Vapor Intrusion Assessment With Different Foundation Types

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Workshop 04 Part 2: US. EPA State of Vapor Intrusion Science

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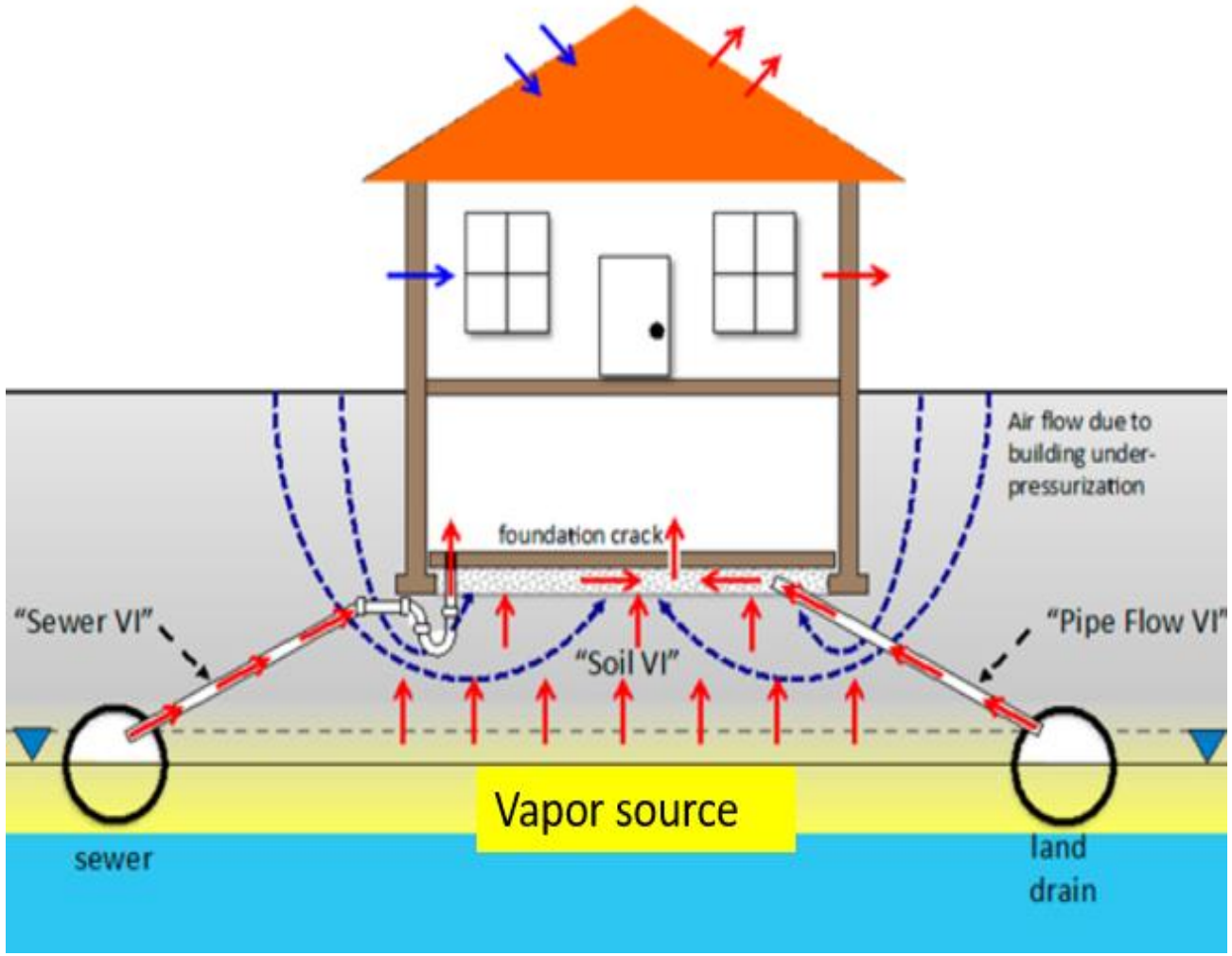
Outline

- Current understanding of VI conceptual site model (CSM)
- VI CSM in buildings with different foundations (garage and crawlspace)
- Case studies with current VI assessment practice for buildings overlying garage and crawlspace
- Summary

Current understanding of VI CSM

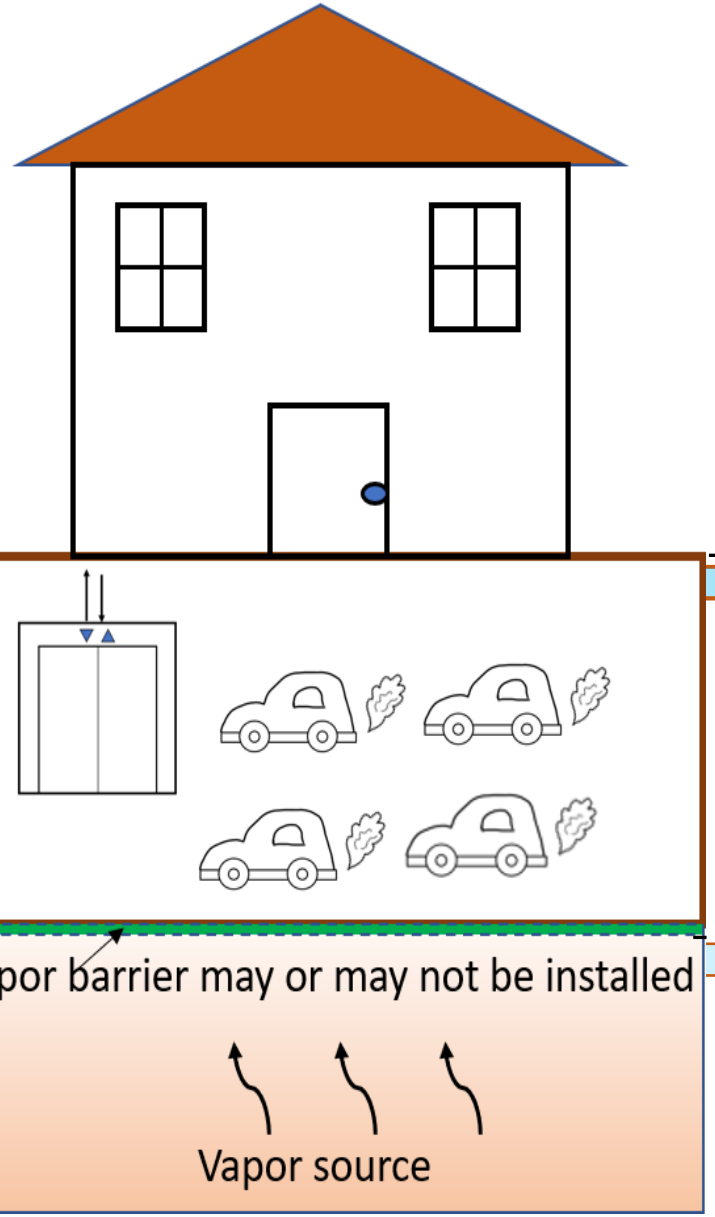


Adapted from Guo et al (ES&T 2015)

- Most current understanding of VI CSM for building with a concrete foundation (slab-on-grade or basement)
- Most comprehensive VMPs shown:
  - Conventional soil vapor intrusion
  - Sewer VI
  - Pipe flow VI
- Sewer VI and pipe flow VI are rare for PVI due to fast/easy biodegradation

VMP – Vapor migration pathway

VI CSM for Buildings Overlying a Garage



F&T of VOCs

VOCs from outdoor air

Air Exchange

Added VOC from IA sources

Garage air migration?

Added VOC source from garage exhaust

Air exchange required per building code

Reduced VOC

Diffusion and/or biodegradation of SG VOC

Vapor Source

Expected VOC conc.

IA

IA/OA/Garage air mixing zone

GA

Garage air mixing zone

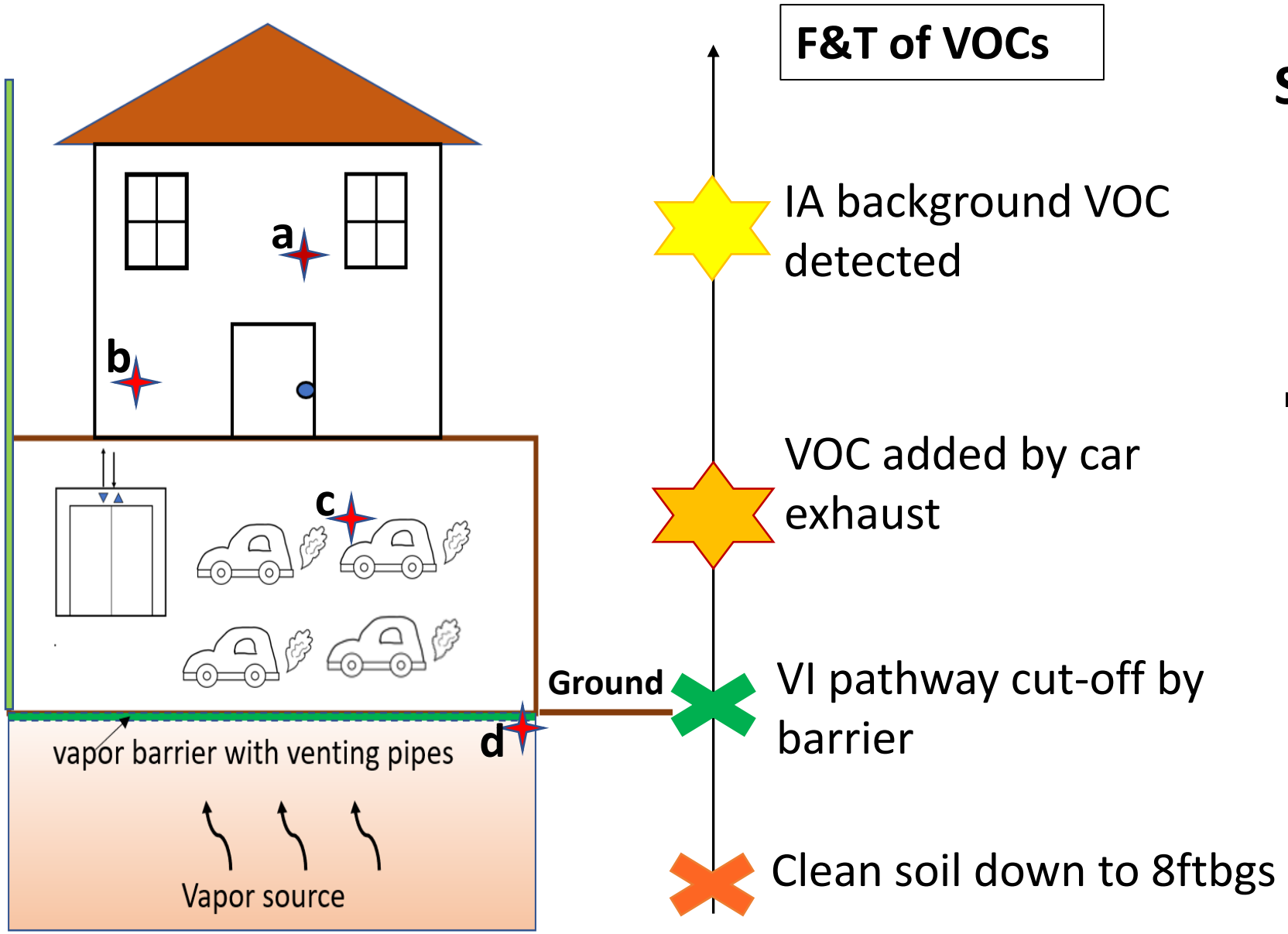
Potential VI occurs here

SG

SG zone

F&T –fate and transport
GA – Garage air SG – Soil gas

Case Study –Site Current Sampling Strategy

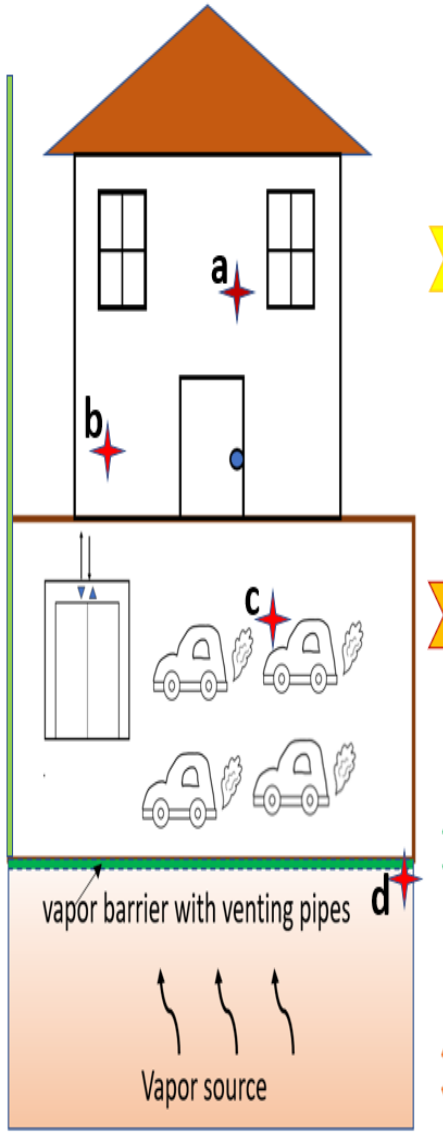


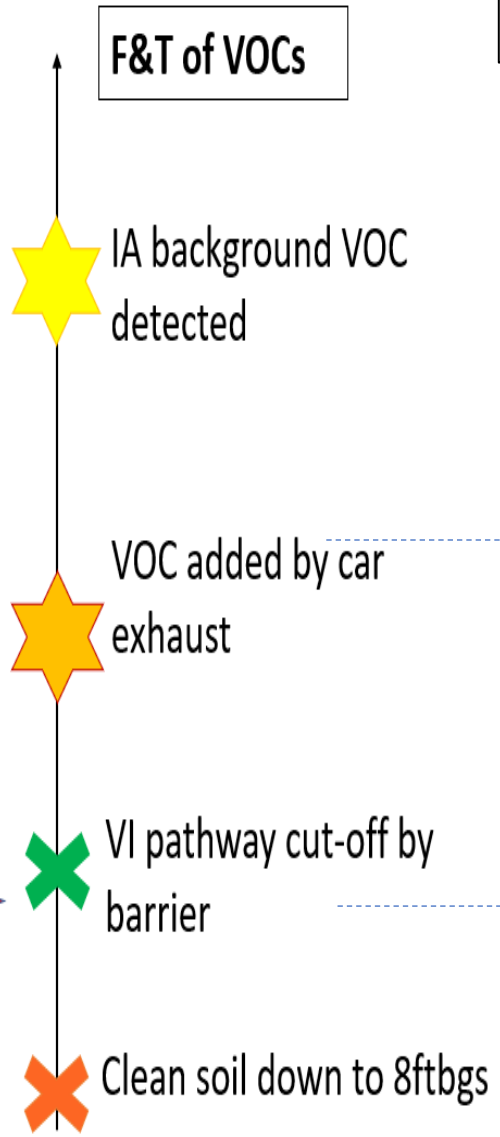
Site conditions:

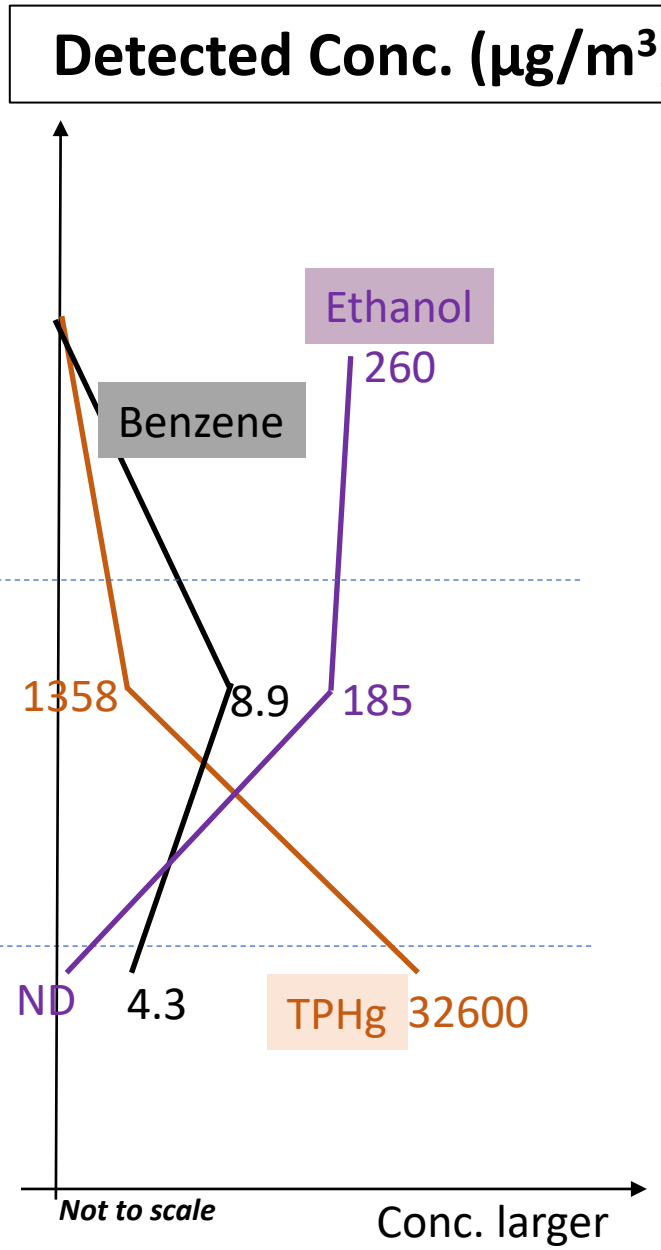
- Old gas station and soil excavated and backfilled with clean soil down to 8ftbgs
- Barrier with venting system installed
- Multi-story condos overlying the garage
- Air phase samples collected at a, b, c, d

F&T –fate and transport

Case Study –Site Data







$$\frac{\text{Emission rate from car exhaust*}}{\text{Emission rate from sub-barrier}^{\#}} = 5\text{x}10^{6}$$

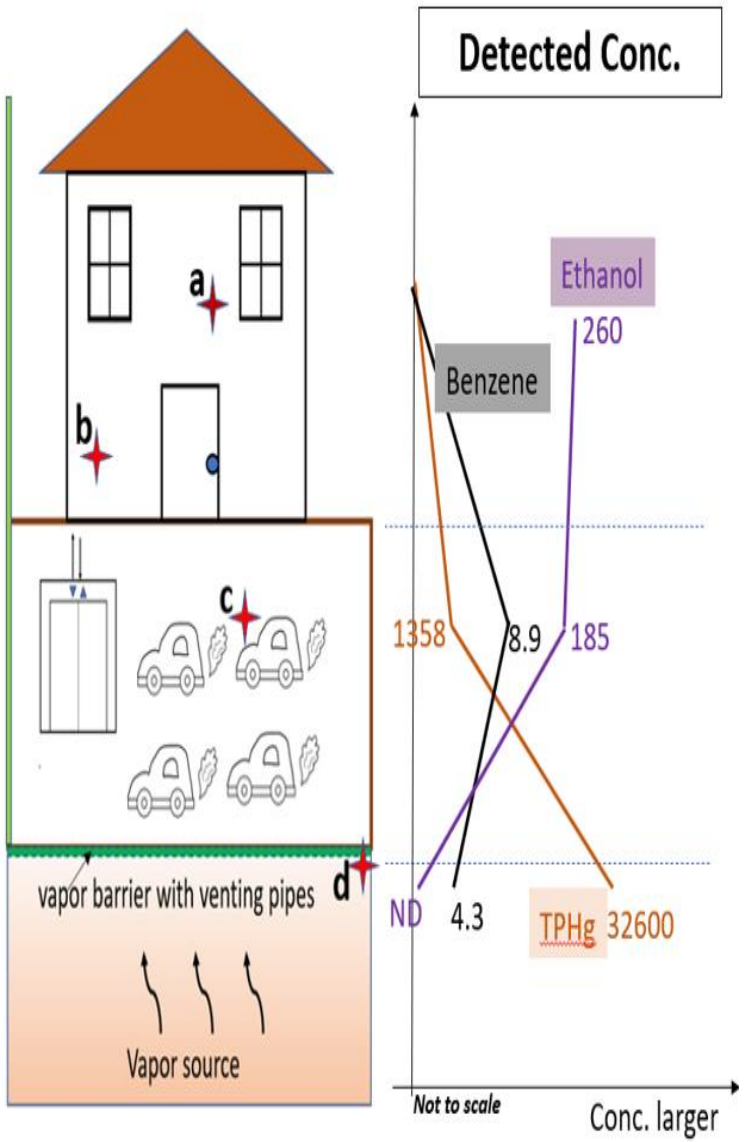
Garage air quality is determined by car exhaust

Inputs to the calculations:

** BZ emission rate from Lisa et al (2012) and Environmental Canada ERMD #99-26768-1; assumed 20 cars using a 5000 sqft -garage*

 # Calculations based on common vapor barrier benzene Deff ~1E-15 m^2/s; gas entry rate of 5 L/min

Case Study – Questions Encountered



Q1: Should we sample based on the understanding of site-specific VI CSM?

A: No.

Car exhaust determines the garage air quality. Sites with this type of building foundation may be excluded from VI investigations unless there is a reason to believe VOC emission rate from subsurface dominants.

Q2: How to interpret the data with essentially the same suite of chemicals from garage and possibly IA source?

A: It is difficult in general.

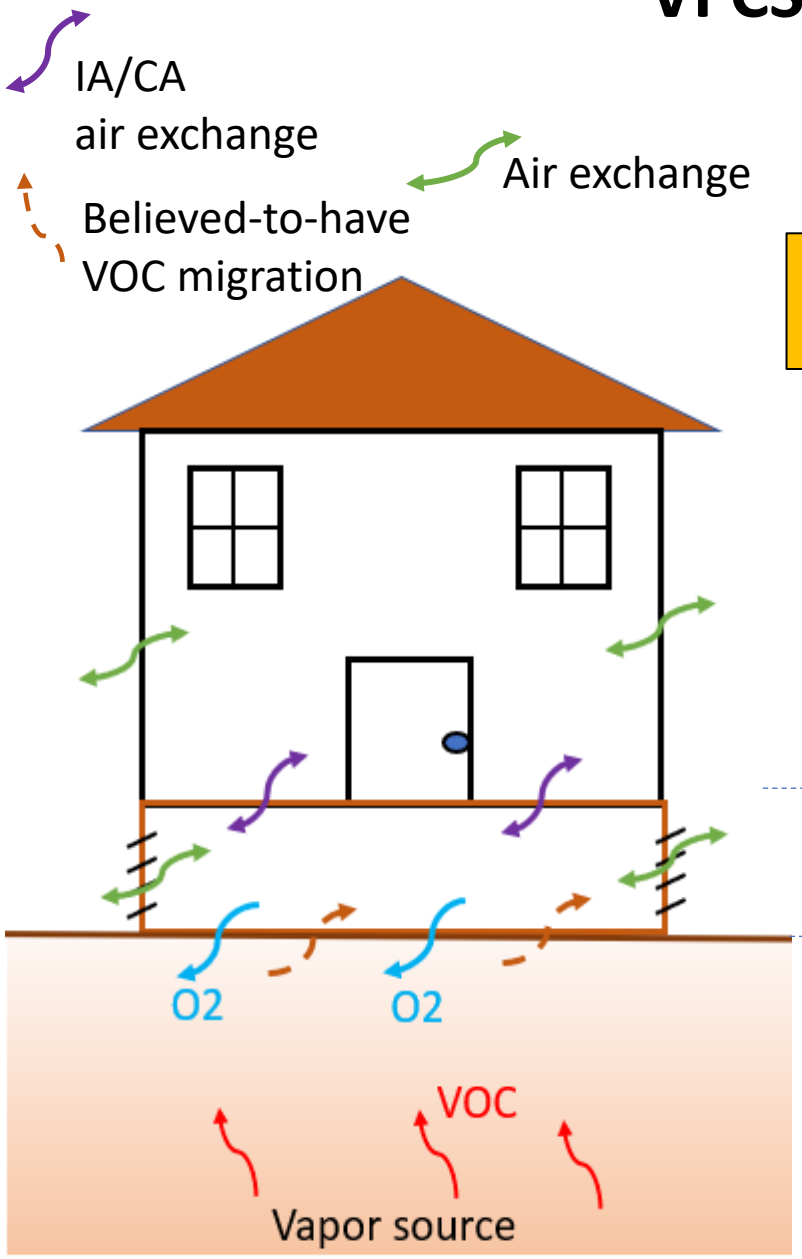
There are only limited tools with limited effectiveness to help.

Q3: Is there a need to do seasonal IA sampling?

A: No in this scenario.

1) if potential VI is not an issue, there is no seasonal change issue;
2) IA seasonality is more likely due to its own building use and changes in GA ventilation not soil vapor concentration changes; repeated IA is not necessary for VI evaluation.

VI CSM for Buildings with Crawlspace



Fate of VOCs

VOCs added from OA sources

IA/OA air exchange

VOC added from IA sources

Mixing IA/CA

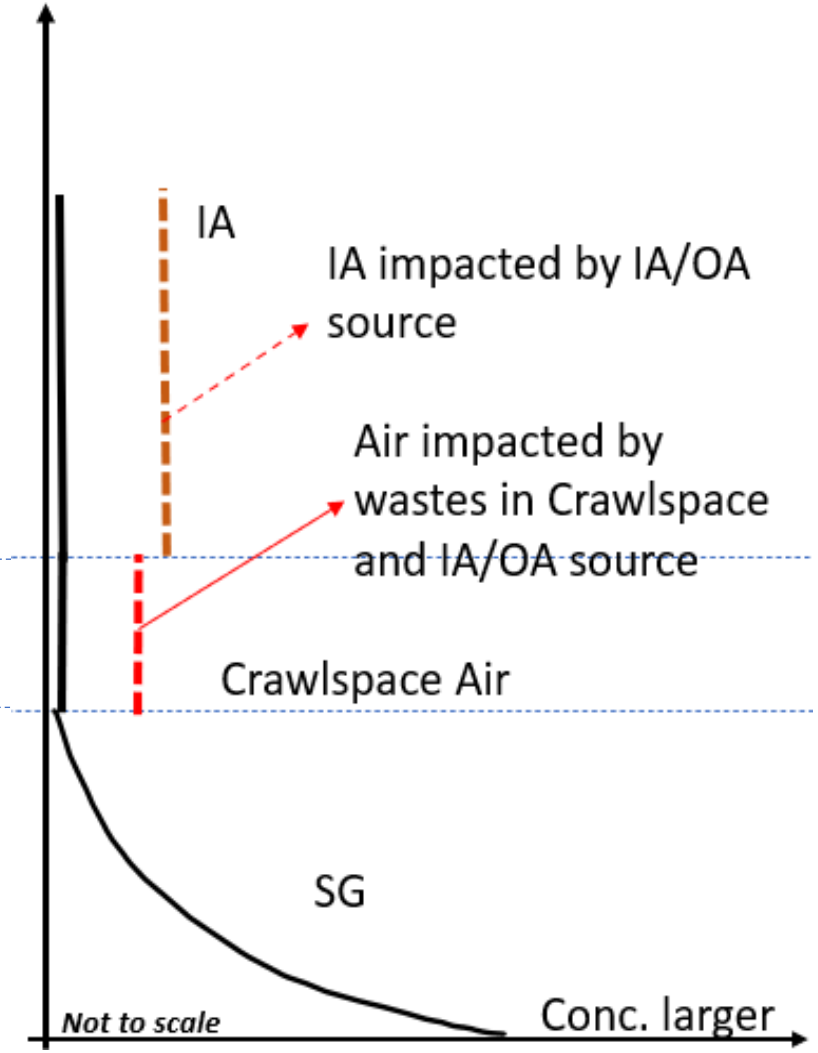
CA/OA mixing

VOC reduced significantly

VOC in SG diffusion and biodegradation

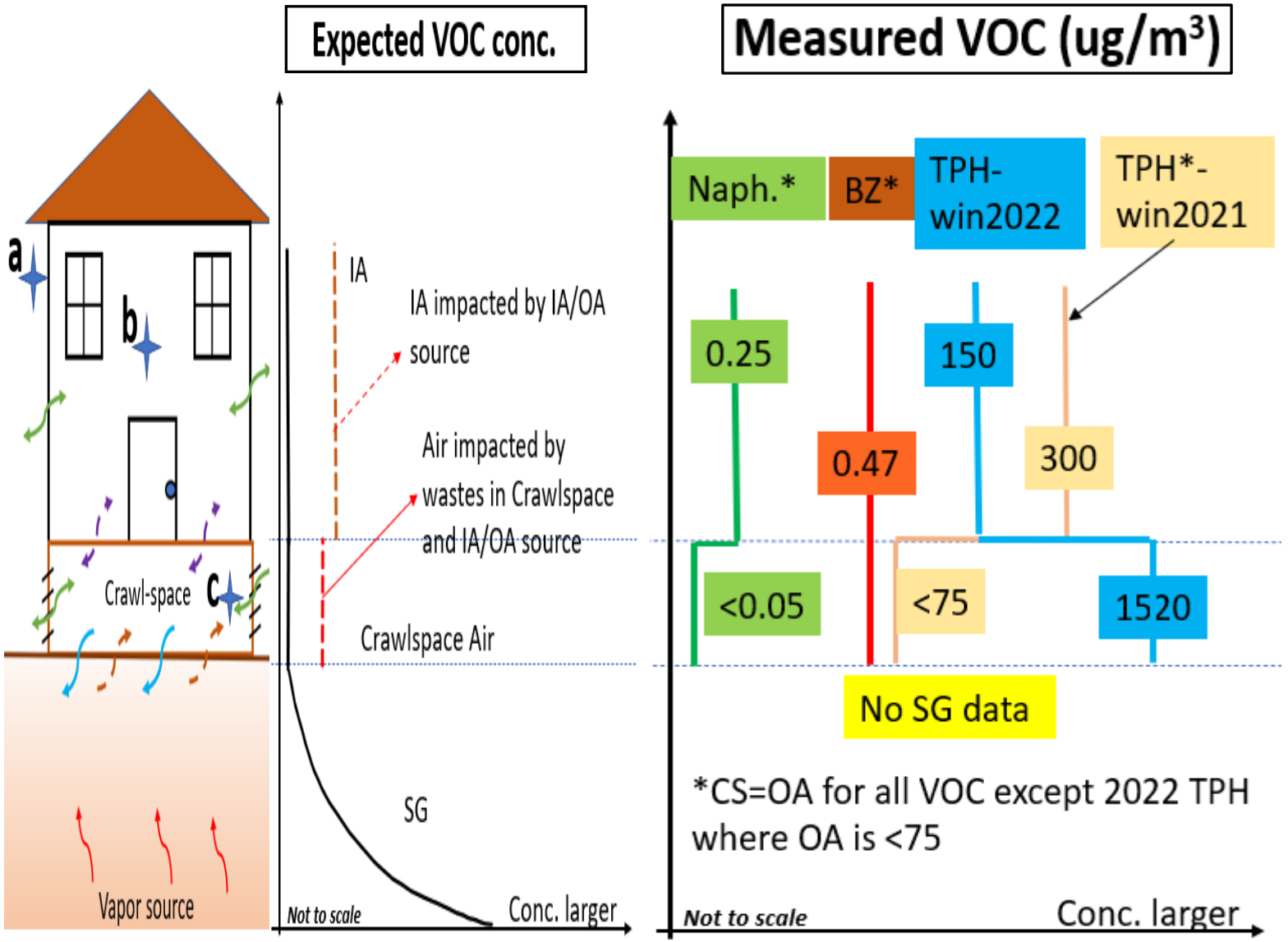
Vapor Source

Expected VOC conc.



CA– Crawlspace air

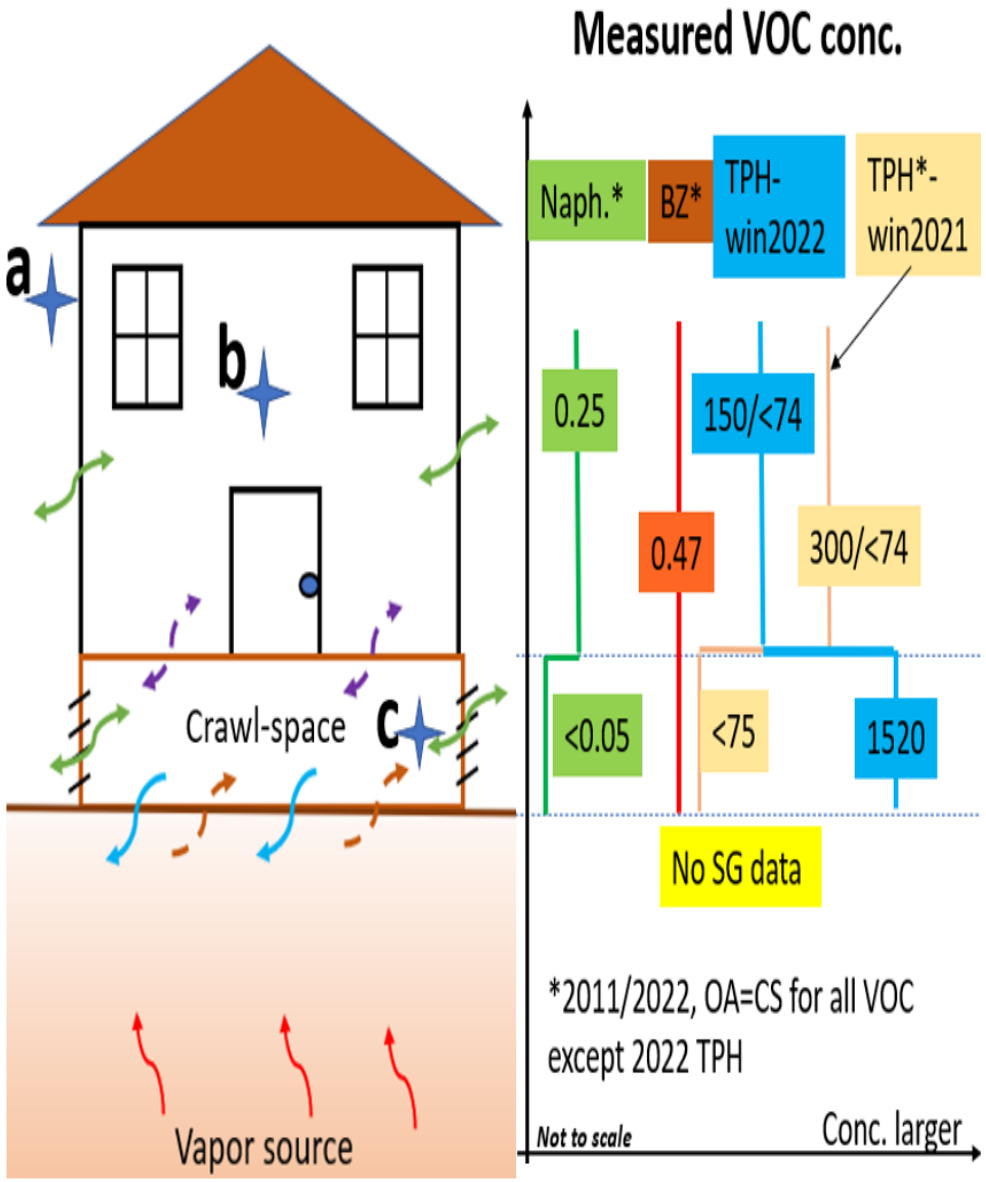
Case Study -Current Sampling Strategy and Data Interpretation



Key observations

- Similar OA/CS conc. indicating a good mixing of CS and OA
- Similar OA/IA/CS for all other VOCs except TPH and Naph.
  What caused the TPH change in 2022?
- **Obvious IA sources(smoking)** influencing Naph. and TPH. What if there were only OA and CS conc. measured?
- No VI here. What other tools to use to help?

Case Study – Questions Encountered



Q1: Should we sample based on the VI CSM?

A: Depends on site-specific CSM.

Crawlspace ventilation strategy (per building codes), and bio-barrier in oxygenated shallow soil for PHCs are key considerations.

Q2: How to interpret IA/CS/OA data sets esp. for PVI sites where IA source is ubiquitous?

A: **Difficult in general** when conc. are similar and IA screening values are extremely low. Heavily rely on professional judgements. Conc. ratios? Indicators? Building-specific AF?

Q3: Where should we sample if required?

A: 1. Is sampling really necessary based on site CSM?

2. If samples are taken (such as IA/OA/CS), how much confidence we have in correct data interpretation?

Federal and State Guidelines

Building Design Tech Sheet

Building Design for Passive Vapor Intrusion (VI) Mitigation

Vented Garages and Raised Foundations

Effective passive VI mitigation can sometimes be accomplished through building design. Building design for passive VI mitigation includes the construction of vented parking garages or raised foundations between a subsurface source of vapors and an occupied space intended for living or working. Building design for VI mitigation does not include barriers (e.g., asphalt latex membrane, composite membranes, thermoplastic liners) or venting (e.g., aerated floors, sub-slab venting). This ITRC technology sheet provides basic information about relying upon building design for passive mitigation of VI and discusses advantages, limitations, and associated cost considerations of building design to mitigate VI risks. This Technology Sheet also describes the basic components of building design for the purpose of VI mitigation, design considerations, and verification of ventilation when constructing buildings designed to mitigate potential VI risks.

Figure 1. Schematic of a vented garage. *(Source: J. Kasunic, used with permission.)*

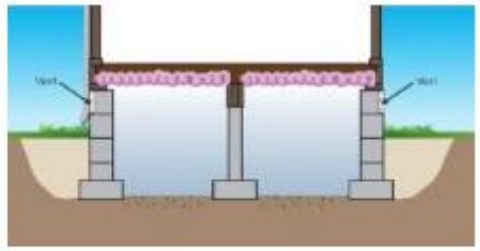


Figure 3. Schematic of a building with a crawlspace. *(Source: J. Kasunic, used with permission.)*

California Water Boards

Vapor Intrusion Mitigation Guidance

Technical Resource Document

San Francisco Bay
Regional Water Quality Control Board

2C.2 New Buildings

Two common building designs expected to be less susceptible to VI, as compared to slab-on-grade buildings, include raised foundation buildings and enclosed ventilated parking garages.

2C.2.a Open Air Ground Floor Buildings

Open air ground floor buildings (e.g., open-air garages, podium-style construction, buildings raised floor without an enclosed space) typically are well-ventilated enough to break the exposure pathway to upper floors. This is due to height of the open-air ground floor (e.g., 11 feet), which allows for free air movement that can dilute and break the VI pathway. However, potential vapor conduits (e.g., elevators, stairwells, and utilities) should be evaluated as a potential migration pathway for subsurface vapors at all raised foundation buildings. Placing or routing these features away from areas of subsurface contamination is recommended (DTSC 2011b). Crawl space buildings are not

https://vim-1.itrcweb.org/building-design-tech-sheet/

https://www.waterboards.ca.gov/rwqcb2/water_issues/programs/sitecleanup/2022_VIM_Guidance.pdf

Summary

- In general, site CSM + building VI CSM both are important to
  - ✓ Determine if sampling at specific buildings based on these VI CSM is warranted
  - ✓ Enable a good sample strategy (what/where to sample)
  - ✓ Help with data interpretation
- Correct understanding of VI CSM for building overlying garage and crawlspace is necessary to
  - ✓ Avoid unnecessary sampling
  - ✓ Be prepared for difficult data interpretation challenges
- Very challenging data interpretation with more doubts than clarity
  - ✓ Limited data analysis tools to deal with extremely low IA screening criteria and common IA/OA sources
  - ✓ Heavily relying on professional judgement
  - ✓ Unnecessary site investigation, esp. for crawlspace

Thank you!

Questions?