VAPOR INTRUSION SITE CHARACTERIZATION AND SAMPLING APPROACHES

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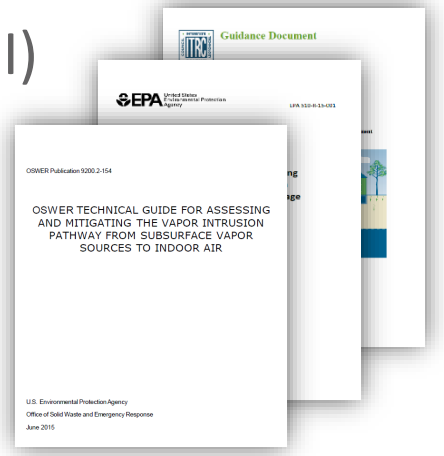
Agenda

- Introduction
- Conceptual Site Model
- Case Studies
- Wrap Up

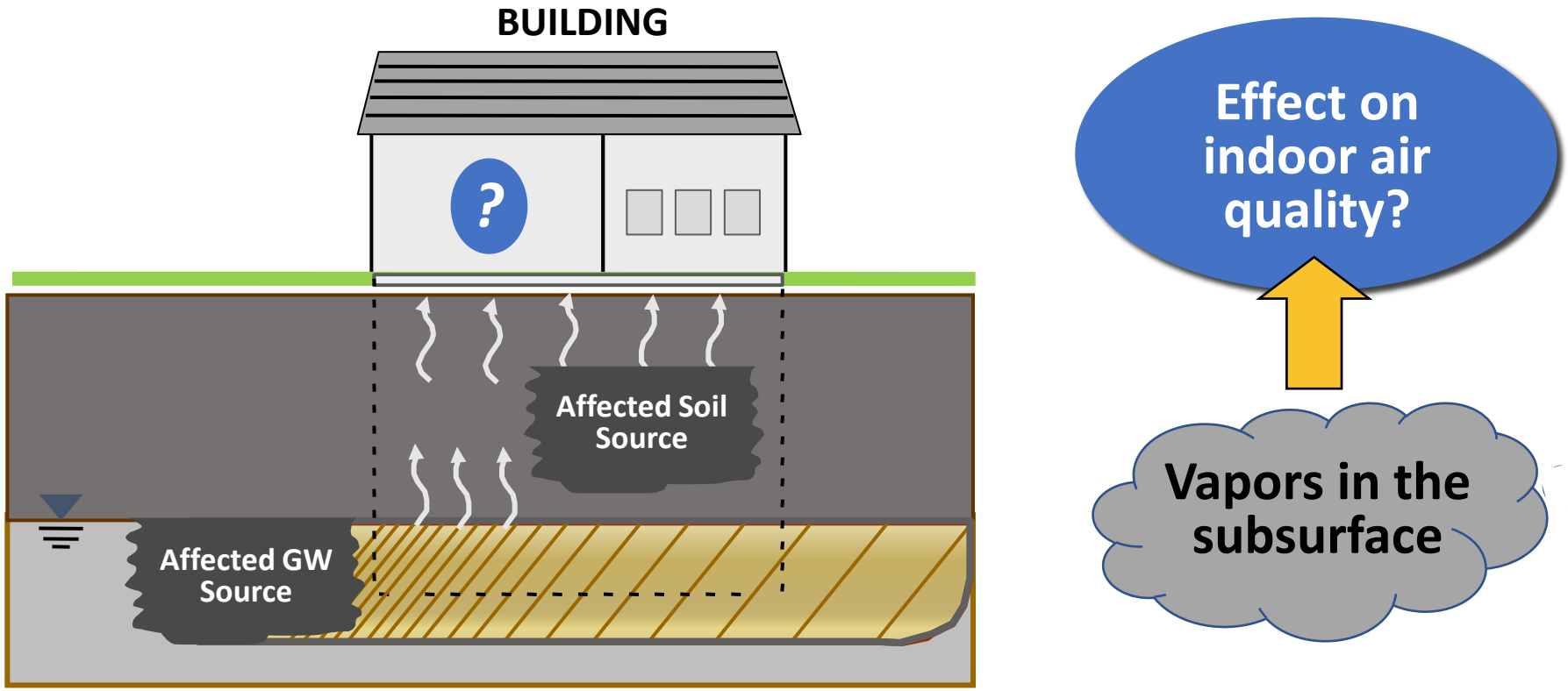
A Brief History of (Chemical) Vapor Intrusion

- 1980s Radon intrusion
- 1990s More focus on VOC vapor intrusion, Johnson and Ettinger Model
- 2000s More studies (e.g., Redfield, CO), guidance – Federal (draft), ITRC, States
- 2008-2013 ASTM E2600 (Vapor Encroachment) & ASTM E1527 (Phase I)
- 2011-2014 Petroleum vs. non-petroleum VI
- 2015 USEPA finalizes VI guidance
- 2015 More changes, principally recognition of sewer/conduit preferential pathways



KEY POINT Regulations, guidance, and the science have been evolving, with many recent changes.

Basic Vapor Intrusion Conceptual Model



DEFINITION Vapor intrusion is the vapor-phase migration of volatile organic compounds (VOCs) from the subsurface into indoor air.

Motivations

REGULATORY DRIVERS
(chemical releases)

- State requirements
- USEPA guidance
- HRS & CERCLA 5-year reviews

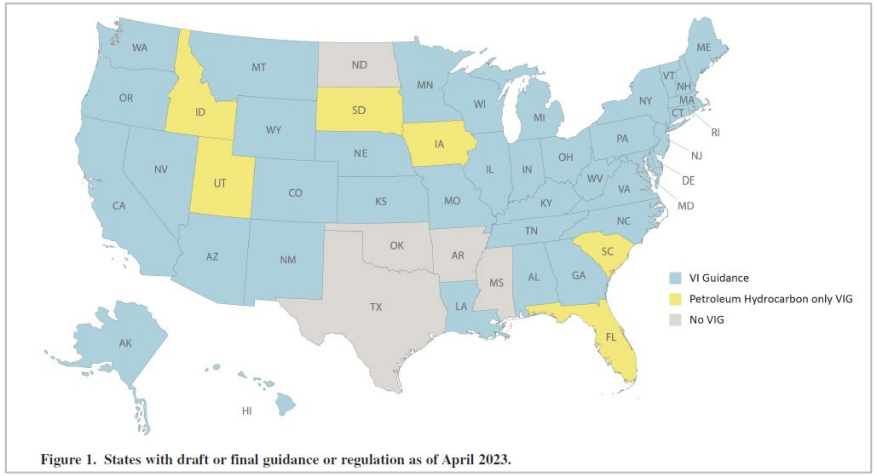
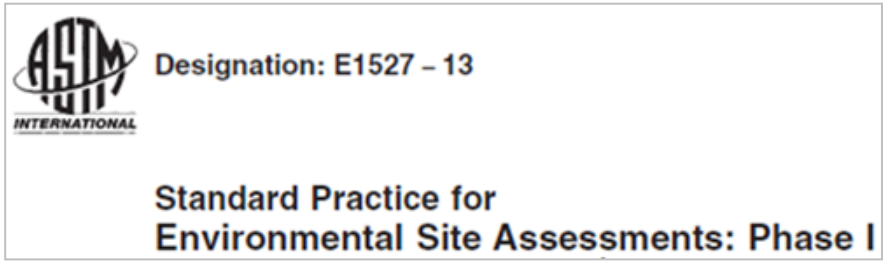


Figure 1. States with draft or final guidance or regulation as of April 2023.

Eklund, Regan, Rago, Beckley, 2024. Overview of state approaches to VI

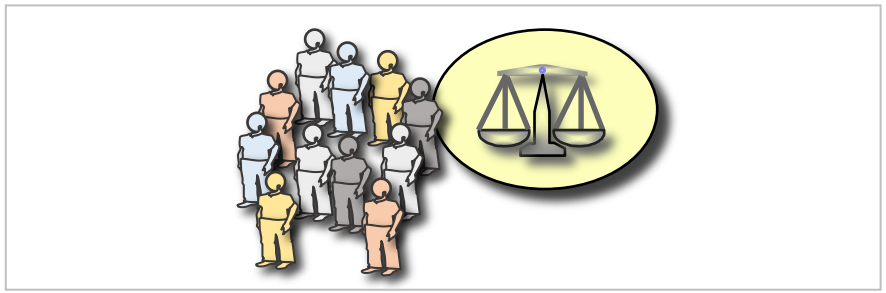
BUSINESS DRIVERS

- Due Diligence
- ASTM Phase I Standard



OTHER

- Community Concerns
- Litigation



KEY POINT Vapor intrusion concerns can come up from many different perspectives.

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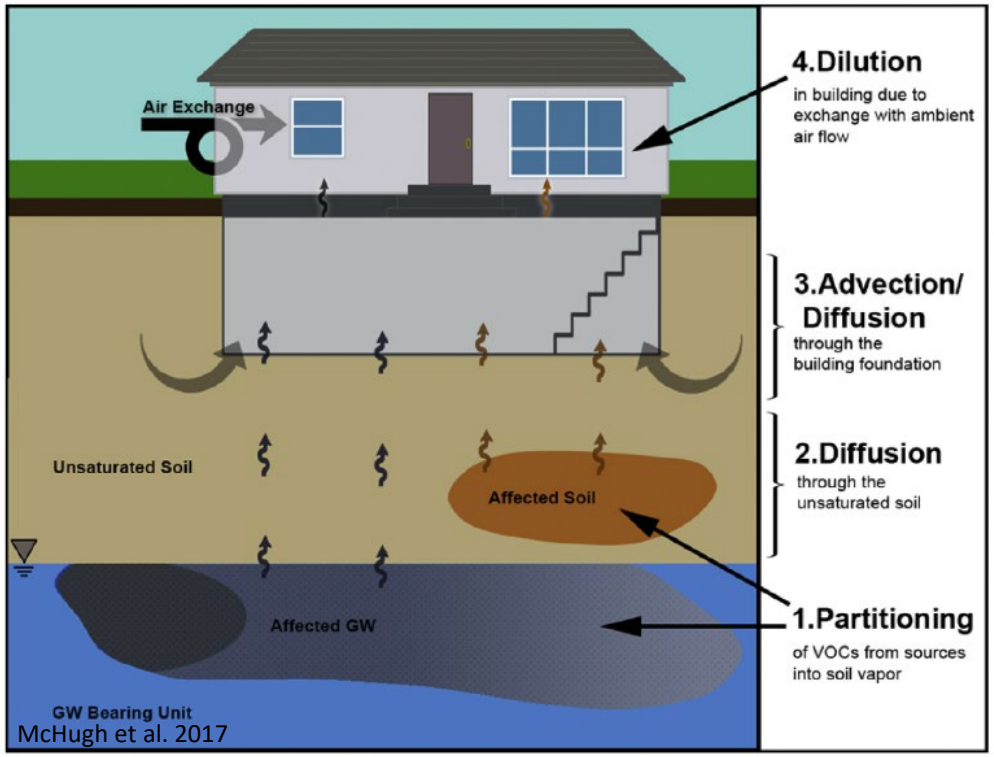
Evaluation Approaches based on Basic CSM

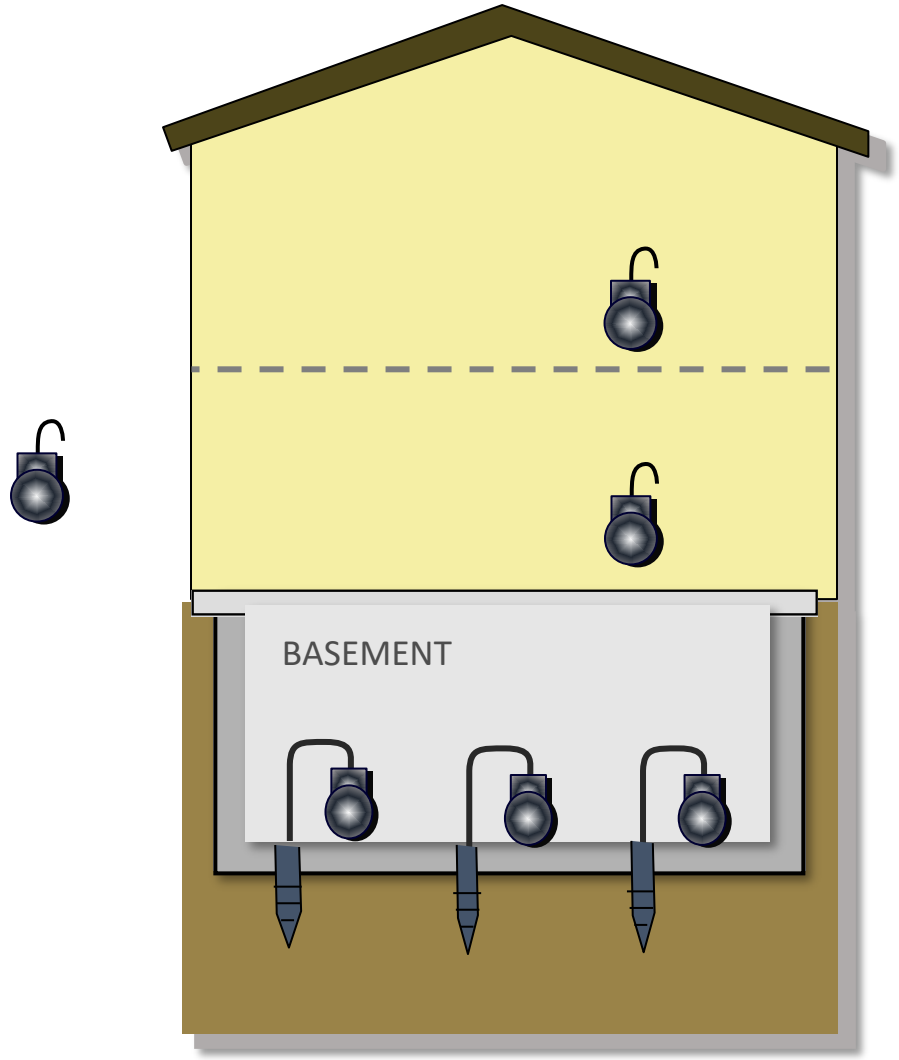
- **Groundwater Screening Level** – are concentrations in groundwater high enough to cause a VI concern?
- **Soil Gas Sampling** – are concentrations in soil gas high enough to cause a VI concern?
- **Building-specific Sampling**



McHugh et al. 2017

KEY POINT Testing occurs along different points in the VI pathway.

Typical Building-specific Testing Approaches

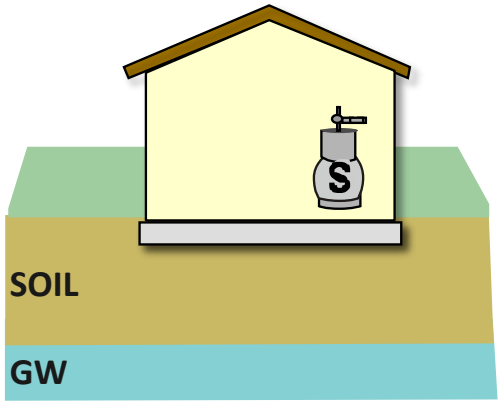


Summa Canister Testing

Sub-Foundation Vapor Probes

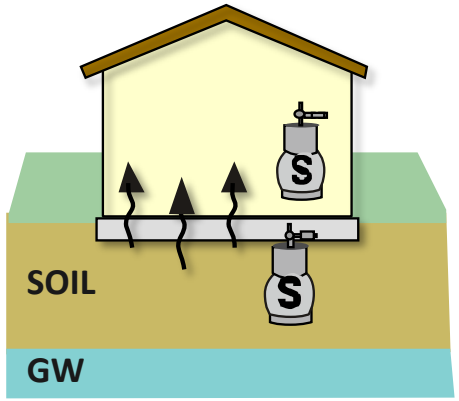
Indoor Air Investigation: Multiple Lines of Evidence

Indoor Air Screening



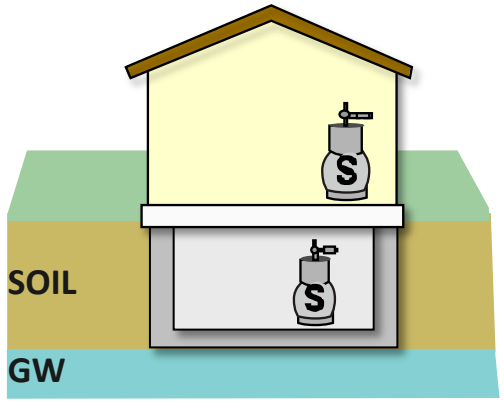
Higher than normal levels?

Sub-Foundation Vapors



High enough to cause impact?

Indoor Spatial Distribution



Pattern suggests vapor intrusion?

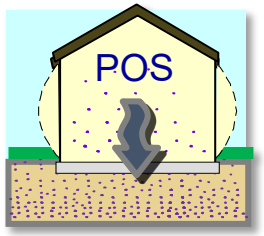
Indoor Sources

Sources of vapors in house?

KEY POINT Patterns can be difficult to interpret using standard data collection methods.

“Advanced” Testing Approaches

GENERAL APPROACH	EXAMPLE METHODS
Lab Analysis / Chemical Fingerprinting	■ **Concentration Ratios** ■ **Compound-specific Isotope Analysis (specialty lab)** ■ **Extended TO-15 Analysis for Petroleum (specialty lab)**
On-Site Analysis	■ **Grab sampling for rapid source identification** ■ **Automated, high-frequency monitoring to document temporal variability**
Building Pressure Cycling	■ **Turn VI on or off to address temporal variability in sampling**



See Ma et al 2020 for more information on these and other advanced methods.

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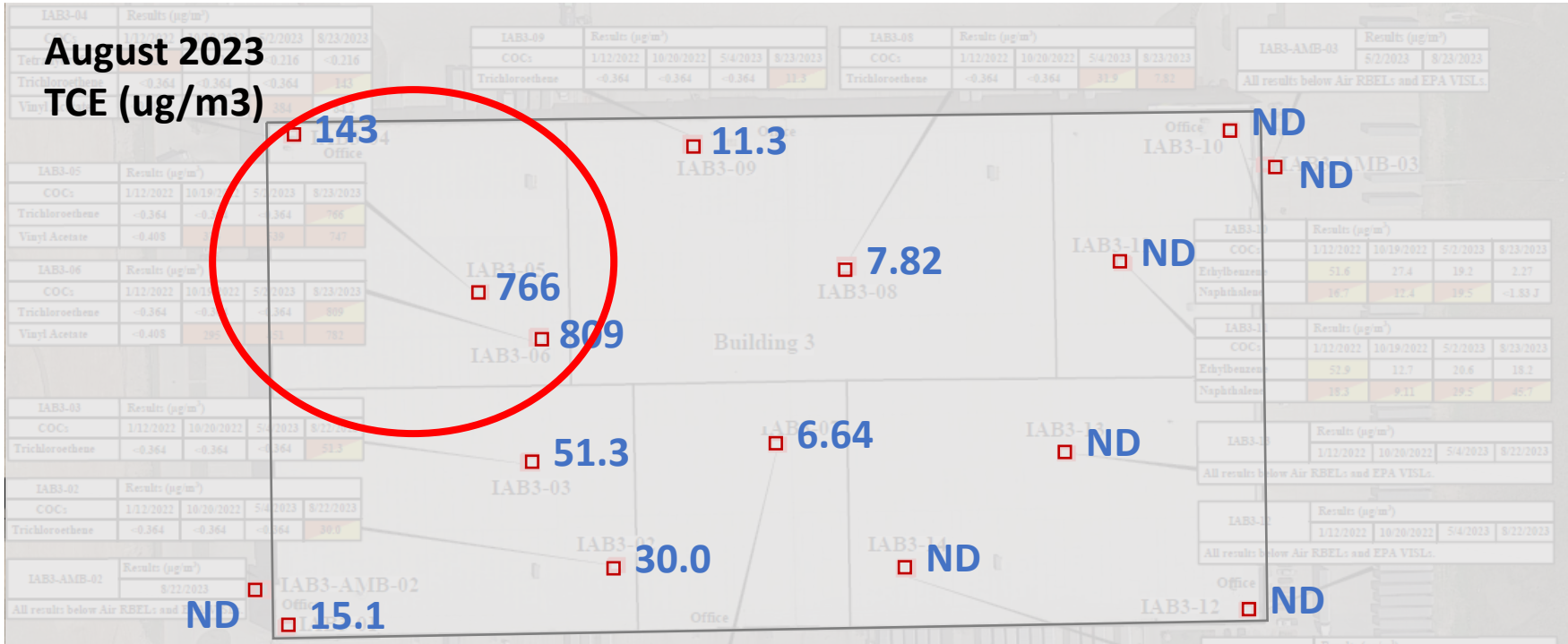
Case Study 1:
Brownfields Redevelopment Site

The Problem:

High TCE concentration in indoor air

- **Standard investigation approach (IA sampling in Summa canisters)**
- **Jan 2022-May 2023**: Generally low/ND results
- **Aug 2023**: TCE, with highest conc in suite on NW side of building

- **Is it VI?**



Methods:

Source Investigation using AROMA-VOC

- **On-site analysis done rather than repeating traditional testing approach**
- **Possible Sources:** Subsurface COCs? Adhesives, other products?
  Site personnel reported no products known to contain TCE, based on SDS

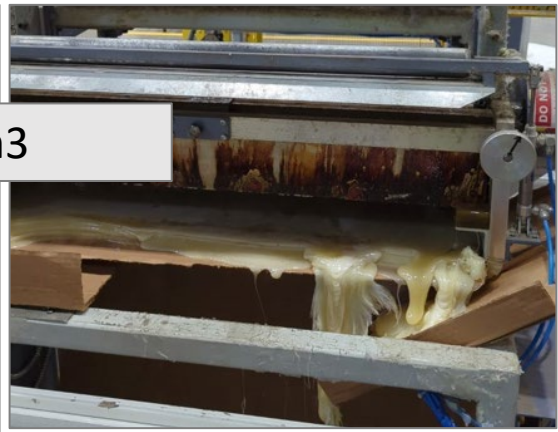
1) Is it subsurface (vapor intrusion)?

   Finding – concentrations at cracks, plumbing comparable to bulk indoor air

2) Is it the adhesives?

   Finding – Adhesives are not the TCE source

Adhesives: TCE 290 - 520 ug/m3



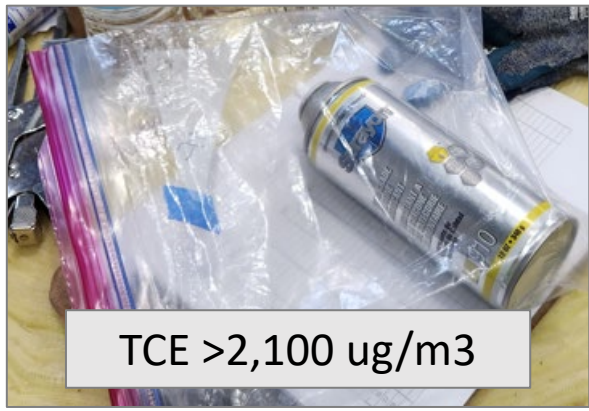
More Observations:

- **Steady TCE conc decrease** in bulk air over 3 days
- **Higher conc locally**

Near equipment, flammables cabinet 470 - 710

Source Found!

- Food Grade Silicone Lubricant
  - Headspace > 2,100 µg/m^3
  - TCE on label
- Per plant manager, they use a lot of LU 910 on Mondays
  - Consistent with change in observed bulk air concentrations over sampling period
- Per plant manager, changed vendors in June
  - Inadvertant change in products?
  - Timing consistent with appearance of TCE in indoor air



LU 210 vs. LU 910: *Not Vapor Intrusion!*

LU 210

GRAINGER
FOR THE ONES WHO GET IT DONE

Close this window

Common Name: LU 210 FOOD GRADE SILICONE LUBRICANT AER
Manufacturer: SPRAYON PRODUCTS
SDS Revision Date: 3/13/2015
SDS Format: GHS-US

SECTION 3. COMPOSITION/INFORMATION ON IN

SUBSTANCE/MIXTURE: MIXTURE

OTHER MEANS OF IDENTIFICATION: NOT AVAILABLE.

CAS NUMBER/OTHER IDENTIFIERS:

INGREDIENT NAME	% BY WEIGHT
HEXANE	42.0
2-METHYLPENTANE	19.4
PROPANE	15.0

Photo from eBay

LU 910

SAFETY DATA SHEET

SC0910000

Section 1. Identification

Product name	:	LU™910 Food Grade Silicone Lubricant Aerosol
Product code	:	SC0910000
Other means of identification	:	Not available.
Product type	:	Aerosol.

Relevant identified uses of the substance or mixture and uses advised against

Paint or paint related material.

Section 3. Composition/information on ingredients

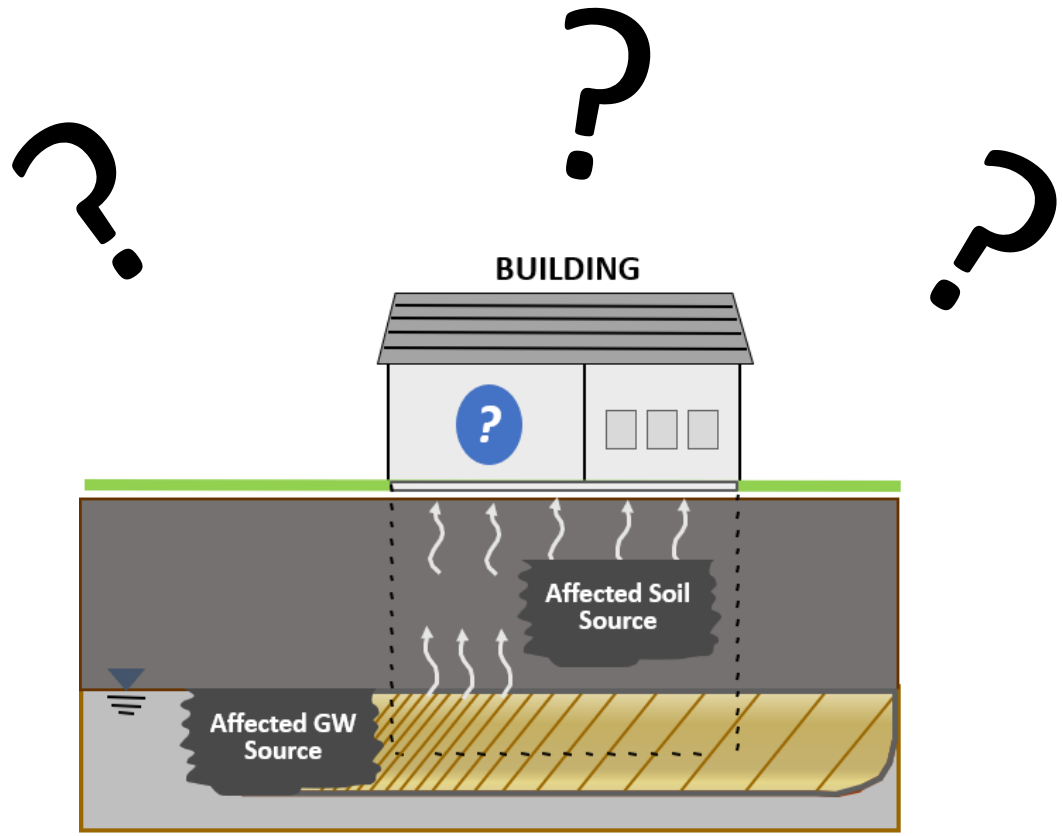
Substance/mixture	:	Mixture
Other means of identification	:	Not available.

CAS number/other identifiers

Ingredient name	% by we
Trichloroethylene	≥25 - ≤50
Propane	≥25 - ≤50
Butane	≥10 - ≤25

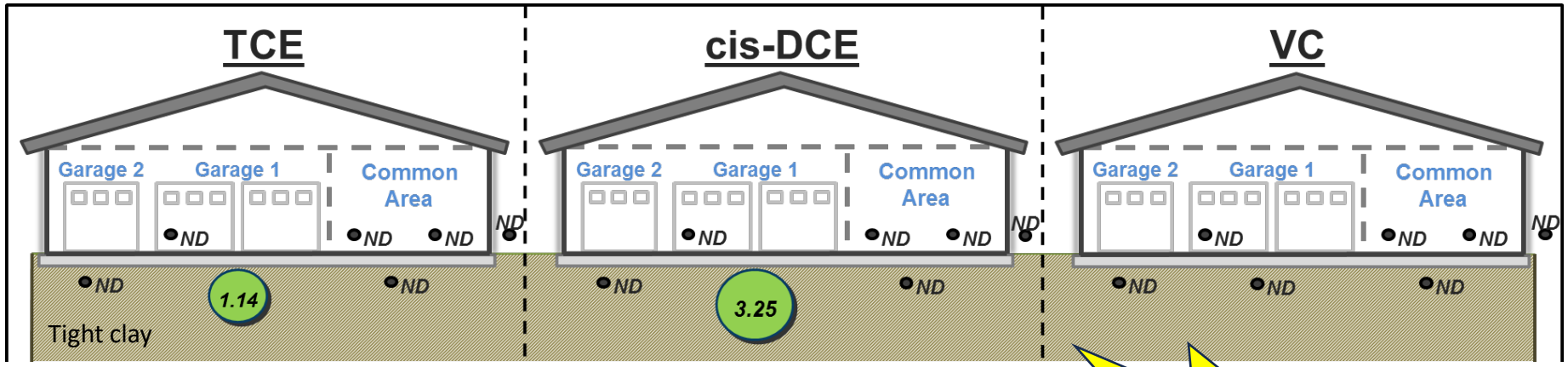
Any concentration shown as a range is to protect confidentiality or is due to batch variatic

Case Study 2:
How are vapors getting into indoor air?

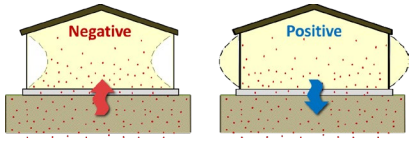


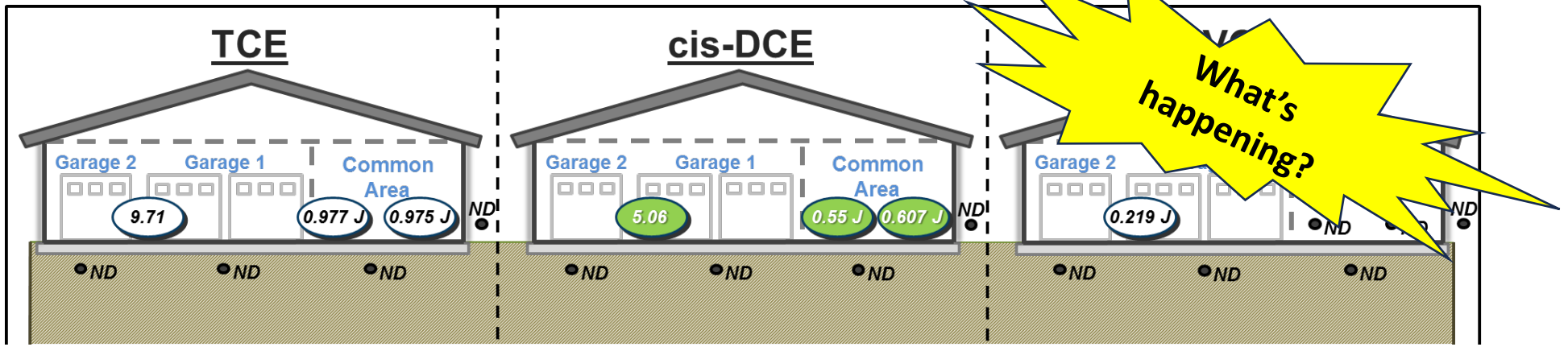
Building within 100 feet of TCE Plume

Round 1
Conventional Sampling Approach



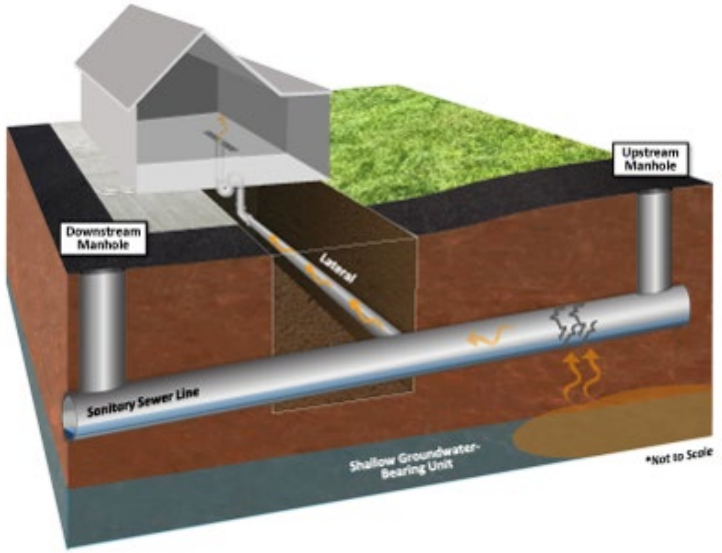
Round 2
Testing under Depressurized Conditions





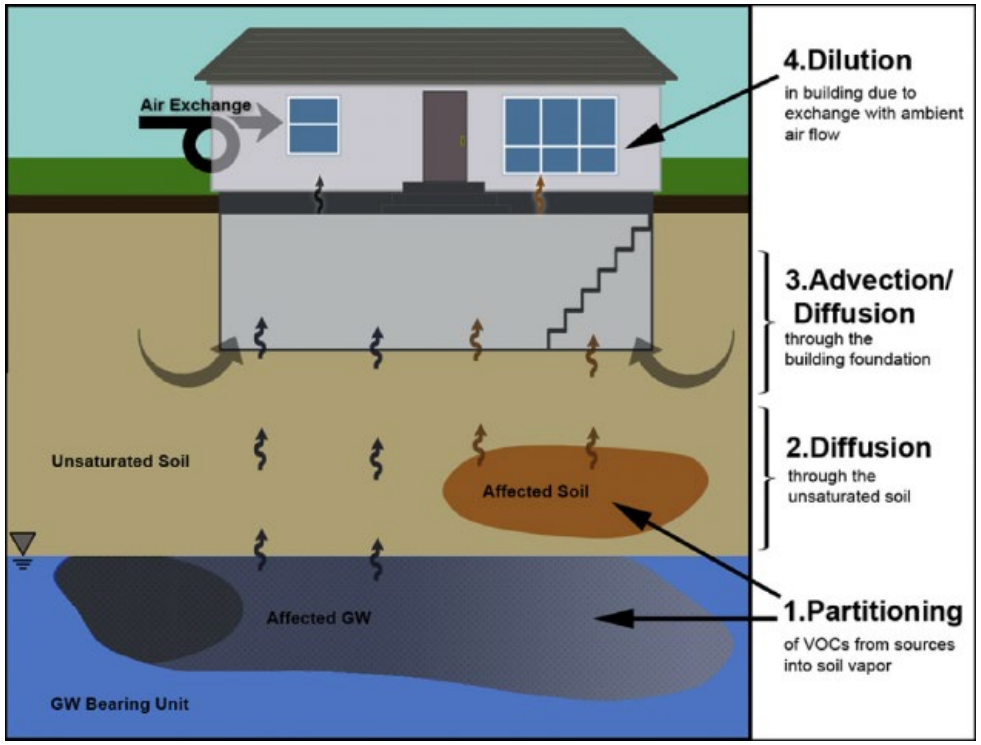
Building within 100 feet of TCE Plume

- Data do not support “conventional” VI; rather: indoor source or conduit pathway
- Hypothesis tested using on-site analysis
  - Conduit pathway more likely
  - Sewer vapor concentrations in nearby manhole: TCE & cis-DCE > 100 ug/m3
- Updated conceptual model: intermittent VI resulting from conduit pathway
- Mitigation solution: sewer and manhole lining

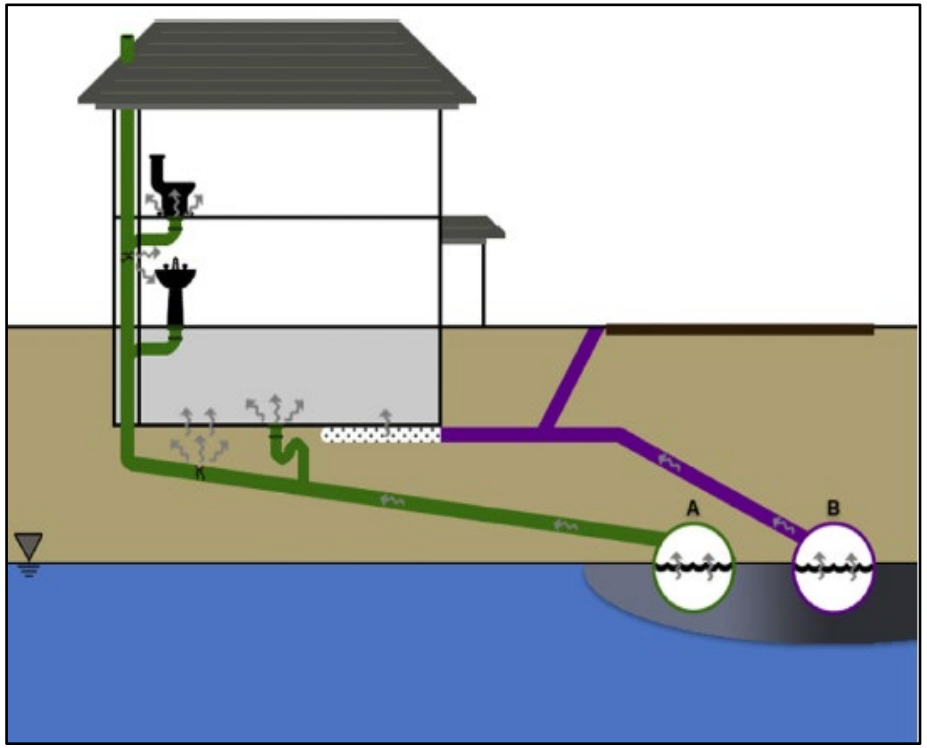


Evolving Science

Conventional Model

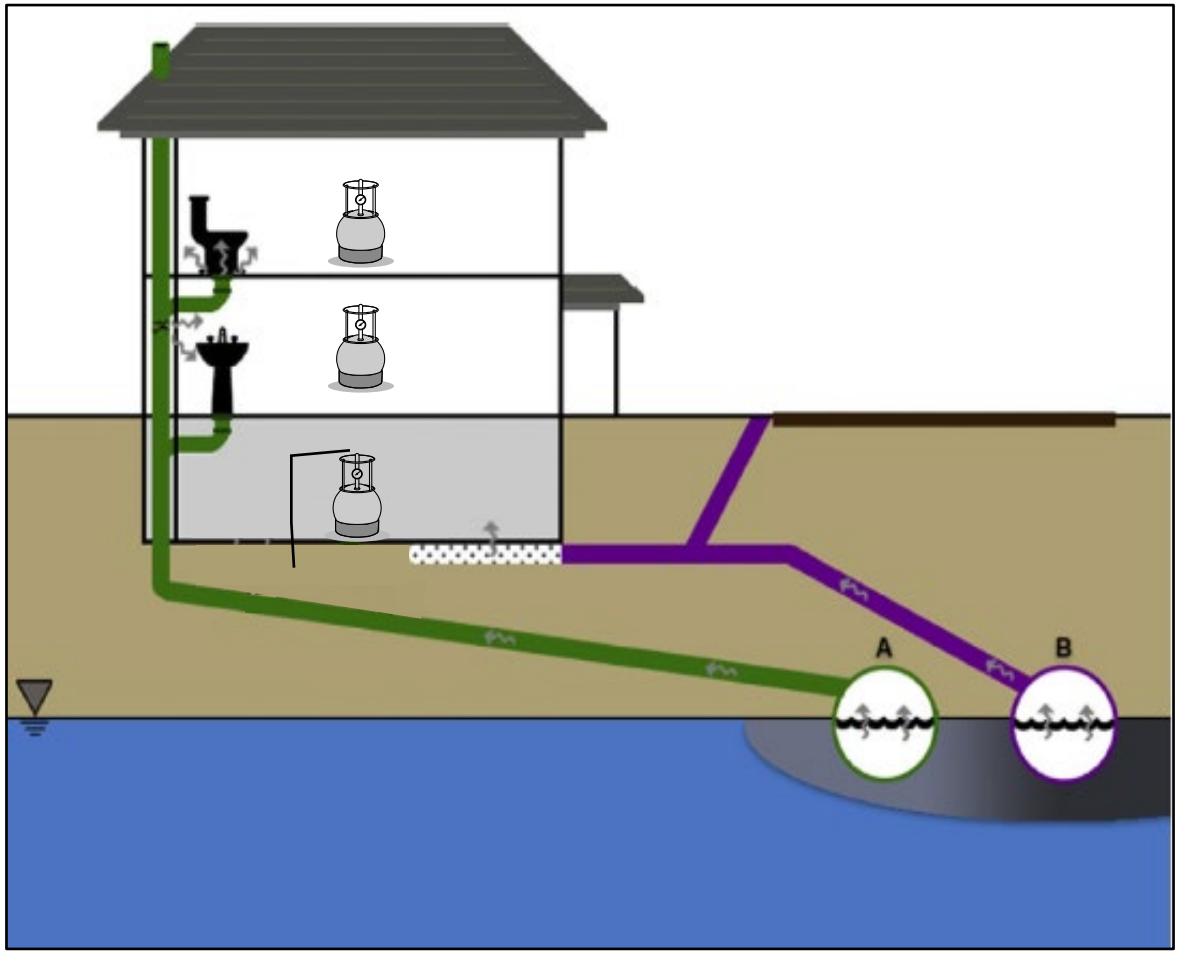


Through Subsurface Conduits



McHugh et al., 2017, Recent advances in vapor intrusion site investigations, Journal of Environmental Management
Beckley and McHugh, 2020, Conceptual Model for Sewer Vapor Intrusion, STOTEN
McHugh and Beckley, 2020, ESTCP ER-201505 Research Project Report

Sampling Approaches



KEY POINT: **Within a given building, standard testing approaches may not identify conduit VI. Evaluation of risk factors and use of advanced testing methods can help.**

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Wrap-up

- Most regulatory guidance and testing programs are based on “conventional CSM”
- In reality, many site- and building-specific factors at play
    - Indoor sources
    - Conduit pathways
- Understanding VOC source and source strength are critical for decision-making.
    - Non-standard testing methods may be needed to understand vapor source(s)
    - VI mitigation likely ineffective unless source is understood

Questions?

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