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50 State Review of Vapor Intrusion Guidelines – 2020 Update

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Northeast Waste Management Officials' Association (NEWMOA) Webinar
Vapor Intrusion Assessment: Guidelines, Data Collection Methods, & Advancements
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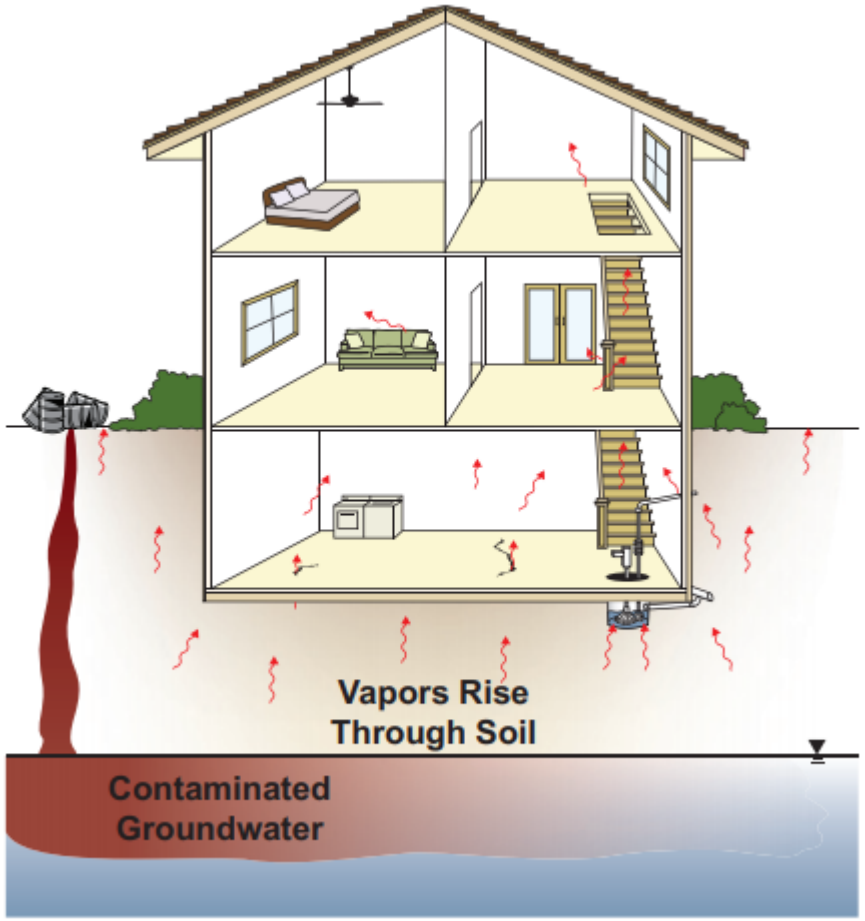
What is Vapor Intrusion?

- "[T]he migration of hazardous vapors from any subsurface vapor source, such as contaminated soil or groundwater, through the soil and into an overlying building or structure."
  (US EPA VI guidance, June 2015)

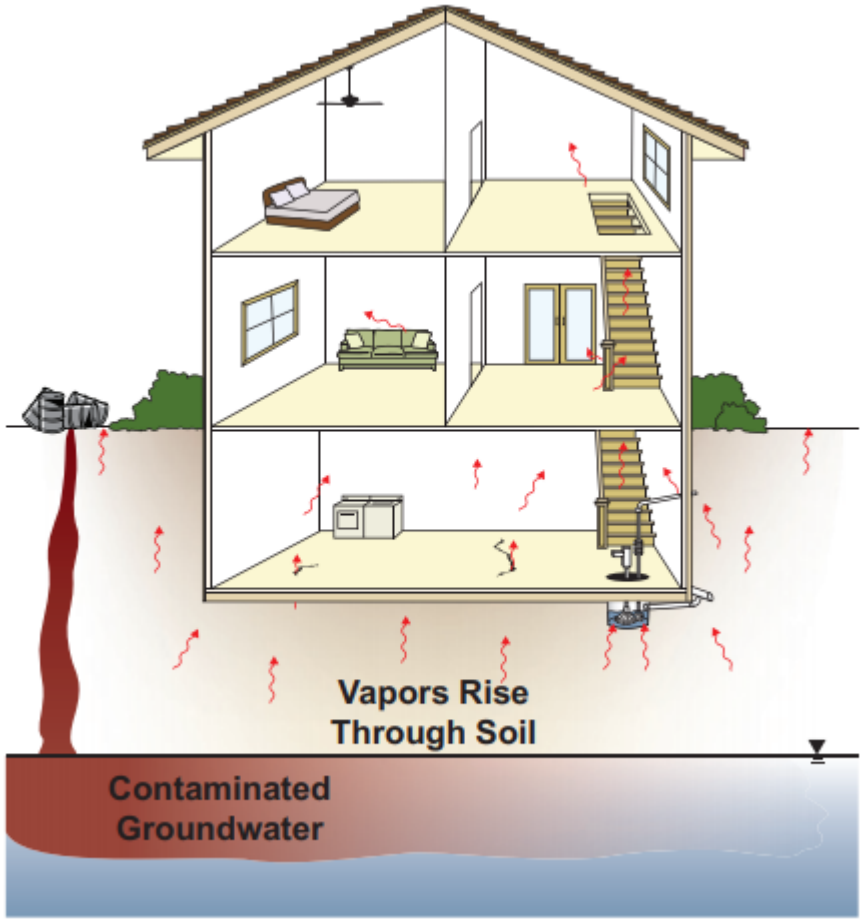
- Conditions for a complete VI pathway:
  1. A source of vapor-forming chemicals under the building
  2. A route along which vapors can migrate
  3. Building susceptibility to vapor entry
  4. Vapor-forming chemicals associated with the source present in indoor air
  5. Building is occupied by individuals



Source: EPA, 2012 (Citizen's Guide to VI Mitigation)

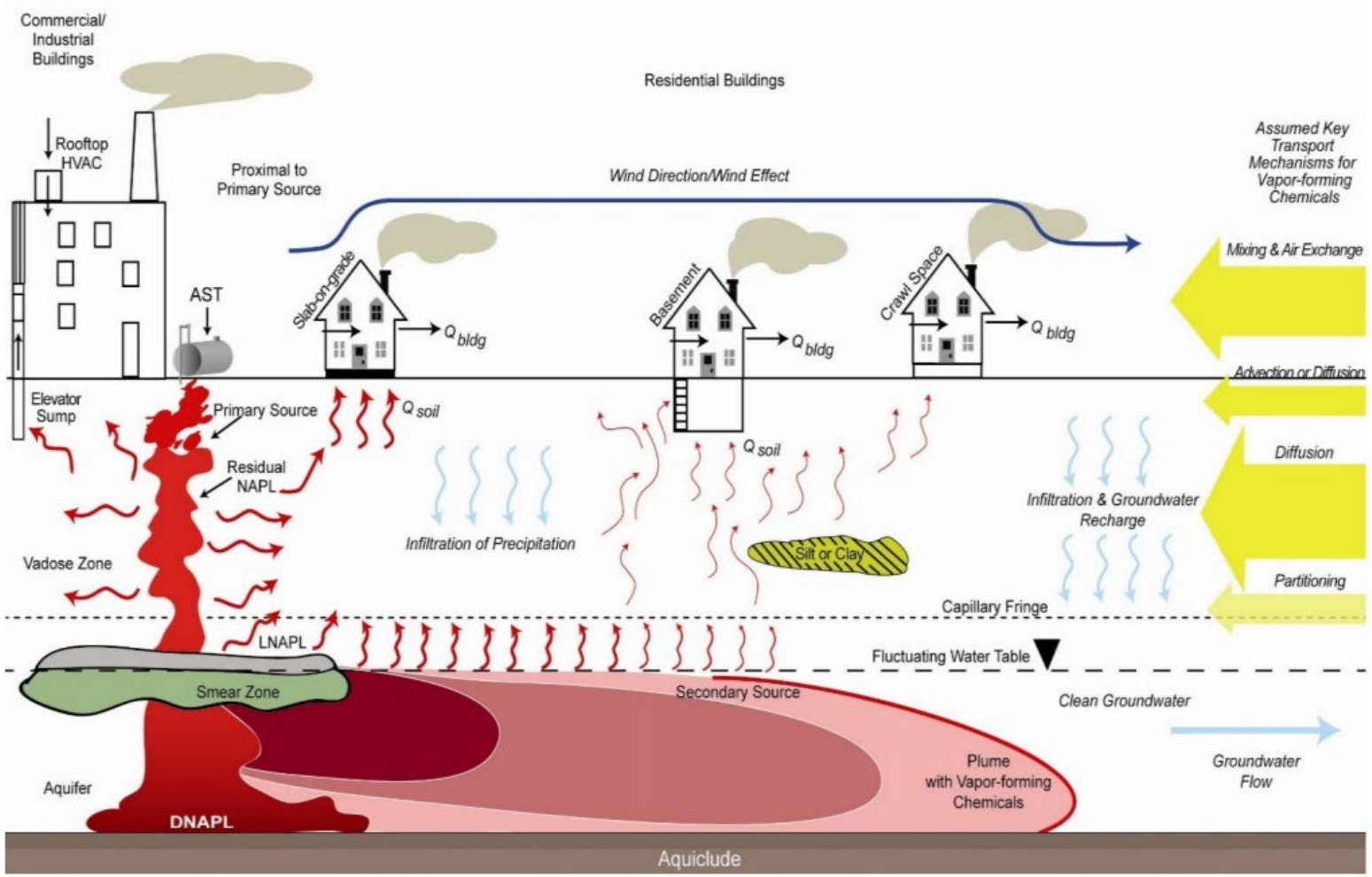
Why is Vapor Intrusion a Concern?

- The VI pathway may pose unacceptable risks of long-term exposure via inhalation of chemicals present
- Potential (and controversial) concerns associated with short-term exposure to TCE is technically challenging to address
- Common chemicals driving VI concerns:
  - Trichloroethylene (TCE) – degreasing solvent
  - Tetrachloroethylene (PCE) – dry cleaning fluid
  - Benzene – gasoline constituent



Source: EPA, 2012 (Citizen's Guide to VI Mitigation)

It's complicated…



Source: EPA, 2015 (OSWER VI Guidance)

Key VI concepts:
- Soil gas entry
- Building air exchange
- Spatial and temporal variability

What influences (or may influence VI)
- Stack effects
- Differential temperature
- Differential pressure (e.g., HVAC)
- Barometric pressure
- Wind speed (and wind direction)
- Precipitation

It's confounding

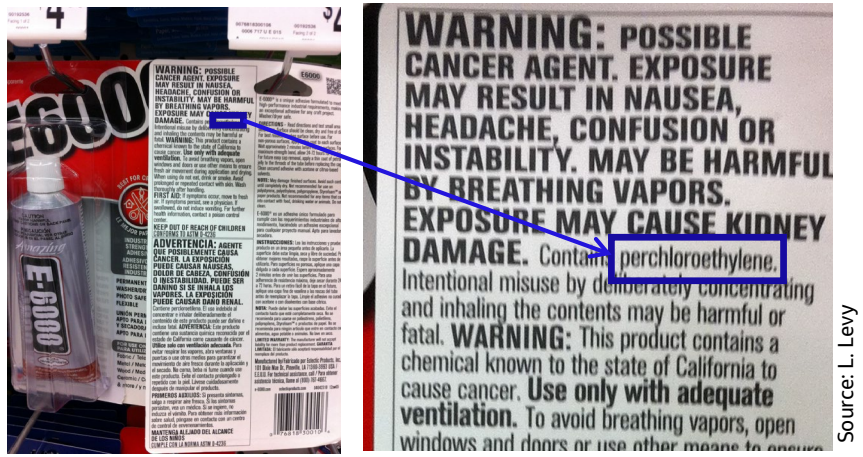
- Indoor air samples often contain background levels of volatile organic compounds (without VI occurring)

Typical background IA concentrations in North American Residences – 1990-2005

Compound	Median Values	Detection Frequency
Benzene	ND to 4.7 µg/m^3	91%
PCE	ND to 2.2 µg/m^3	63%
TCE	ND to 1.1 µg/m^3	43%
cis-1,2-DCE	ND	4.9%

Data Source: EPA, 2011

- Potential sources of volatile compounds in indoor air:
  - Upholstery, adhesives, dry cleaned clothing, cars/trucks (outdoor air), cleaning products (e.g., gun cleaner [TCE], brake cleaning spray [PCE], specialty solvents [trans-1,2-DCE]), plastic products (1,2-dichloroethane)

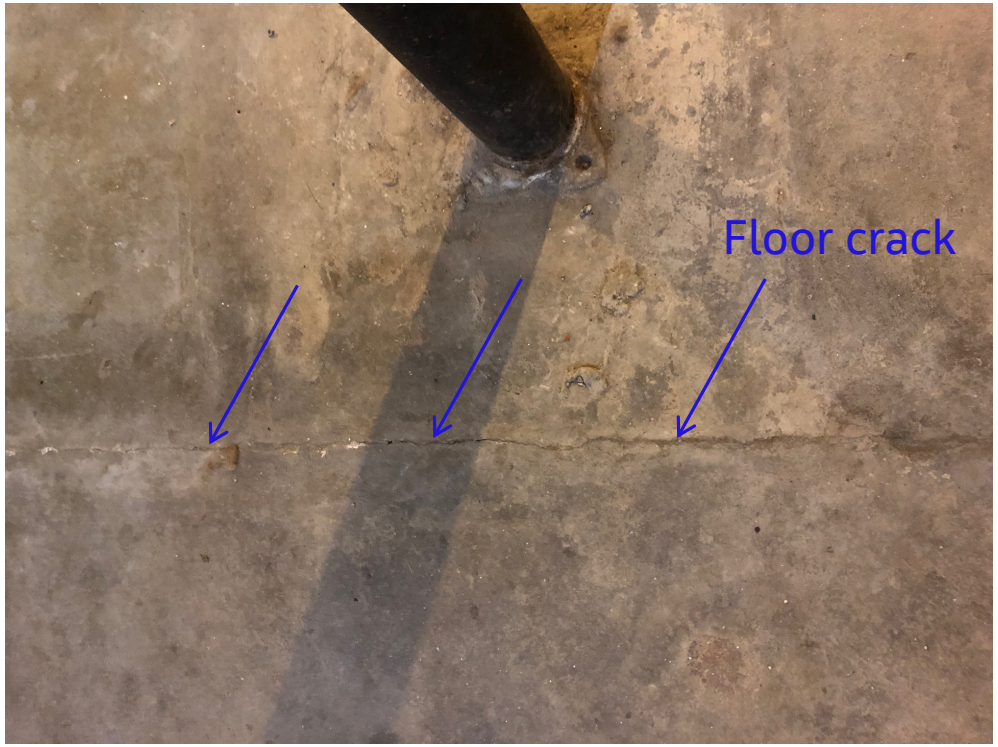


Source: L. Levy

“Conventional” -vs- “Atypical”

All VI pathways can be viewed as “preferential” but…

Conventional VI pathway
(perimeter cracks, joints, gaps)



Source: L. Levy

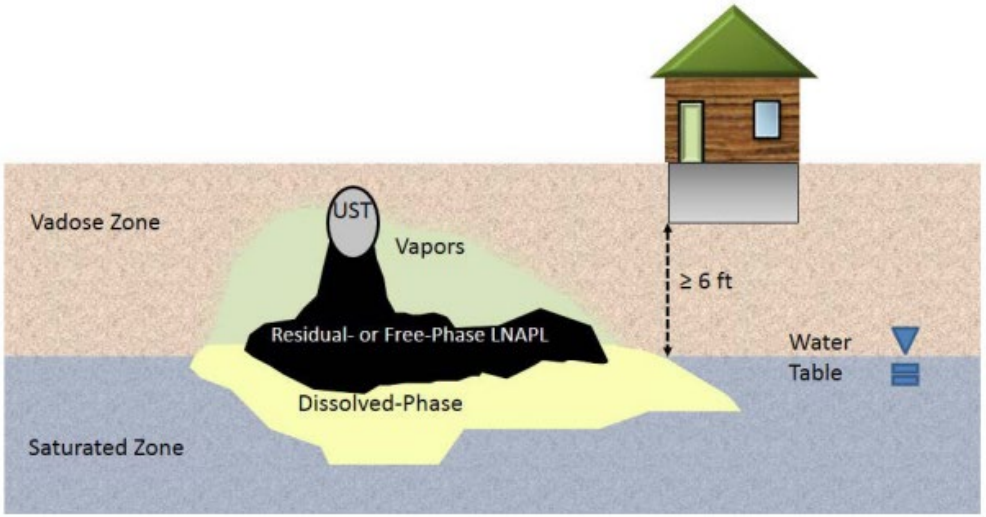
Atypical preferential VI pathway
(sewer lines, vaults, utility penetrations)

Source: L. Levy

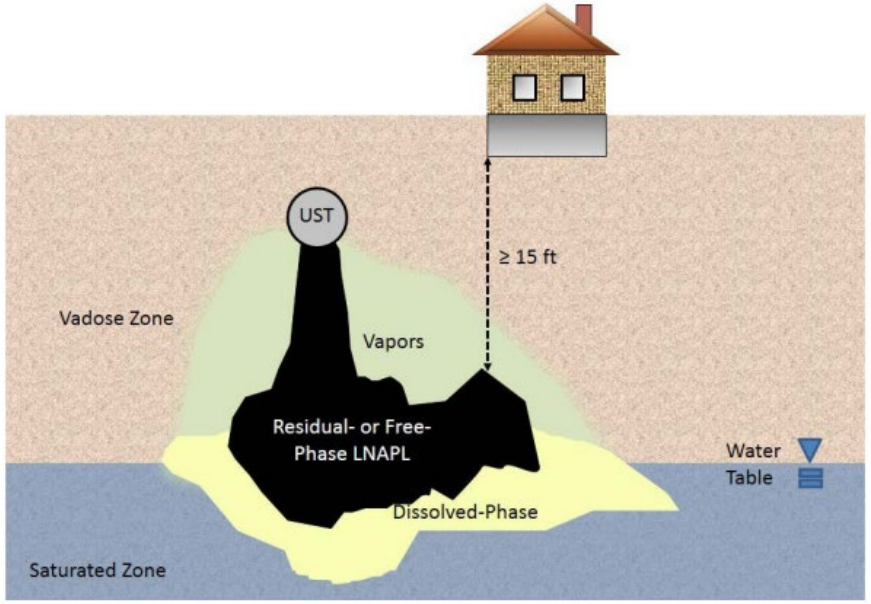
Beware of screening levels in atypical settings!

Petroleum VOCs vs. Chlorinated VOCs

- Petroleum VOCs are less prone to result in VI issues because of aerobic biodegradation in vadose zone soils (ITRC, 2014 PVI guidance; EPA, 2015 PVI UST guidance)
- Most states tend to incorporate PVI-related considerations (e.g., NJ, MA, VT, ME, [NH])



Vertical separation distance criteria for dissolved phase petroleum VOCs (EPA – 6 ft; ITRC – 5 ft)



Vertical separation distance criteria for LNAPL
- EPA/ITRC – 15 ft for UST/AST;
- ITRC – 18 ft for petroleum industrial sites

Source (both figures): EPA, 2015 (UST PVI Guidance)

A brief history of VI guidance

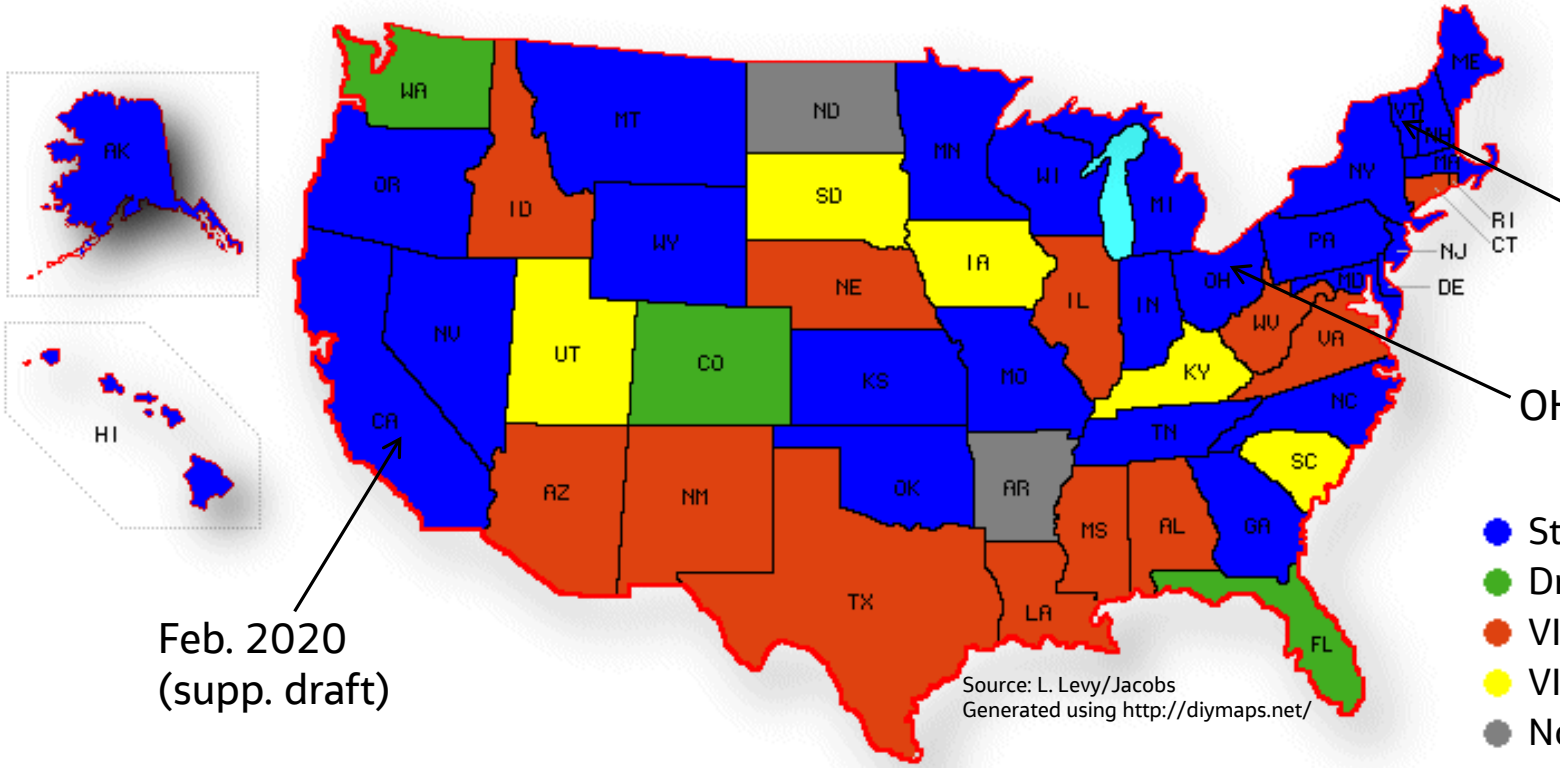
- Mid-late 1990s – VI concerns raised/early guidance
- 2000s
  - 2002 – EPA publishes draft VI guidance
  - 2007 – ITRC publishes VI guidance
  - Many states publish VI guidance during the 2000s
- 2010s
  - 2014 – ITRC publishes petroleum VI (PVI) guidance
  - 2015 – EPA finalizes VI guidance and issues PVI guidance for USTs
  - TCE short-term effects (fetal heart development concerns)
  - PCE toxicity (liver cancer vs. leukemia endpoints)
  - Many states update existing guidance (atten. factors, TCE rapid response, PVI)
  - Late 2010s – less focus on VI – all hands on PFOS/PFOA deck!
- 2020s – Predictions
  - More VI mitigation guidance (e.g., ITRC fact sheets/tech sheets, 2020-21)
  - Attenuation factors for commercial/industrial buildings
  - Short-term TCE (continued…)?
  - More real-time monitoring and less canister sampling?
  - Indicators, tracers, and surrogates (e.g., radon)

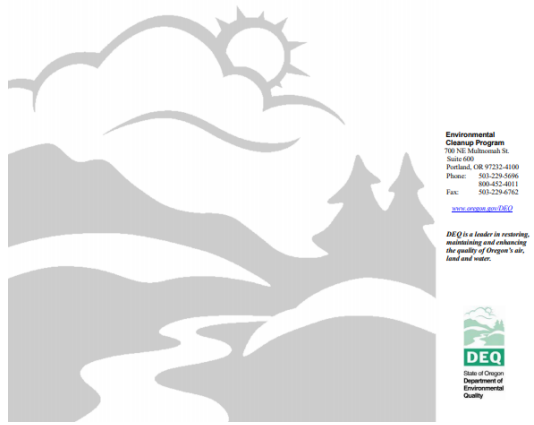
Source: L. Levy, Jacobs

Source: L. Levy

States with VI Guidance or Guidelines (as of August 2020)

- What constitutes "guidance" can be subject to interpretation (e.g., GA, OK, TX)
- Varying level of details (e.g., state-specific vs. "see EPA/ITRC", SOPs, mitigation)
- Guidance update vs. updated guidance (e.g., CA, MI, NH, NY, OH, OR, WI)
- D/EDGS – Disappearing/Eternal draft guidance syndrome (e.g., FL, IA, LA, WA)





Source: ORDEQ, 2010/2020

- Stand-Alone Vapor Intrusion Guidance (27 states)
- Draft Vapor Intrusion Guidance (3 states)
- VI Guidelines within Program (e.g., VCP) (13 states)
- VI Guidelines within UST Cleanup Program (5 states)
- No VI guidelines found (2 states)

Typical Vapor Intrusion Assessment/Mitigation Process

- Assess the potential presence of a VI pathway
  - Conceptual site model (CSM) development/review
  - Exceedance of groundwater volatilization screening levels
  - Presence of occupied structures within lateral inclusion zone
  - Vertical separation distance from source/plume (PVOCs vs. CVOCs)
  - Presence of atypical preferential pathways (e.g., sewer intersects plume)
- Conduct VI investigation
  - No. of samples, no. of sampling events, and sampling timing may vary
  - Collection of SSSG, IA, and outdoor air samples is typical
  - Conduct building survey (background sources, HVAC, pref. pathways)
  - Other samples as appropriate (e.g., sewer gas, crawlspace, exterior soil gas)
  - Compare results to VI screening/rapid response levels, evaluate multiple lines of evidence
- Next steps
  - No further action
  - Additional monitoring/background source assessment
  - Rapid response (e.g., TCE)
  - Mitigation and long-term management plan

Don't forget public outreach!

Source: L. Levy, Jacobs

Spatial variability – how many SSSG samples in a 50,001 ft² structure?

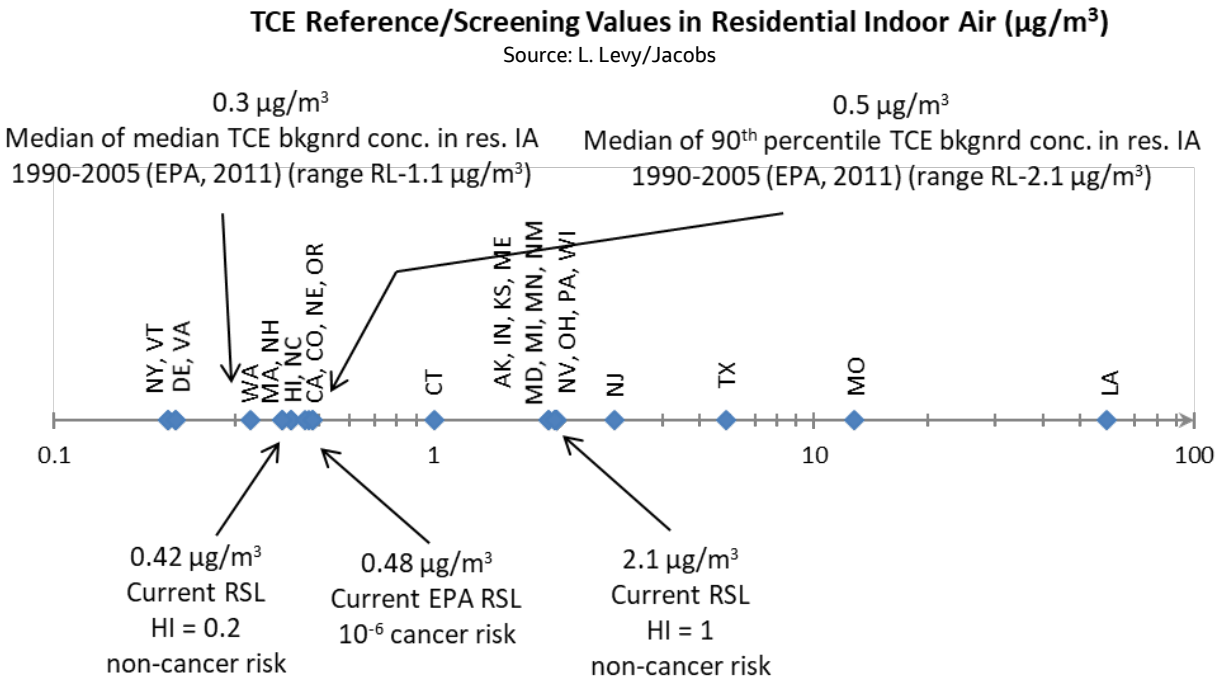
NJ	8	NJDEP, 2018, Table 3-2 (N = 8 for 50,001-250,000 ft²)
Mich.	25	MI DEQ/EGLE, 2013/2020, Table 5-2 N = 9 + (S-10,000 ft²)/2,500 ft²

Indoor Air Screening Levels Vary Broadly Between States…

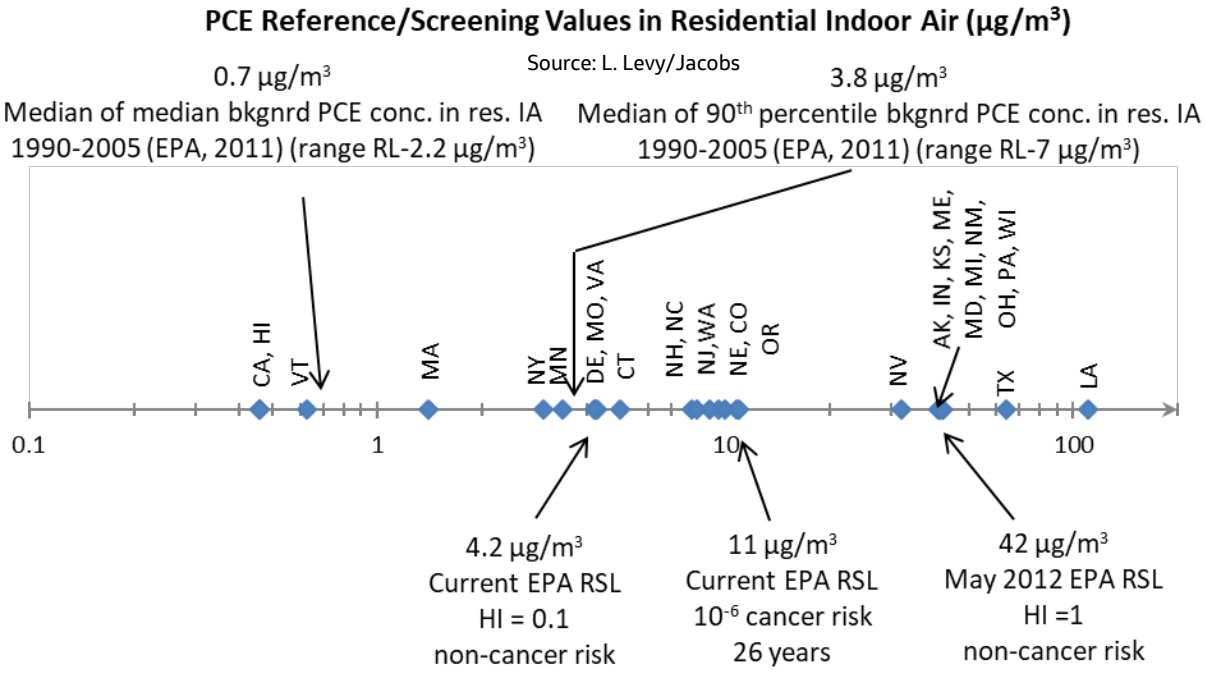
- Concentrations can have different meanings ("screening", "target", "rapid action level"…)
- Typically health-based criteria (10^{-5} or 10^{-6} cancer risk and noncancer HI = 0.1, 0.2, 0.25, or 1)
- Sometimes based on background level studies (e.g., MA, CT, NH, NY)
- Occasionally based on TO-15 reporting limits (e.g., MA, NH)
- State-specific exposure duration (e.g., 26 years, 30 years, or 70 years for residential exposure)
- State-specific toxicity study or study interpretation (PCE in particular [CA, HI, MA, MN, VT])

Source: L. Levy

Range of residential indoor air screening levels for TCE and PCE



TCE – 0.20 to 59 µg/m³



PCE – 0.46 to 110 µg/m³

Note: nonresidential screening levels are most often different from the above values due to different exposure duration assumptions (commonly 8 hours/day // 250 days/year // 25 years)

From Indoor Air to Subslab Soil Gas (SSSG) (or Groundwater) Screening Levels

- Different methodologies can lead to different screening levels (or not)
- Example for SSSG residential screening levels for PCE in MA, NH, and VT

	PCE Residential IA Screening Level (µg/m³)	Generic SSSG-to-IA Attenuation Factor (AF)	PCE Residential SSSG Screening Level (µg/m³)
Massachusetts	1.4 (median bgrd)	1/70 ~ 0.014	98
New Hampshire	8 (0.2 x RfC [EPA])	0.02	400
Vermont	0.63 (70 yr + tox)	0.03	21

A smaller generic AF
assumes more attenuation

- Currently:
  - Most states that use generic AFs tend to use a SSSG-to-IA AF of 0.03 (consistent with EPA VI guidance)
  - Sampling of both SSSG and IA (+outdoor air) is often an expectation

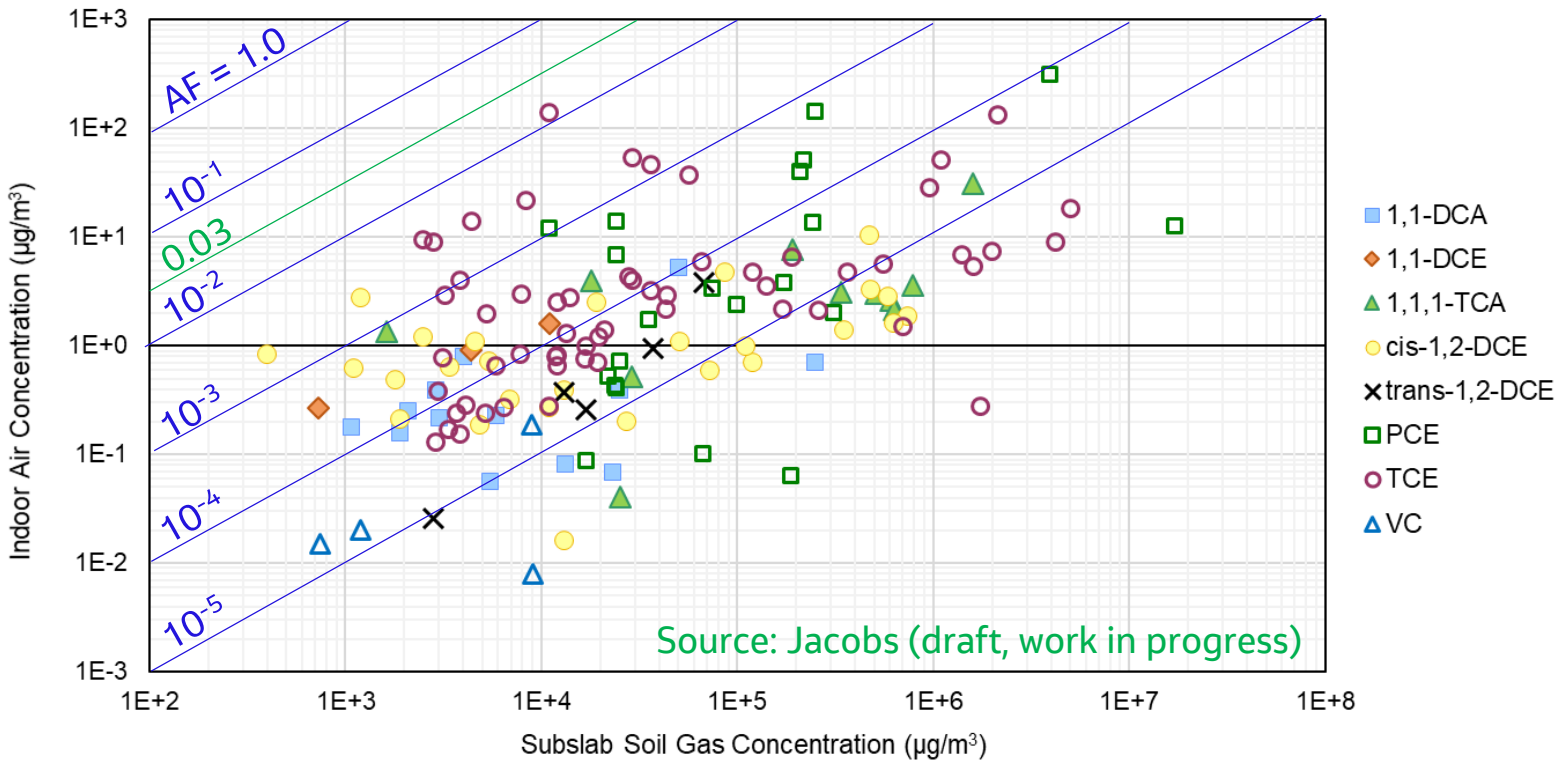
AFs in Residential Settings vs. Commercial/industrial Settings

- EPA SSSG-to-IA AF of 0.03 based on chlorinated VOCs in residential settings (EPA VI database, 2012) but also recommended by EPA for nonresidential settings despite recognition that more attenuation would be expected in large commercial/industrial buildings (EPA, 2015)
- Most states use identical AFs for both settings with some exceptions

State	Nonresidential	Residential	Ratio	Reference
Pennsylvania	0.0078 (7.8×10^{-3})	0.026	3.3	PA DEP, 2019
North Carolina	0.01 (10^{-2})	0.03	3	NC DEQ, 2014
Oregon	0.001 (10^{-3})	0.005	5	OR DEQ, 2010
Wisconsin	0.01 (10^{-2}) (large comm./indust.)	0.03 (school, small comm.)	3	WI DNR, 2018

SSSG vs. IA – Source Strength Screened, Sampling Zone-Averaged Plot

- Analysis of a dataset of DoD industrial/commercial buildings indicates a SSSG-to-IA AF in the range of 10^{-5} to 10^{-3} (10^{-3} is the 93rd percentile)



Each point represents a SSSG/IA analyte pair for a given building zone and sampling event (142 pairs from various DoD installations)

Source strength screening conducted consistent with EPA methodology to limit the effects of background contributions (EPA, 2012)

More info: Venable et al., 2015
https://clu-in.org/download/issues/vi/TR-NAVFAC-EXWC-EV-1603.pdf

Concerns Related to TCE Short-Term Exposure

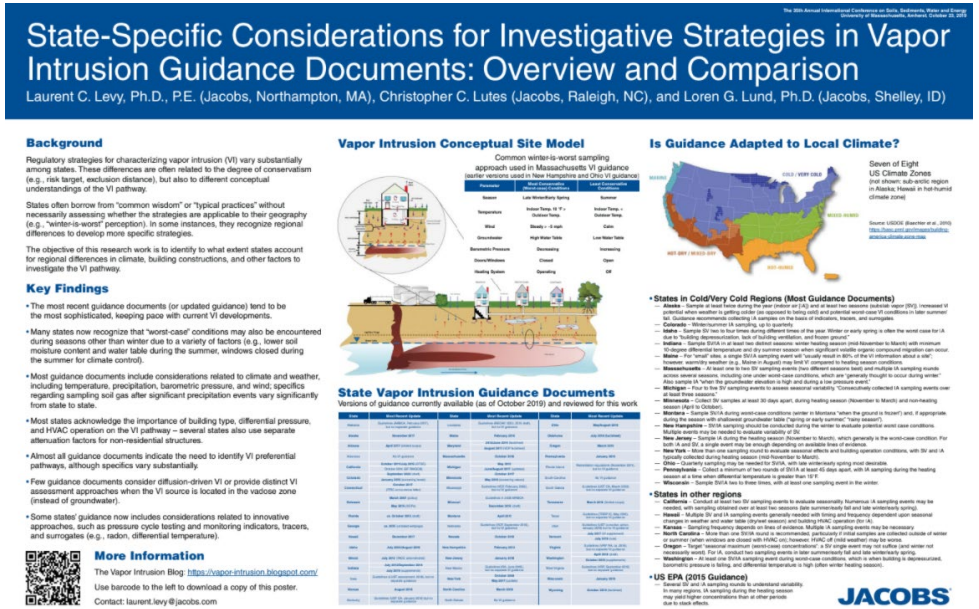
- 2011 – EPA lowered non-cancer risk reference concentration (RfC) to 2 µg/m^3
  - RfC based on fetal cardiac malformations during 1st trimester of pregnancy
  - Sensitive population = women of child-bearing age
  - Remains controversial
- 2011-2014 – For residential setting, EPA Region 9 recommends
  - accelerated response action level (RAL) of 2 µg/m^3 and urgent RAL of 6 µg/m^3 (HI = 3)
  - also adopted by California in Aug. 2014
  - value of 2 µg/m^3 also adopted by US EPA Region 10 in 2012
- 2013-present – States develop short-term action levels
  - MA (Jan 2013/Mar. 2014) imminent hazard value of 6 µg/m^3
  - NH (Feb. 2013) recommends 2 µg/m^3 (inform and potentially relocate)
  - NJ (Mar. 2013) rapid action level lowered to 4 µg/m^3
  - CT (Feb. 2015) short-term target IA concentration of 5 µg/m^3
  - NY (Aug. 2015) TCE air guideline lowered to 2 µg/m^3
  - IN dissents (Mar. 2016) "accelerated response is not scientifically supportable"
  - Other states and EPA regions develop some short-term guidelines for TCE, including MI, MN, NC, NE, OH, OR, VT, WA, WI, EPA Regions 3 and 7

- Prompt follow up investigation, notification, or reporting requirements
- Rapid response mitigation (e.g., APUs)
- Shorter long-term mitigation implementation timeframe

- Remains difficult to tackle given temporal variability of indoor air concentrations

When to sample? Is “winter-is-worst” true?

- Short answer: it tends to be true
  - Windows/doors/bay doors are more likely to be closed → less building air exchange
  - Stack effects will result in negative diff. pressure → more soil gas entry
  - Sampling on a day with a cold temperature or a large drop in temperature may be more important than sampling on any winter day
- Factors that may be conducive to “summer-is-worst”
  - Lower moisture content in vadose zone
  - Lower water table, greater subsurface temperature
  - Diffusion-driven soil gas entry
  - Windows closed (HVAC)
- In general, guidance documents recommend sampling during different seasons (including at least one event during the heating season) to characterize temporal variability
- Identifying the worst-case indoor air concentration is still a challenge without continuous monitoring
- More information, see Levy et al., 2019 (AEHS East UMass Amherst Poster Link)



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