indoor background source), therefore baseline concentrations and those with VI on are very similar, under positive pressure the TCE was pushed out of the garage resulting in lower concentrations.
- As expected, no change in ambient conditions due to building pressure cycling.
- Indoor source of SF6 (sulfur hexafluoride) was released into the building as part of the experiment and concentrations under positive and negative pressure conditions were similar, as with the indoor source of TCE.

Building Pressure Cycling: Summary



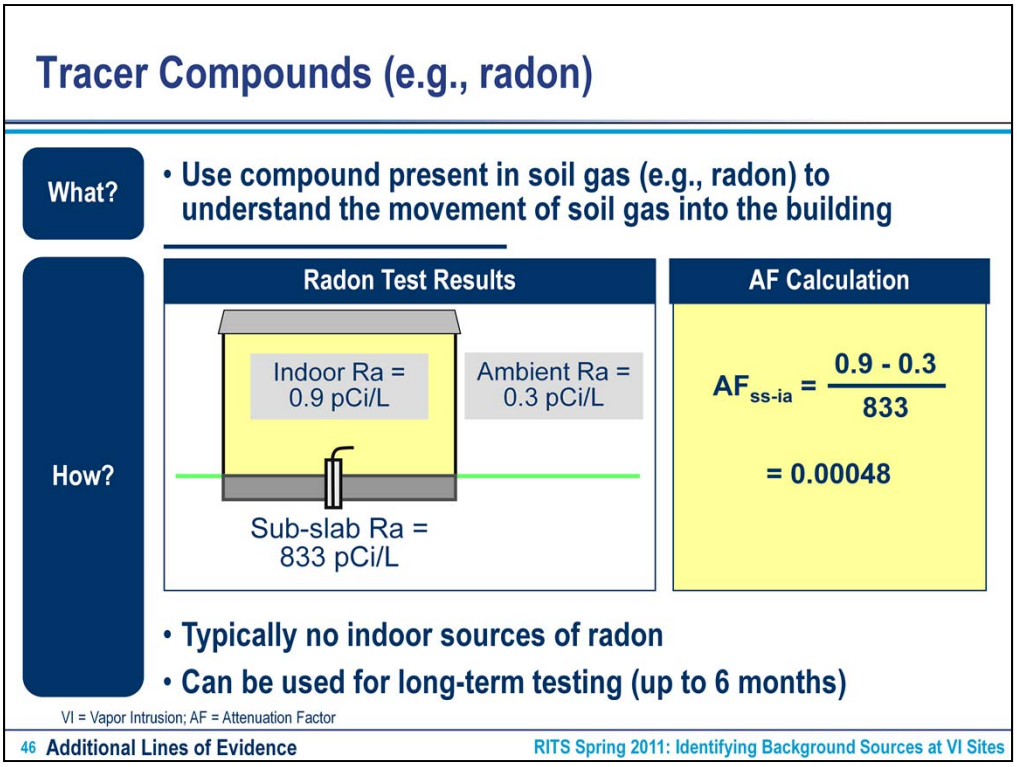
KEY POINTS:

- **Method to "Turn On" or "Turn Off" vapor intrusion for scheduled sample event**
- **Demonstrated through USEPA ETV program (Report Pending)**
- **Pressure control can be combined with other methods (e.g., on-site analysis)**

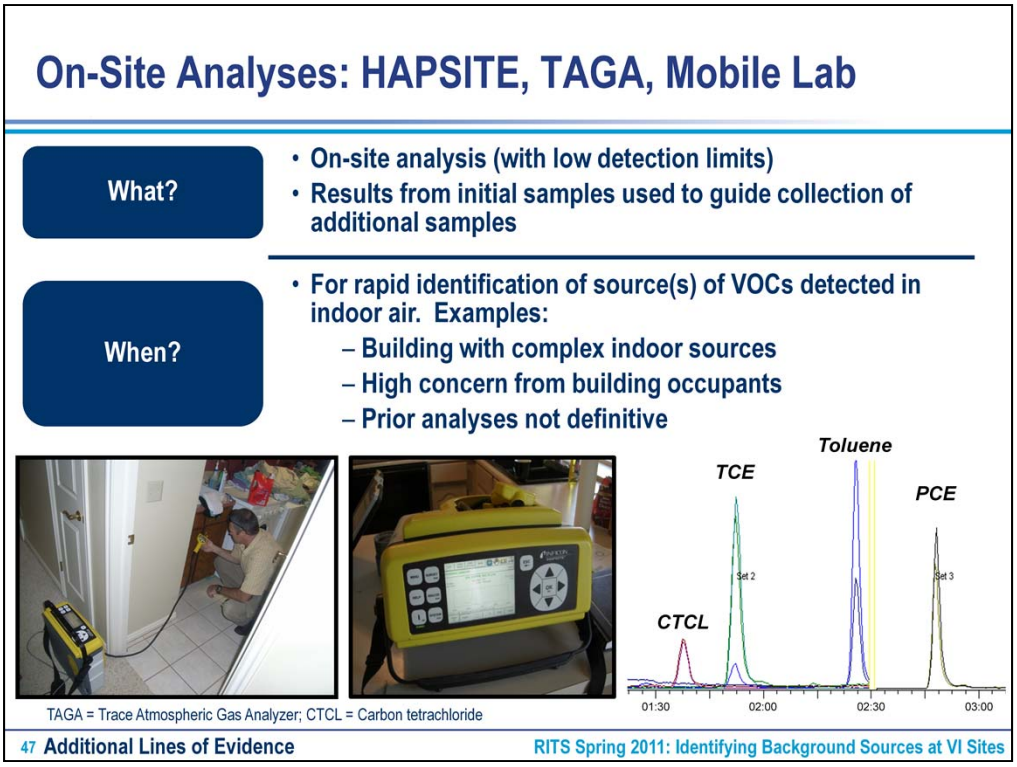
ETV = Environmental Technology Verification

45 **Additional Lines of Evidence** RITS Spring 2011: Identifying Background Sources at VI Sites

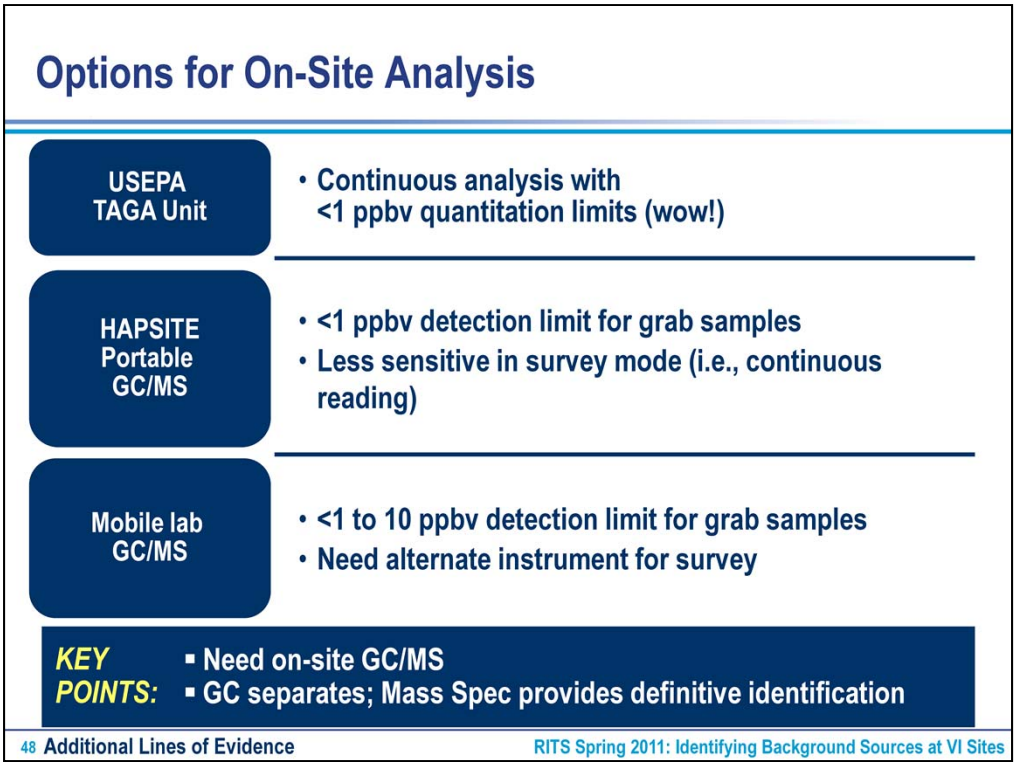
- Tool that can be used to reduce concerns with uncertainty.
- When used in conjunction with on-site analysis can assist in identifying indoor sources and/or VI entry points.



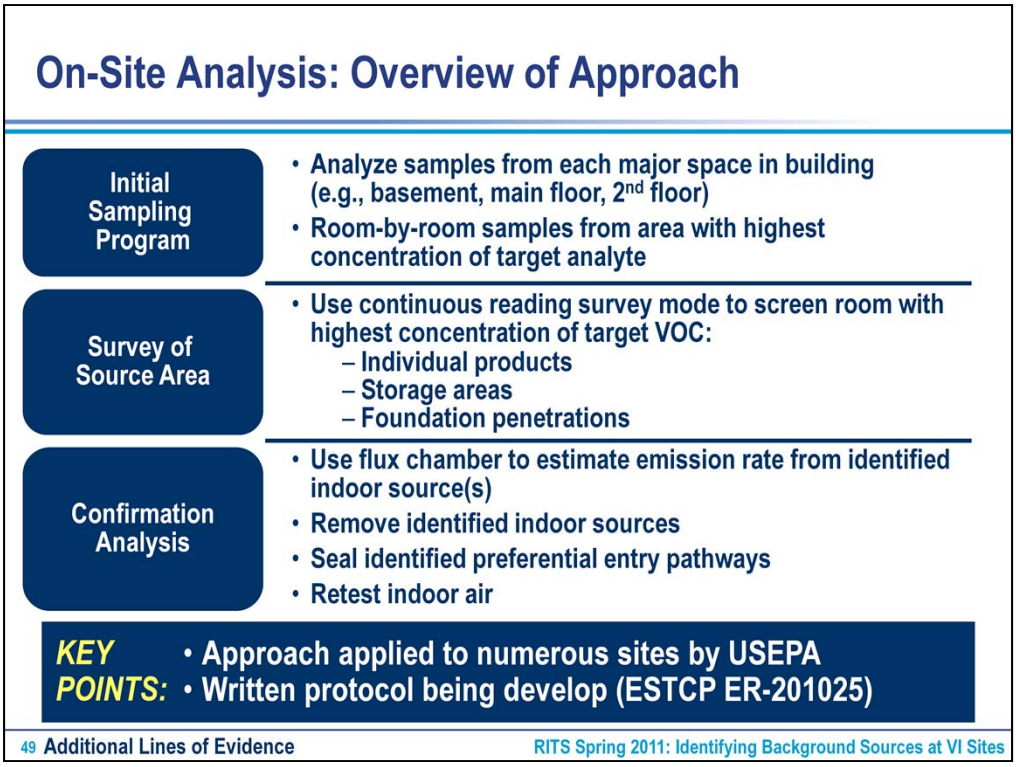
- Radon was discussed during the previous discussion on building pressure cycling as an effective tracer compound that is naturally occurring in soil gas.
- Can also be used to predict expected attenuation factors for transport of VOCs from the sub-slab to indoor air. Measurements can be collected in conjunction with a typical VI sampling program (i.e., summa canisters) for a relatively low additional cost.



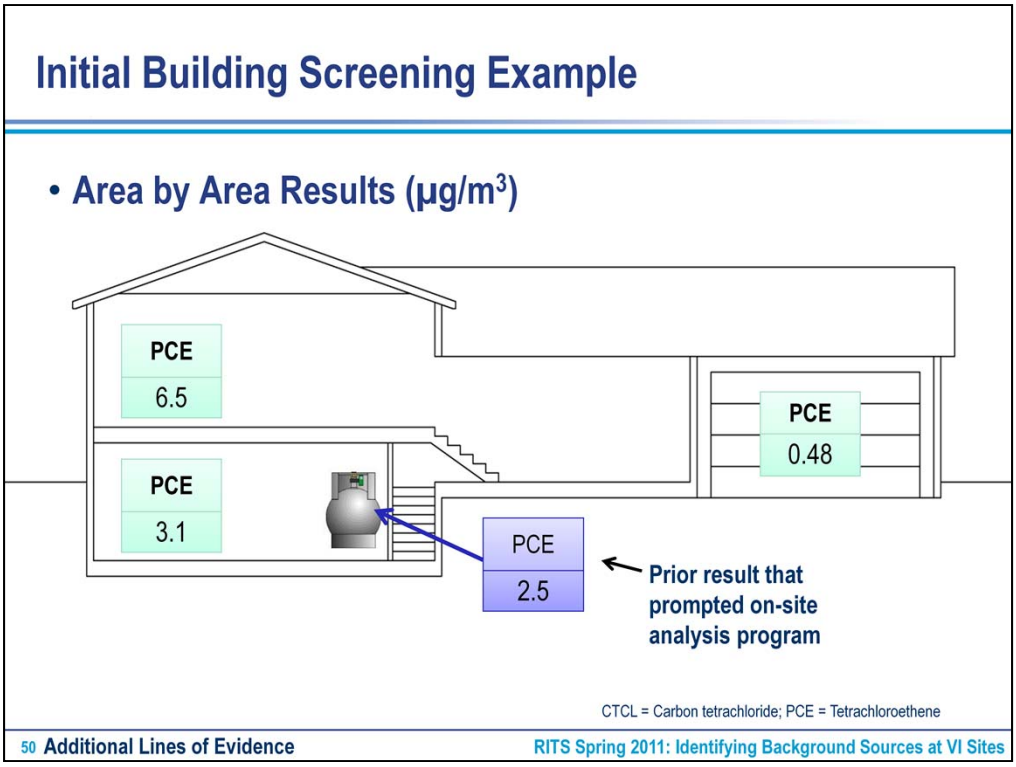
- On-site analysis is currently the best available tool for distinguishing between background sources and vapor intrusion and can be done quickly with definitive results in most cases.
- Mass spec with the HAPSITE gives chemical specific results, while other re-time instruments (e.g., PID) are not chemical specific and there is a lot of interference from non-COC indoor sources of VOCs.
- Can be used to find specific indoor sources, confirm removal of indoor sources, indentify VI entry points, etc.



- The HAPSITE is the least expensive method and provides both quantitative and real-time chemical specific survey results.
- HAPSITE has been successfully used by both Hill Air Force Base team and GSI to indentify indoor sources in both residential and commercial structures.
- Lack of survey mode with mobile lab GC/MS is a limitation.



- All decisions can be made while on-site and additional data collected as needed, versus typical VI investigation where the investigator is in the dark until results received from the laboratory weeks later.
- The source of indoor air impacts can typically be identified in 1-day of testing and reduces the need to complete multiple mobilizations.
- We will discuss the 3 main elements of the on-site analysis approach in the following slides.



- The initial screening results are used to identify the areas of potential indoor sources.
- This example shows that there is a potential background source on the main floor.

Initial Building Screening Example (cont.)

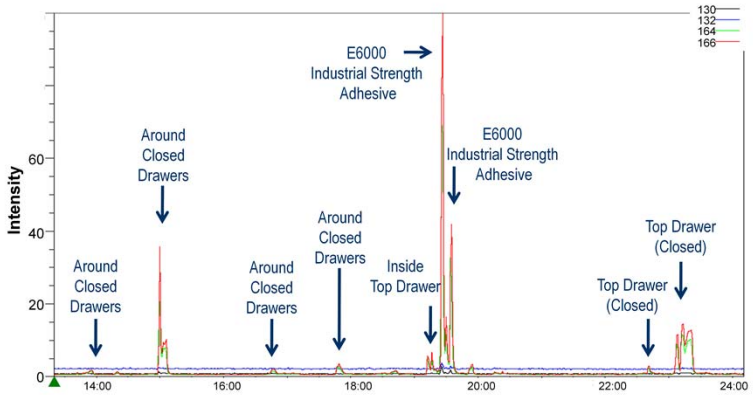
- **Room by Room Results – Upstairs (µg/m³)**

CTCL = Carbon tetrachloride; PCE = Tetrachloroethene

51 Additional Lines of Evidence RITS Spring 2011: Identifying Background Sources at VI Sites

- Based on the first round of sampling results, additional room by room sampling is conducted on the main floor to further refine the potential source area.
- The room on the lower right has the highest PCE result and additional survey mode screening in this area should be conducted in an effort to identify the specific background source of PCE.

Real-Time Survey to Identify Sources



52 Additional Lines of Evidence RITS Spring 2011: Identifying Background Sources at VI Sites

- Real-time screening was able to identify the source of PCE.
- Discuss the intensity peaks and how the tube of glue was found.
- Very difficult to find visually, also not identified by resident in the occupied dwelling questionnaire.
- If removal of background sources had occurred, this could have been easily missed, leading to false conclusions regarding vapor intrusion.
- Flux chamber sampling confirmed that the E6000 hobby glue was a significant source of PCE with regard to indoor air quality.
- This source could be removed and the house re-sampled using on-site analysis after 24-hour flushing period to confirm no other indoor sources prior to collection of 24-hour summa canisters.

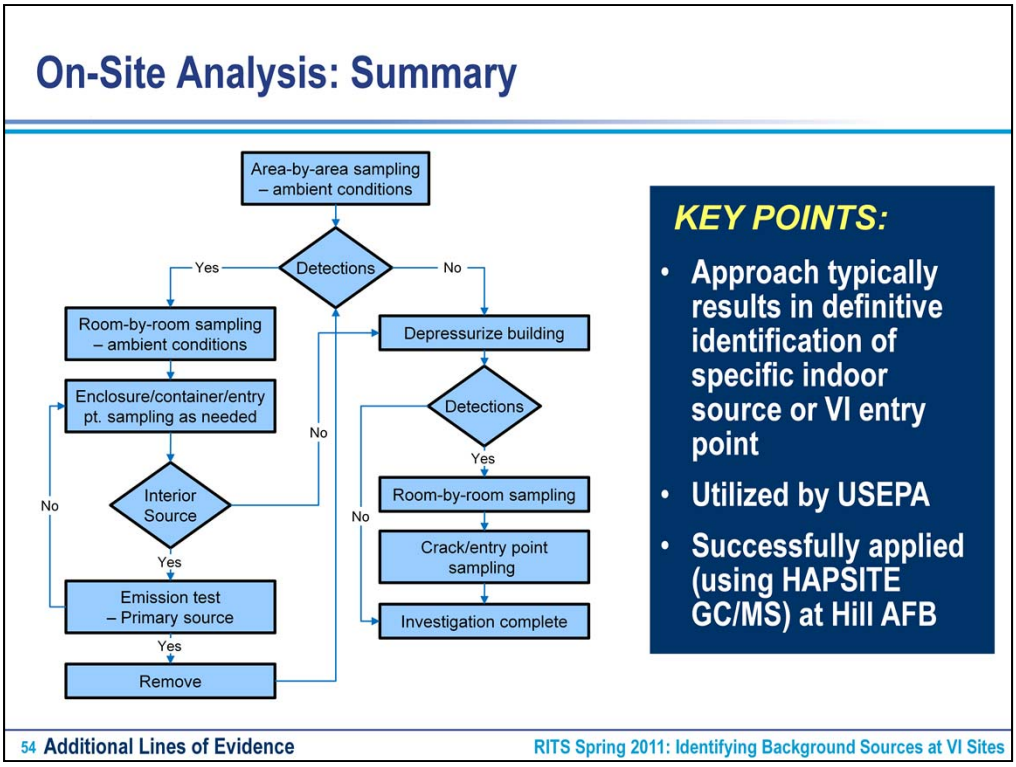
Real-Time Survey to Identify VI Entry Points

- Same continuous-read survey mode
- Typically conducted after search for indoor sources (indoor sources can contaminate sub-slab soil gas)
- Entry points can be isolated, if needed
- Can depressurize building to enhance inflow of soil gas

Examples provided by Kyle Gorder and Erik Dettenmaier, Hill AFB

53 Additional Lines of Evidence RITS Spring 2011: Identifying Background Sources at VI Sites

- HAPSITE or other instrument can be used to find the entry points, these can be sealed and indoor air retested.
- Important to note that air can flow in both directions through the slab and that indoor sources can contribute to what is measured in the sub-slab, as discussed previously.



- Again, on-site analysis is the best tool currently available for definitive identification of the source of indoor air impacts.
- USEPA uses this, it's why they have their million dollar TAGA van.
- GSI and the Hill AFB team have successfully applied this methodology at numerous residential and commercial structures.
- Easy to understand and defend the results.

Presentation Overview

- Introduction
- Steps Leading to Background VI Evaluation
- Indoor Air Testing (Typical Program)
- Exploratory Data Analysis
  - Primary Lines of Evidence
  - Additional Lines of Evidence
- ► Forensic Methods and Multivariate Analyses
- Case Studies
- Summary

Forensic Analysis: Fingerprinting *(NAVFAC, 2010; Section 4.0)*

What?
- Detailed analysis of vapor samples to quantify 10s to 100s of individual VOCs

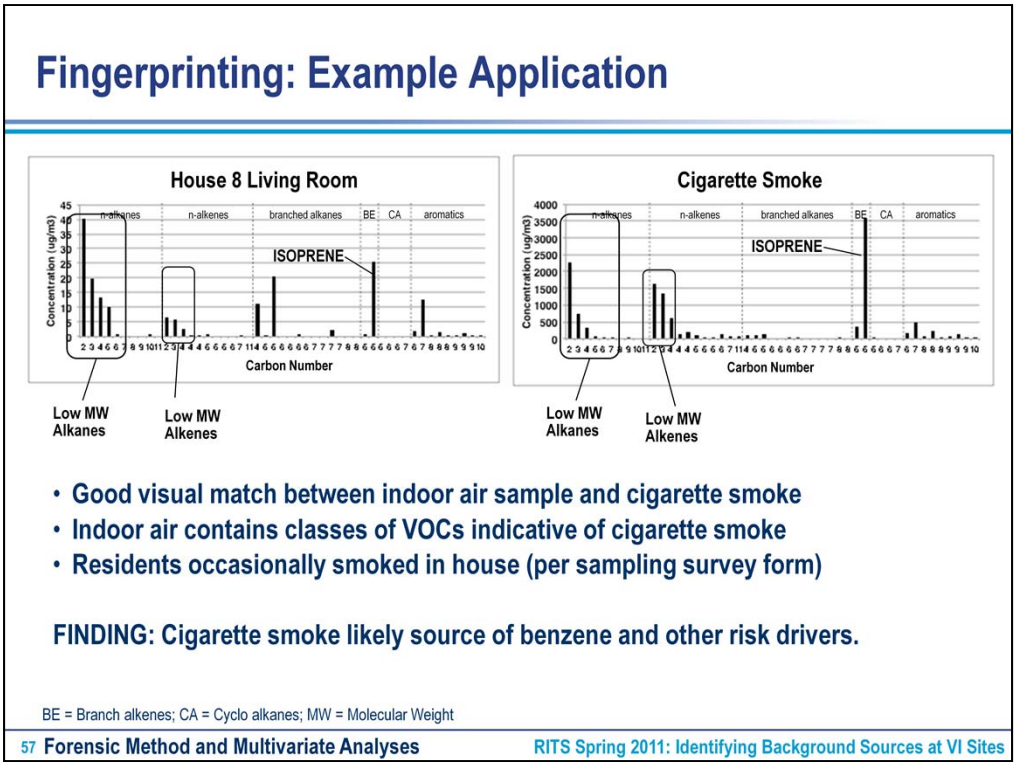
When?
- Useful to identify source(s) of petroleum hydrocarbons detected in indoor air

Who?
- Limited number of laboratories have sufficient analyte list for adequate fingerprinting analysis

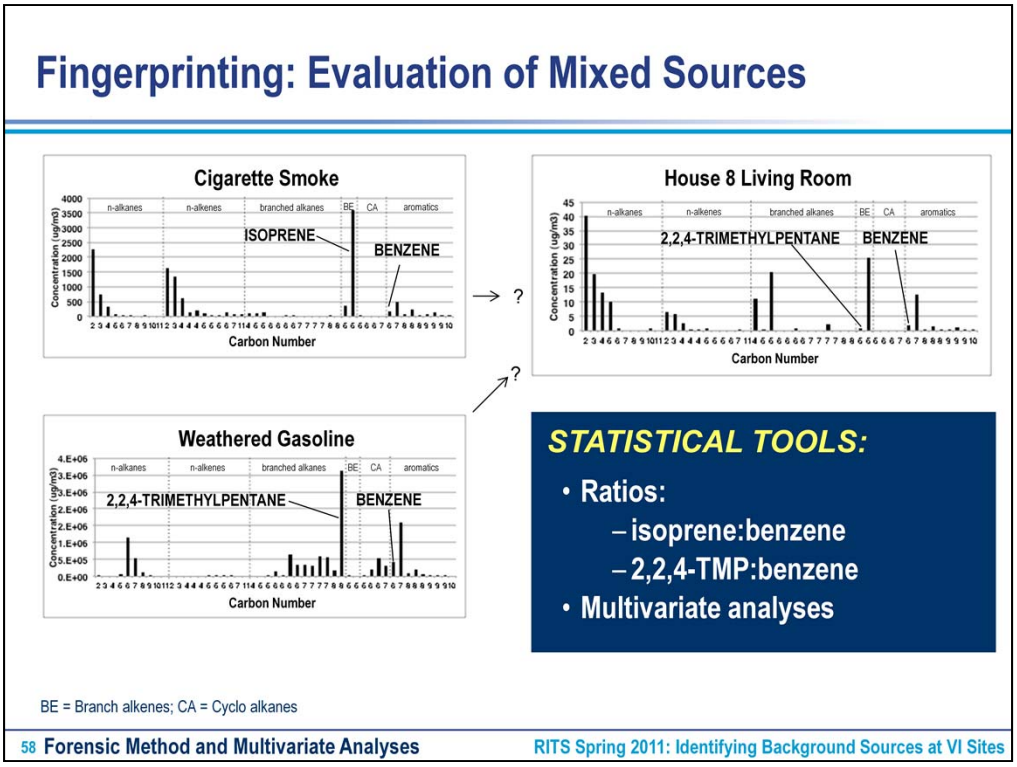
How?
- Conduct analysis on one or more indoor air samples, one or more soil gas samples
- Consider sampling potential sources, if identified (e.g., gasoline, solvent-based cleaner, natural gas)
- Use exploratory and statistical methods to compare indoor air to potential sources

56 Forensic Method and Multivariate Analyses — RITS Spring 2011: Identifying Background Sources at VI Sites

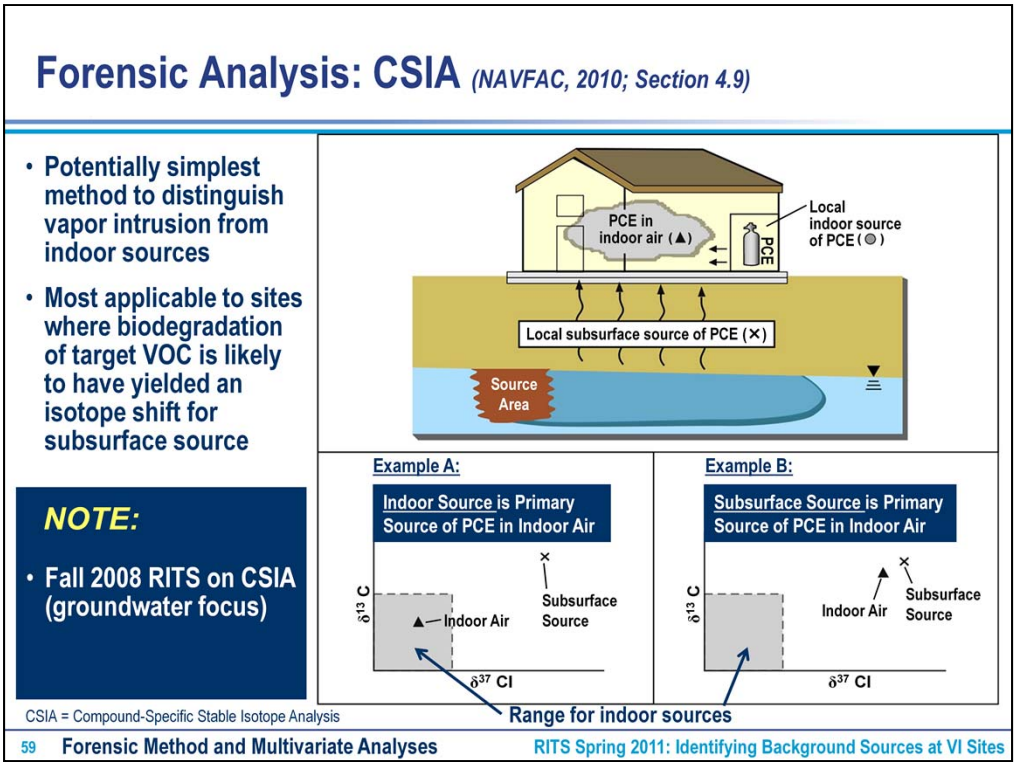
- Works well with petroleum hydrocarbons as each source has a distinctive carbon range fingerprint and contain 100's of different chemicals.
- Exploratory, look at the carbon ranges and compare fingerprint, look at specific chemicals.
- Statistical, look at concentration ratios or do a multivariate analysis such as a cluster analysis.



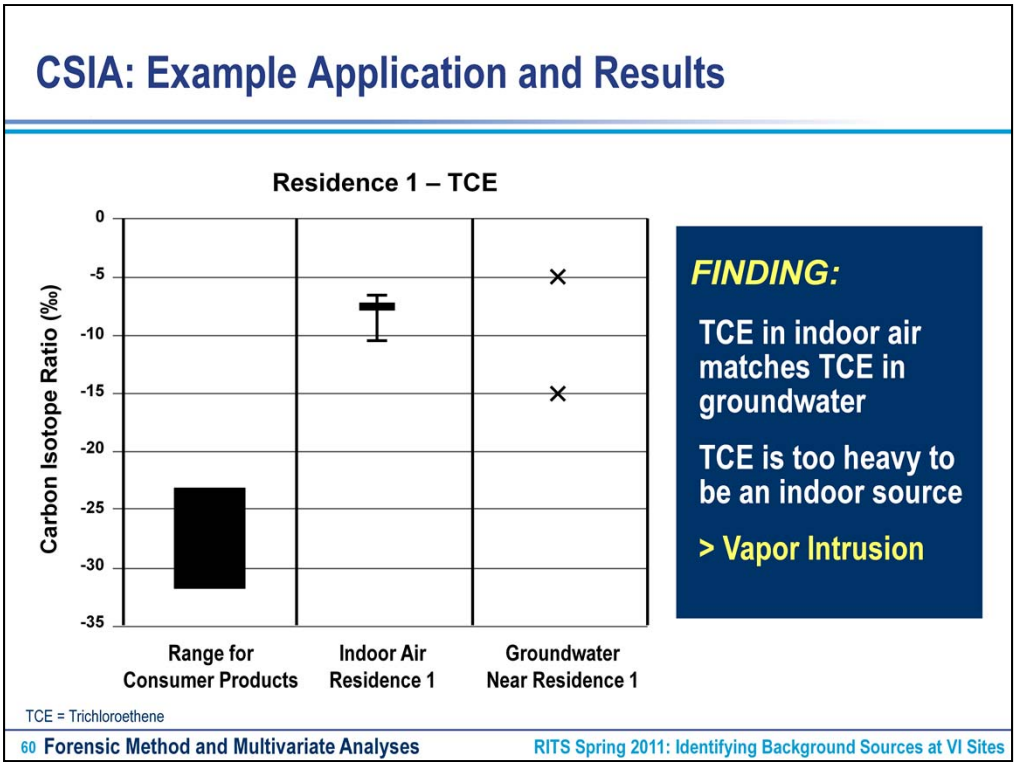
- First, the visual match is pretty good between indoor air and cigarette smoke.
- Same classes of VOCs are observed in both samples.
- After additional inquiry, it came to light that the residents do indeed smoke in the home.



- The question of mixed sources is often raised (i.e., indoor and VI both contributing).
- Use statistical tools such as the ratios of key indicator parameters or conduct a more rigorous multivariate analysis (e.g., cluster analysis).
- The ratios of isoprene:benzene and 2,2,4-TMP:benzene show that the indoor air is much more similar to cigarette smoke, rather than a weathered gasoline in the subsurface.



- Since previous RITS was conducted on this concept we will not go into the details of the chemistry during this presentation, etc.
- Biodegradation in the source will make the compound heavier.
- Gray box is a typical range of the isotope ratios that is seen in indoor sources.
- In this example we are looking at the ratios of isotopes, carbon and chlorine as they pertain to PCE.



- Single isotope comparison shows that the ratio in indoor is similar to that observed in the groundwater vs. the typical range for consumer products, indicating the indoor air concentration is being caused by vapor intrusion.

CSIA: Summary

- Can provide definitive finding from as few as two samples (i.e., one indoor and one subsurface)
- Paper on Hill AFB study under review
- Additional work being supported by ESTCP
  - Project ER-201025

Multivariate Statistical Methods *(NAVFAC, 2010; Section 5.0)*

What?

- Statistical methods that utilize multiple characteristics (e.g., concentration results for multiple VOCs) to evaluate differences between groups

When?

- Typically requires large datasets (e.g., extensive analyte list for multiple samples from indoor air, background indoor air, ambient air, soil gas)
- May be useful when simpler analyses are not definitive

Examples

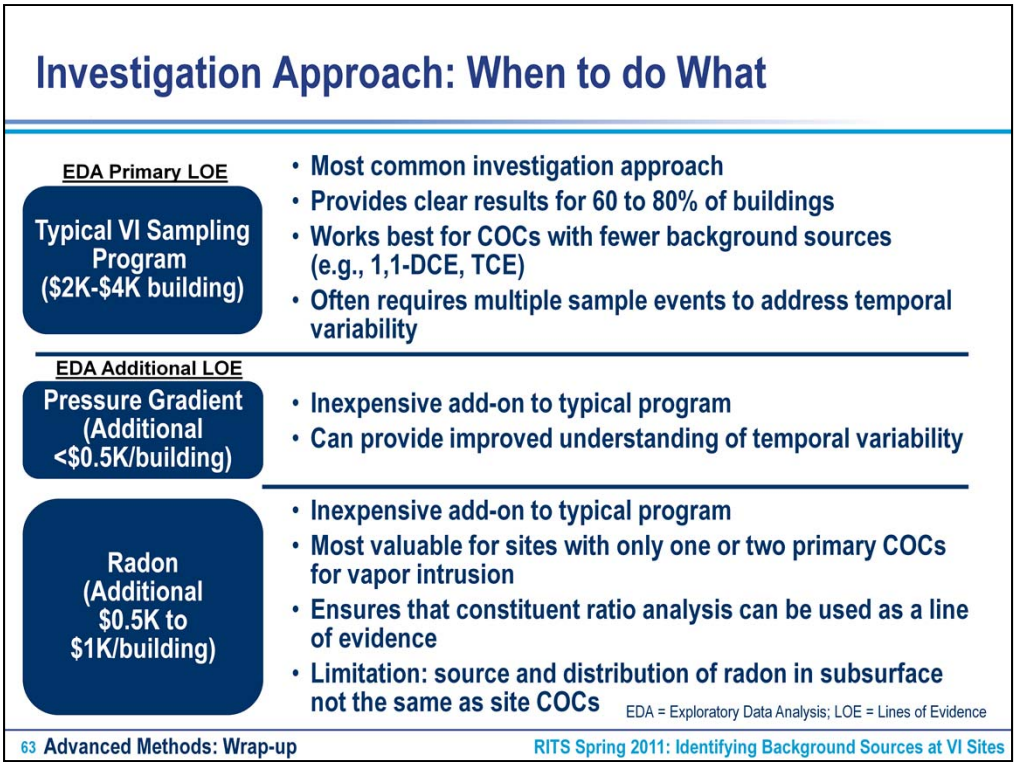
- Principal Component Analysis: Consolidates results for multiple individual chemicals into "principal" components based on correlations in individual results
- Cluster Analysis: Groups samples into cluster based on overall similarity for multiple characteristics (i.e., multiple chemical concentration results)

KEY POINTS:

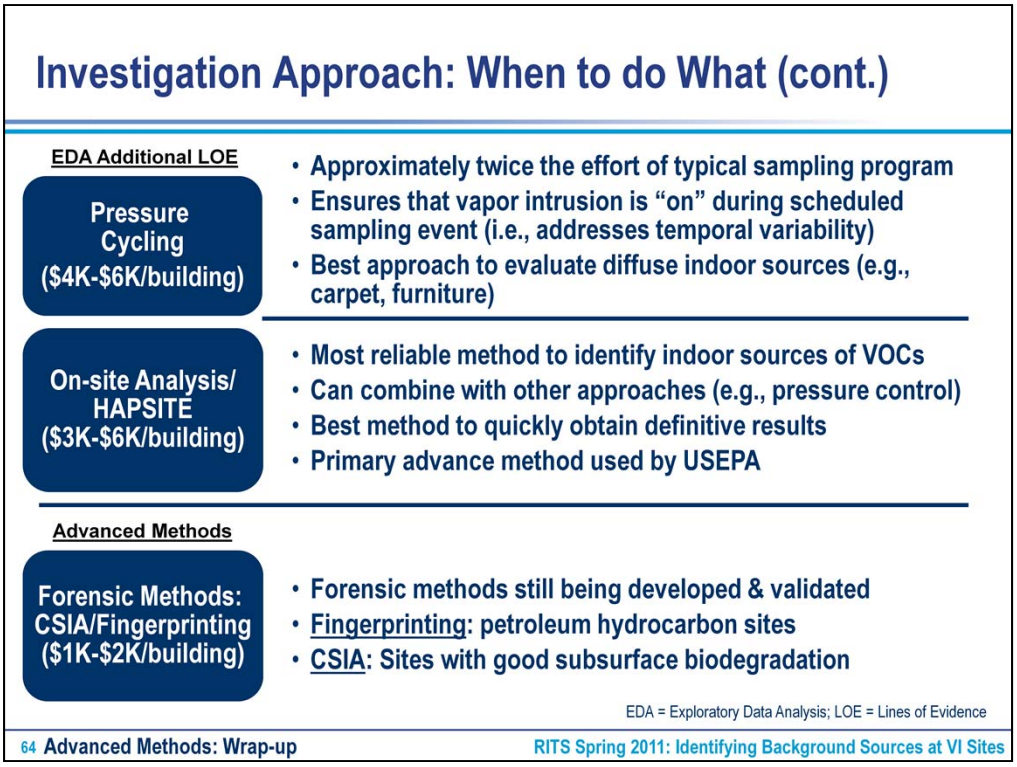
- Statistical expertise required for proper application
- Methods and results can be difficult to explain

62 Forensic Method and Multivariate Analyses — RITS Spring 2011: Identifying Background Sources at VI Sites

- This is a more complex method that takes a high level of expertise and as such, can be difficult to explain and make the stakeholder comfortable with the outcome.
- This should be a quick slide, only to introduce the concept, we are not going into any detail on this subject.
- This has been tabbed as a potential RITS topic in the future.



- Walk through the level of effort, benefits, and limitations for each of the additional lines of evidence with respect to a typical sampling program.
- In many cases the data collected during a typical sampling program and use of the primary lines of evidence is sufficient to determine whether vapor intrusion is occurring.



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JEB = Joint Expeditionary Base; MCRD = Marine Corps Recruit Depot

Case Studies

Case 1:
JEB Little Creek, VA

- ***Site***: Current barracks buildings
- ***Objective***: Evaluate current PCE/TCE vapor intrusion

Case 2:
Parris Island, SC Dry Cleaner (Site 45)

- ***Site***: Dry cleaner drop station above PCE plume
- ***Objective***: Evaluate current PCE vapor intrusion

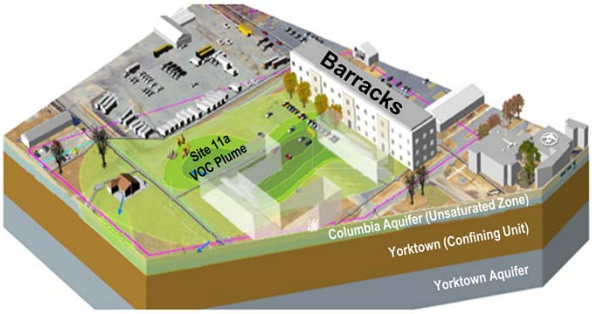
Case 3:
Hill AFB, UT Building 514

- ***Site***: On-base industrial building above mixed chlorinated solvent plume
- ***Objective***: Evaluate potential for vapor intrusion

Case Study 1: JEB Little Creek

- Identifying Potential VI Source and COPCs
  - Groundwater 5-7 ft bgs
  - Clay confining unit at ~25 ft bgs
  - Chlorinated VOC plumes in groundwater
- Lateral Distance Criteria
  - Potential VI source within 100-ft of Barracks
- COPC Screening Criteria (GW and Sub-Slab)
  - Groundwater > VI screening criteria
  - Sub-slab > VI screening criteria

Site 11a: Former Waste Storage Tank and Current Barracks



INITIAL FINDINGS:

- Indoor air sampling required

>> Must Consider Background

67 Case Study 1: JEB Little Creek, VA — RITS Spring 2011: Identifying Background Sources at VI Sites

- Introduce the site and conditions.
- Since groundwater and sub-slab sampling results exceeded screening criteria, indoor air sampling was required, requiring that background sources of the site VOCs be carefully considered during indoor air assessment process.

Case Study 1: Indoor Air, Sub-slab Soil Gas, and Outdoor Air Results at Barracks (cont.)

- **Concurrent indoor/outdoor/ sub-slab sampling 2010**
  - **TCE (µg/m³)**
    - Indoor air: No detections
    - Outdoor: 0.1J
    - Sub-slab: 28-270
  - **PCE (µg/m3)**
    - Indoor air: max =2.4
    - Outdoor: 0.15J
    - Sub-slab: 4-520

LS11A-IA06	Mar-10
Chloroethane	0.21 U
Cis-1,2-DCE	0.32 U
Trans-1,2-DCE	0.32 U
PCE	2.4
TCE	0.21 U

LS11A-SV06	Nov-09	Mar-10
Chloroethane	0.19 J	0.052 J
Cis-1,2-DCE	0.19 J	0.32 U
Trans-1,2-DCE	0.1 J	0.32 U
PCE	1.6	3.6
TCE	31	6.1

68 Case Study 1: JEB Little Creek, VA — RITS Spring 2011: Identifying Background Sources at VI Sites

- Note that in March 2010, indoor air concentrations for PCE exceeded the risk-based screening criteria and also barely exceeded PCE concentrations in the sub-slab (suggestive evidence of indoor source of PCE).
- In addition, TCE was not detected in indoor air, even though the sub-slab concentration exceeded that of PCE.

Case Study 1: Exploratory Data Analysis

Compare IA to Screening Criteria

- 1 PCE IA Sample (2.4 ug/m^3) > screening criteria (2.1 ug/m^3)

Typical Background Comparison

- IA > ambient air concentration
- IA within published background range for PCE

IA to SS Ratio

$$\frac{C_{IA}}{C_{SS}} = \frac{2.4}{3.6} = 0.7$$

Initial Findings:

- Typical background comparison inconclusive
- SS < 10x IA suggestive of indoor source

IA = Indoor Air; SS = Sub-slab; AF = Attenuation Factor

Case Study 1: Exploratory Data Analysis (cont.)

Constituent Ratio Comparison

Sample	TCE (µg/m³)			PCE (µg/m³)		
Location	Indoor Air	Sub-Slab	Ratio	Indoor Air	Sub-Slab	Ratio
3	< 0.21	140	< 1.5E-03	0.15	110	1.4E-03
4	< 0.21	52	< 4.0E-03	0.14	48	2.9E-03
6	< 0.21	6.1	< 3.4E-02	2.4	3.6	7.0E-01
8	< 0.21	28	< 7.5E-03	0.21	93	2.6E-03

Final Findings:

- **IA/SS PCE ratio at 1 exceedance location inconsistent with published values AND inconsistent with other site-specific ratios**
- **Weight of evidence strongly suggests indoor source**
- **No further action recommended for VI**

IA = Indoor Air; SS = Sub-slab

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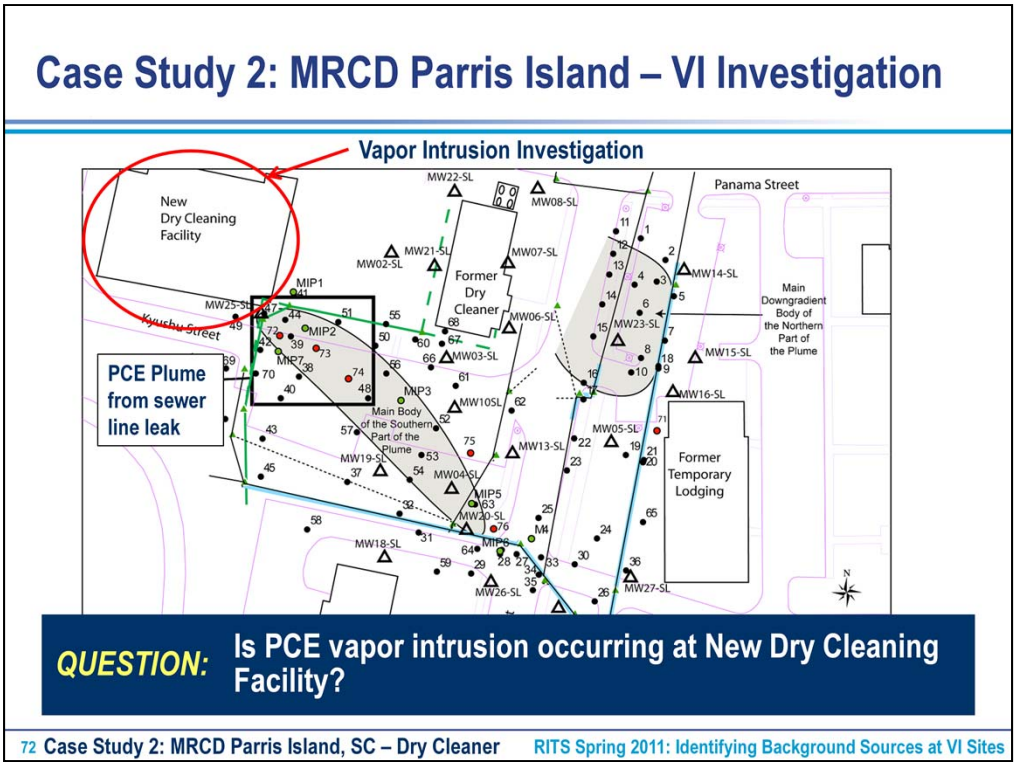
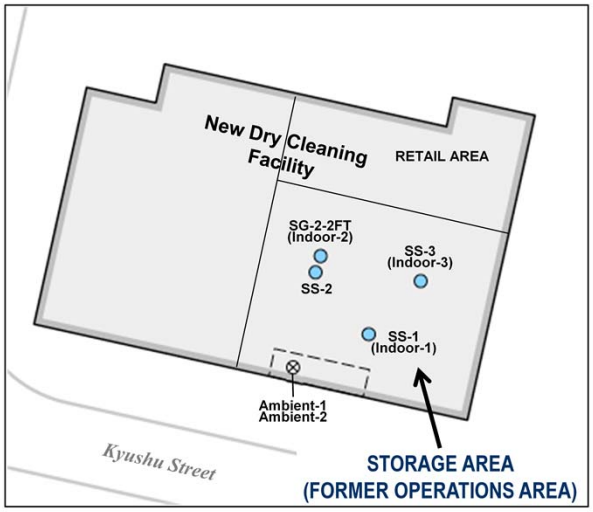


- Introduce site, leak from sewer line caused PCE plume, new dry cleaning facility for pick-up/drop-off only and was told that the off-site facility was not using PCE based cleaning agents.

Case Study 2: Sampling Program

- Indoor air (3), ambient air (1), sub-slab (3)
- VOCs
- Radon
  - Soil gas tracer
- SF_6 (indoor air tracer)
  - for research purposes only



SF_6 = Sulfur hexafluoride

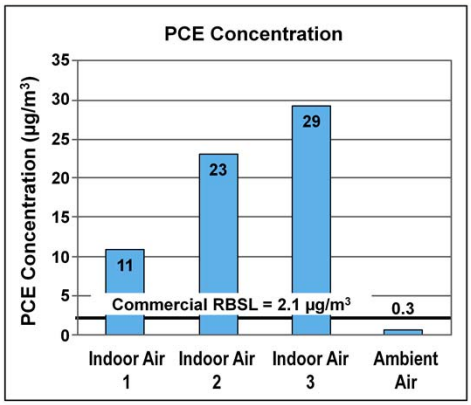
73 Case Study 2: MRCD Parris Island, SC – Dry Cleaner RITS Spring 2011: Identifying Background Sources at VI Sites

- Introduce sampling program, typical program with the addition of radon as a natural soil gas tracer.
- Also plan to use positive building pressure to turn “off” VI.

Case Study 2: Comparison of Indoor Air to RBSLs

Initial Findings

- PCE in indoor air exceeds commercial RBSL
- PCE in indoor air exceeds ambient concentration
- However, dry cleaned clothing stored in building for customer pick-up



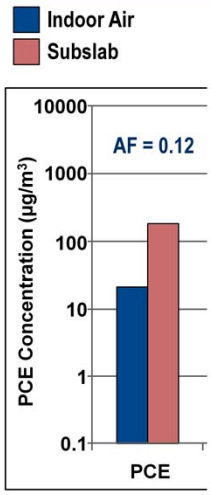
MLE evaluation required to determine source of PCE in indoor air

RBSL = Risk-Based Screening Level; MLE = Multiple Lines of Evidence; RBSL value for PCE from USEPA Regional screening tables.

74 Case Study 2: MRCD Parris Island, SC – Dry Cleaner RITS Spring 2011: Identifying Background Sources at VI Sites

- Results indicate potential vapor intrusion so multiple lines of evidence required to distinguish between VI and indoor background sources of indoor air quality impacts.

Case Study 2: Multiple Lines of Evidence Evaluation



Subslab Results

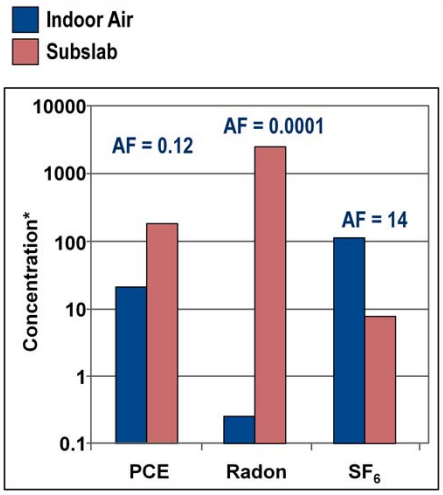
- PCE concentration is higher in subslab
- Attenuation factor (AF) is 0.12, close to USEPA default of 0.1
- PCE is only VOC detected in subslab (i.e., can't use ratios LOE)

PCE = Tetrachloroethene; LOE = Line of Evidence

75 Case Study 2: MRCD Parris Island, SC – Dry Cleaner RITS Spring 2011: Identifying Background Sources at VI Sites

- PCE attenuation factor is close to USEPA default, although less than the typical observed (100-1000 times attenuation from sub-slab to indoor air).
- Since only PCE detected in sub-slab, ratios of multiple constituents can't be compared.

Case Study 2: Multiple Lines of Evidence Evaluation (cont.)



Other Evidence

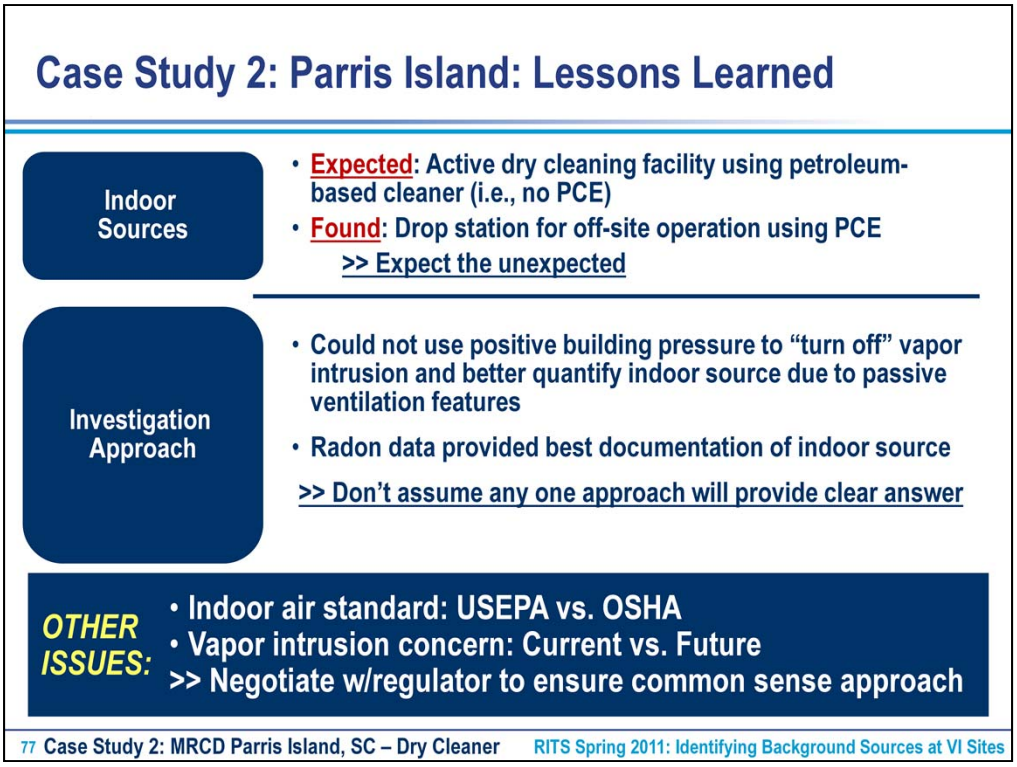
- Confirmed that off-site dry cleaner is using PCE-based cleaning solvent
- Radon attenuation factor is 100x higher than PCE attenuation factor
- SF_6 results confirm little or no air exchange across foundation
- PCE concentration in indoor air far below occupational limits

* = Concentration units for PCE and SF_6 in µg/m^3, radon in pCi/L

AF = Attenuation Factor; PCE = Tetrachloroethene; SF_6 = Sulfur hexafluoride

76 Case Study 2: MRCD Parris Island, SC – Dry Cleaner RITS Spring 2011: Identifying Background Sources at VI Sites

- The radon tracer indicates that the ratio of PCE is not indicative of vapor intrusion but is likely caused by storage of PCE dry cleaned clothing being stored at the facility.



- Expect the unexpected and be prepared to adapt the program to ensure that adequate data is collected.
- More data is better, if the radon samples had not been collected, then the inability to use positive pressure to turn "off" VI, would have resulted in inconclusive results, requiring additional investigation and analysis and increasing costs.

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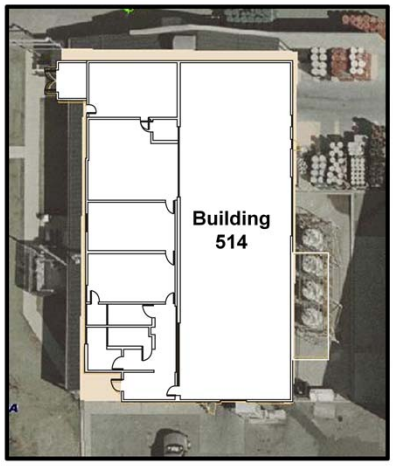
Case Study 3: Hill AFB Building 514

Goal

- Use on-site analysis (HAPSITE) to evaluate vapor intrusion pathway
  - 36 quantitative measurements plus survey mode

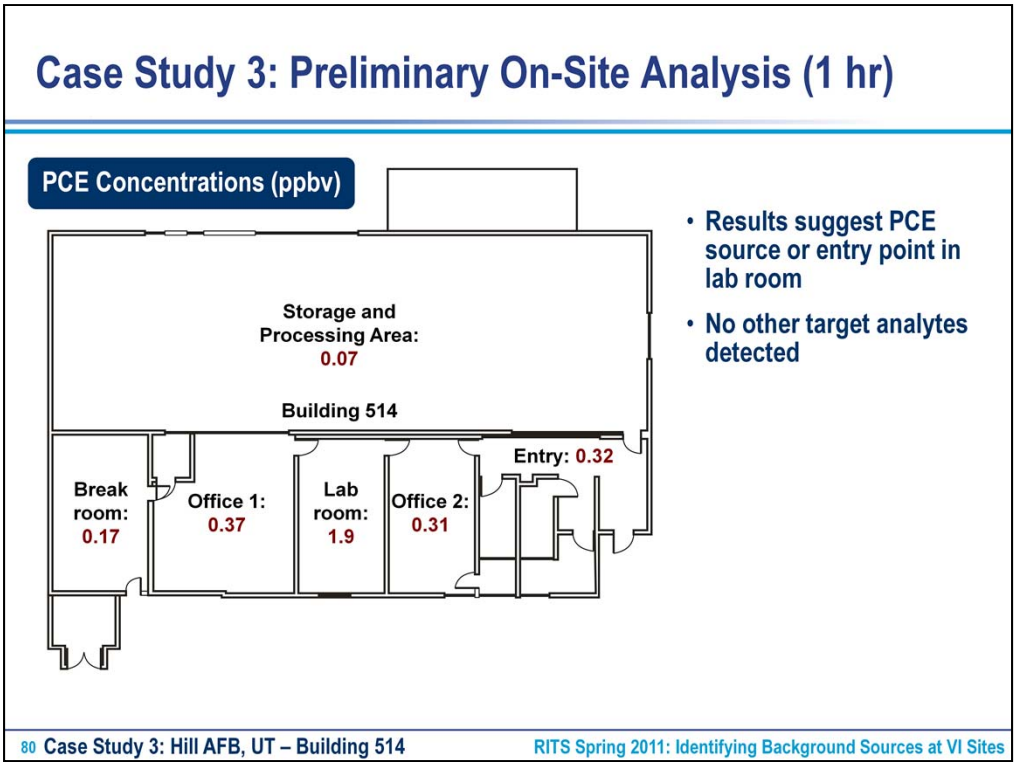
Site

- Building 514 used to store hazardous waste and recycle solvents
- Chlorinated VOCs detected in subsurface with 100 ft of building: 1,1,1-TCE; PCE; 1,1-DCE; TCE
- No prior investigation of indoor air quality in building

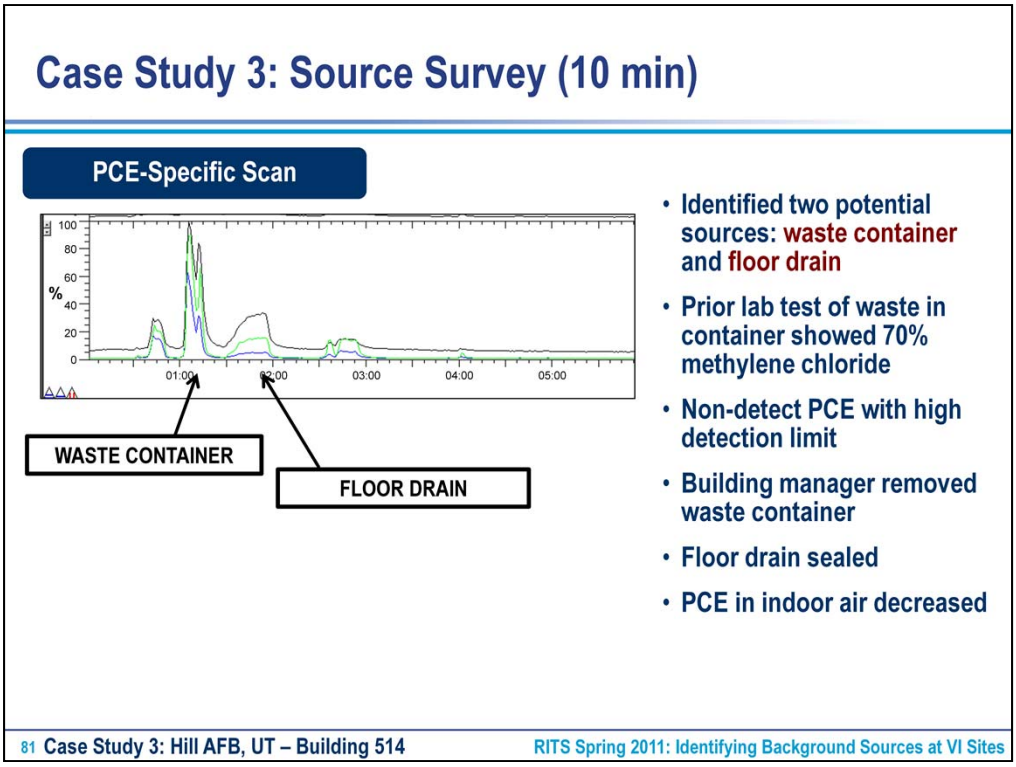


79 Case Study 3: Hill AFB, UT – Building 514 RITS Spring 2011: Identifying Background Sources at VI Sites

- Industrial site with potential for indoor sources.
- While no indoor air samples had been collected prior to the investigation, opted to use on-site analysis to ensure that VI concerns were properly evaluated with a definitive answer in a short period of time.



- Initial screening results show that the highest concentrations for PCE were found in the lab room, potential indoor source or VI entry point.



- Two potential sources of PCE were identified and both were removed/sealed in order to confirm no other significant sources of PCE on indoor air quality.

Case Study 3: Building Depressurization

Goal

- After source removal, PCE in building <0.1 ppbv in all rooms
- Use building depressurization to "turn on" vapor intrusion

What

- Use fan in doorway to depressurize (~12 hours prior to sampling)
- Uncover floor drain in lab room
- Use HAPSITE to look for target VOCS in indoor air
- Use HAPSITE and radon meter to look for VI entry points (floor drains, expansion joints, foundation cracks)

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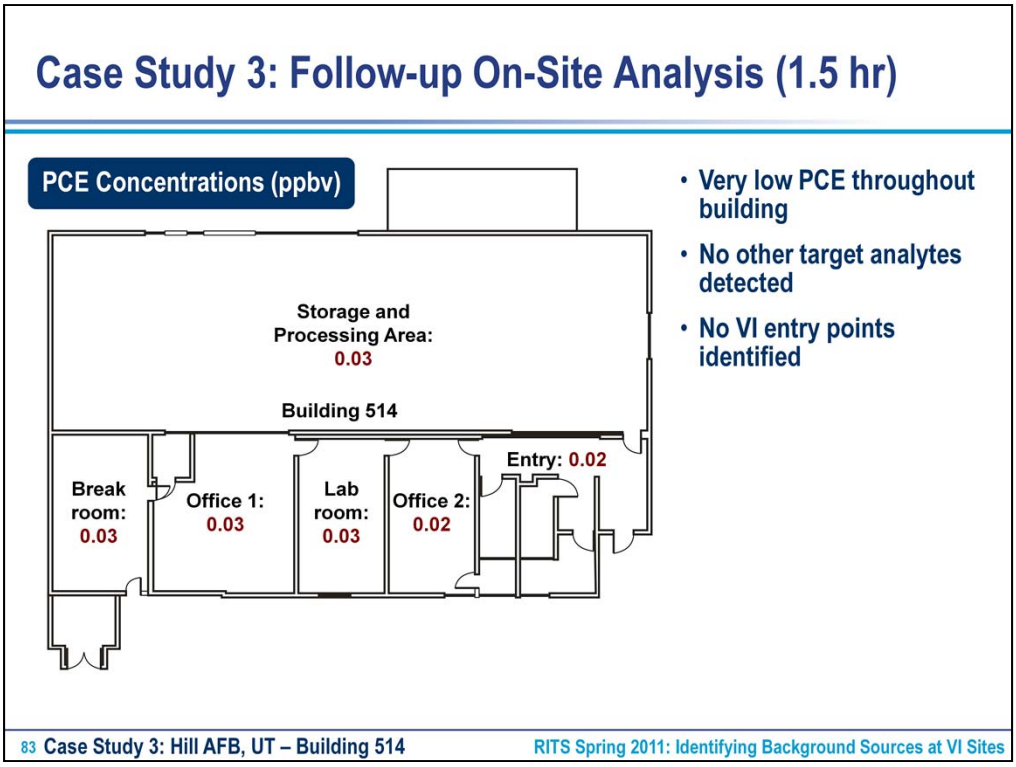
- Since there were two potential sources of PCE, building depressurization was used to turn "on" VI while unsealing the floor drain and keeping the waste container removed. This would maximize the potential for VI at the floor drain and other potential entry points.



- After removal of the waste container, with VI turned “on”, concentrations remained low and no VI entry points were identified.
- Conclusion, source of the initial screening results was the waste container.

Case Study 3: Hill AFB: Lessons Learned

Indoor Sources

- Real-time on-site analysis allowed for identification and removal of indoor source of PCE
- PCE concentration in indoor air decreased rapidly following source removal

Vapor Intrusion

- No evidence of vapor intrusion under baseline or depressurization conditions
- Floor drain in lab room had elevated radon and some PCE and 1,1,1-TCA, but no measurable effect on indoor air
- Two Summa samples collected at end of study confirmed accuracy of HAPSITE results

KEY POINT:

- On-site analyses allowed for definitive VI investigation in a single day

Presentation Overview

- Introduction
- Steps Leading to Background VI Evaluation
- Indoor Air Testing (Typical Program)
- Exploratory Data Analysis
  - Primary Lines of Evidence
  - Additional Lines of Evidence
- Forensic Methods and Multivariate Analyses
- Case Studies
- ► Summary

Take-Home Points

VI Background

- Building-Specific: Can vary by orders of magnitude depending on what is in the building
  - >> Can't compare measured concentration to "background" number
- Chemical-Specific: Big concern for some VOCs; less concern for others
  - >> Plan investigation approach based on site-specific COCs

Investigation Methods

- Best approach depends on: number of COCs, stakeholder concern, building design, building access issues, sub-slab access, site complexity (e.g., preferential pathways), cost of mitigation

KEY POINT: Approaches to VI background are rapidly evolving. Be innovative. Think outside the box.

COCs = Chemicals of Concern

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