



**U.S. EPA “State of VI Science” Workshop**  
***Reducing Vapor Intrusion Uncertainties by More  
Frequent Simple Measurements and Community  
Involvement***

**Review/update on Current State and EPA Guidance on  
Sampling Timing and Temporal Variability**

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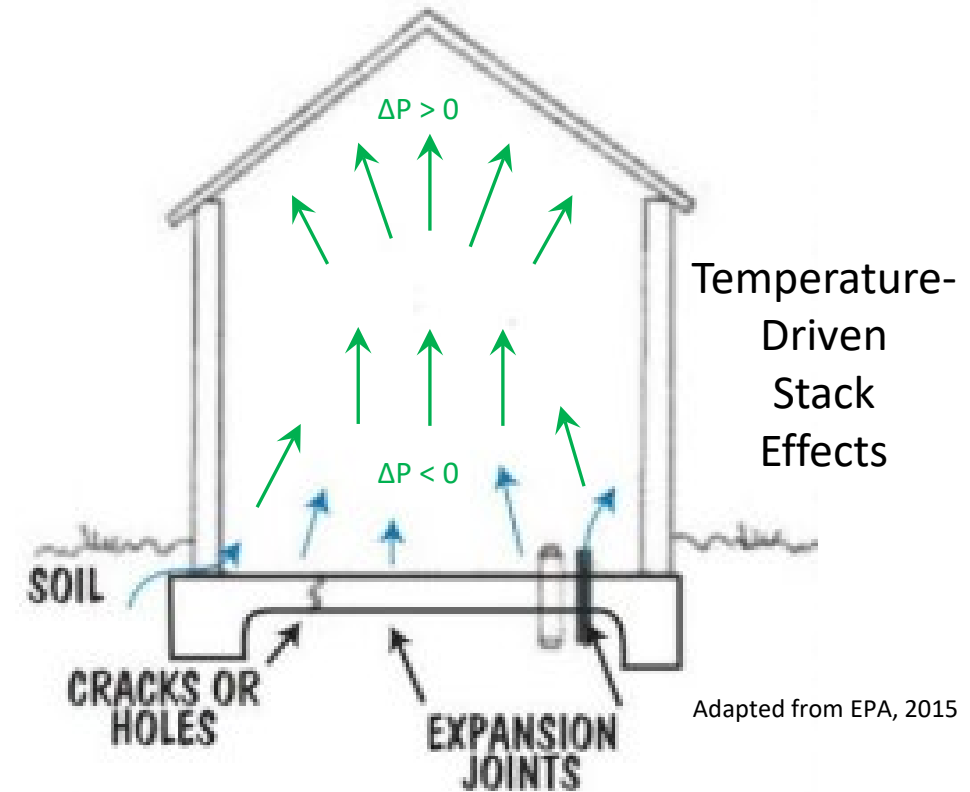
*30<sup>th</sup> Annual International Conference on Soil, Water, Energy, and Air, A Virtual Conference, March 22<sup>nd</sup>, 2021*

# Three Questions

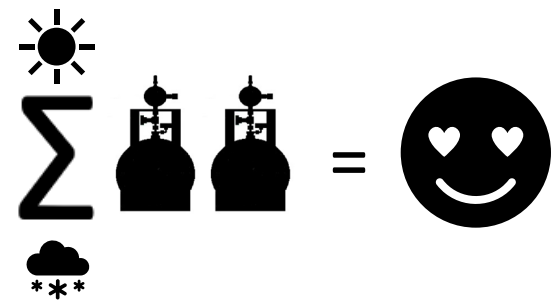
- How do guidance documents address concerns with temporal variability in indoor air (or subslab soil gas) concentrations?
  - Is sampling in the winter/during the heating season recommended?
- What are recommendations regarding HVAC systems?
  - Do guidance documents recommend turning HVAC systems off to achieve near worst-case conditions?
- Do guidance documents provide recommendations for use of indicators, tracers, and surrogates (ITS)?

# Common Assumptions of VI Practitioners

1. Winter – Heating system operation and temperature differences between the inside and the outside lead to stack effects resulting in greater soil gas entry. Doors and windows are closed limiting air exchange.
  2. Summer – Warmer temperatures lead to greater volatilization of VOCs and, presumably, greater soil gas concentrations. There is also less moisture in the soils.
  3. The effects of 1 are generally greater than the effects of 2
- Sample during heating season but...
- Assess temporal variability by sampling during another season



“Several sampling events during different seasons with a focus on the heating season” tends to be the norm...



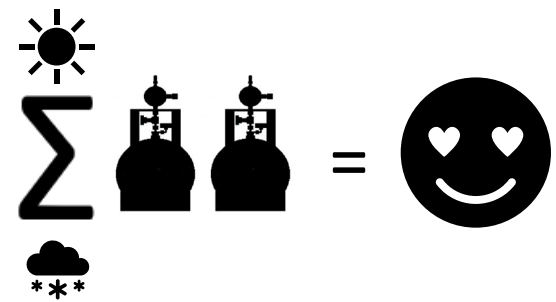
Examples from US EPA and US EPA Region Guidance

- [US EPA](#) (2015) – “[M]ultiple sampling events generally are considered necessary to account for seasonal variations in climate and the habits of building occupants and ensure that related risk management decisions are based upon a consideration of a reasonable maximum vapor intrusion condition. In many geographic areas in the continental United States, indoor air sampling during the heating season may yield higher indoor air concentrations than at other periods.”
- US EPA Region 5 (2020)‡ – “Indoor air concentrations due to VI vary over time and are often higher during the winter season, so additional testing should be considered if initial testing occurred during a mild season when windows are open.”
- [US EPA Region 7](#) (2017) — “In Region 7, a representative data set typically includes one year of quarterly vapor intrusion samples to account for seasonal variability.”

(Underlined US EPA Regions/States provide hyperlinks to guidance)

‡ Document not yet available online

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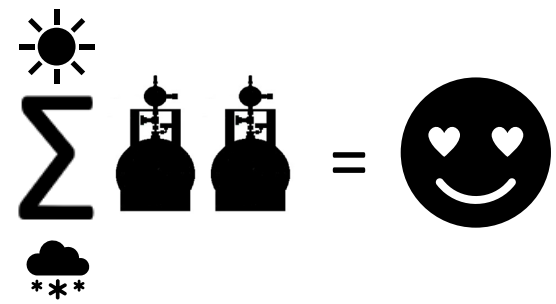
### Examples from State Guidance

- [Massachusetts](#) (2016) – “Multiple rounds of indoor air sampling across several seasons [...] At least one sampling event [...] during worst-case conditions [...] generally thought to occur during winter”
- [Indiana](#) (2012) – “IA sampling during the winter heating and dry summer seasons will account for seasonal variability and [...] provide the best opportunities to capture worst case conditions”
- [Wisconsin](#) (2018) – “At least one sample in winter and one sample in another season. (Times during decreasing temperature change may be best time to sample).”

Parameter	Most Conservative (Worst-case) Conditions	Least Conservative Conditions
Season	Late Winter/Early Spring	Summer
Temperature	Indoor Temp. 10° F > Outdoor Temp.	Indoor Temp. < Outdoor Temp.
Wind	Steady > ~ 5 mph	Calm
Groundwater	High Water Table	Low Water Table
Barometric Pressure	Decreasing	Increasing (3 days before)
Doors/Windows	Closed	Open
Heating System	Operating	Off

From [Mass. DEP guidance](#) (2016)  
(also used by [Ohio](#) and [New Hampshire](#))

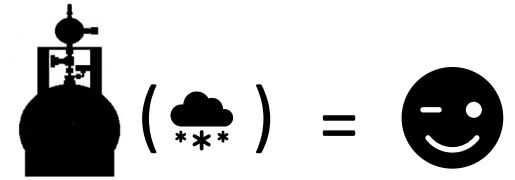
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Some variations:

- [Pennsylvania](#) (2019) – “The indoor air data collected for screening purposes should be collected when the daily average outdoor temperature is at least 15°F (8°C) below the minimum indoor temperature in the occupied space and when the heating system is operating normally. Indoor air sampling can be performed during warmer seasons, but that data should be used for informational purposes only and should not be used to screen out the VI pathway [...] two sampling events should occur at least 45 days apart [...]”
- [North Carolina](#) (2018) – “DWM recommends that one of the samples be collected in winter or summer conditions, typically when it would be expected that the structure would be closed up and the HVAC system operating. However, worst case conditions may also be considered when the building is closed up and the HVAC system is not running. It may be necessary to collect samples under different HVAC operation scenarios for comparison.”

# When one indoor air sampling event may be enough



**The criteria to justify a single event, where acceptable, vary from state to state:**

- [New Jersey](#) (2018) – “[T]he sample event should take place between November 1 and March 31 [...] generally “worst case” conditions for VI to occur. Assuming there are no other contradictory lines of evidence, the single round of indoor/ambient air samples should be able to determine whether the VI pathway is complete.”
- [North Carolina](#) (2018) – “A single round of sampling is acceptable (irrespective of the seasonal timing of the sampling event) when the results are an order of magnitude below the appropriate IASL.”
- [Ohio](#) (2020) – “Generally, if both indoor air and sub-slab vapor samples are collected during more conservative sampling conditions and both are nondetect or below screening values, one round of sampling may be sufficient.”

# Should the HVAC be turned off or kept on?

**“Worst-case” conditions lead to differing HVAC expectations to balance worst-case, representativeness and practicality:**

Off!

- [Delaware](#) (2015) – “De-activate HVAC systems in advance of [indoor air] sampling to more accurately determine natural migration of sub-slab air into the building.”

On!

- [Wisconsin](#) (2018) – “Sample with windows closed, and under normal HVAC operations.”

Probably  
both

- [North Carolina](#) (2018) – “It may be useful to evaluate the potential for VI by collecting indoor air samples when HVAC systems are often turned off, typically during the evening.”

Definitely  
both!

- [California](#) (2020, draft) – “One of the sampling events [...] should include both HVAC-On and HVAC-Off scenarios [...] This means two periods of sampling as part of that event [...] For the HVAC-Off scenario, the sampling duration should begin at least 36 hours following shutdown of the HVAC.”



# Indicators, Tracers, and Surrogates

Use of differential pressure, temperature, barometric pressure commonly referenced in guidance (e.g., Massachusetts)

Radon often referenced in guidance as a possible tracer

- [Montana](#) (2011) – “At this time, the use of radon samples to determine attenuation of VOCs does not appear appropriate, because to date there is not enough evidence to support a direct correlation between subsurface radon intrusion and other vapor intrusion.”
- [Georgia](#) (2020 draft) – “Tracers are substances that are either naturally occurring (such as radon) or not typically found in indoor air from background sources. When tracers are present in the subsurface and in indoor air, they provide a line of evidence that vapor intrusion is occurring.”
- [Washington](#) (2018) – “[U]sing tracer compounds such as radon, may provide some of the information necessary to help justify a building-specific attenuation factor.”
- [Alaska](#) (2017) – “If an investigator utilizes **indicators, tracers, or surrogates** to determine the appropriate times to sample (i.e. identifies worst case short term indoor air concentrations), then the chances of measuring the reasonable maximum inhalation exposure are significantly increased.”

# Summary

- Vapor intrusion guidance documents generally recommend several sampling events to assess temporal variability, with an emphasis on sampling during the heating season
- Although guidance documents commonly recommend HVAC systems remain in operation during sampling, sampling with HVAC system off is also considered
- Indicators and tracers (radon) are often referenced in guidance documents

## State-Specific Considerations for Investigative Strategies in Vapor Intrusion Guidance Documents: Overview and Comparison

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### Background

Regulatory strategies for characterizing vapor intrusion (VI) vary substantially among states. These differences are often related to the degree of conservatism (e.g., risk target, exclusion distance), but also to different conceptual understandings of the VI pathway.

States often borrow from "common wisdom" or "typical practices" without necessarily assessing whether the strategies are applicable to their geography (e.g., "winter-is-worst" perception). In some instances, they recognize regional differences to develop more specific strategies.

The objective of this research work is to identify to what extent states account for regional differences in climate, building constructions, and other factors to investigate the VI pathway.

### Key Findings

- The most recent guidance documents (or updated guidance) tend to be the most sophisticated, keeping pace with current VI developments.
- Many states now recognize that "worst-case" conditions may also be encountered during seasons other than winter due to a variety of factors (e.g., lower soil moisture content and water table during the summer, windows closed during the summer for climate control).
- Most guidance documents include considerations related to climate and weather, including temperature, precipitation, barometric pressure, and wind; specifics regarding sampling soil gas after significant precipitation events vary significantly from state to state.
- Most states acknowledge the importance of building type, differential pressure, and HVAC operation on the VI pathway – several states also use separate attenuation factors for non-residential structures.
- Almost all guidance documents indicate the need to identify VI preferential pathways, although specifics vary substantially.
- Few guidance documents consider diffusion-driven VI or provide distinct VI assessment approaches when the VI source is located in the vadose zone (instead of groundwater).
- Some states' guidance now includes considerations related to innovative approaches, such as pressure cycle testing and monitoring indicators, tracers, and surrogates (e.g., radon, differential temperature).



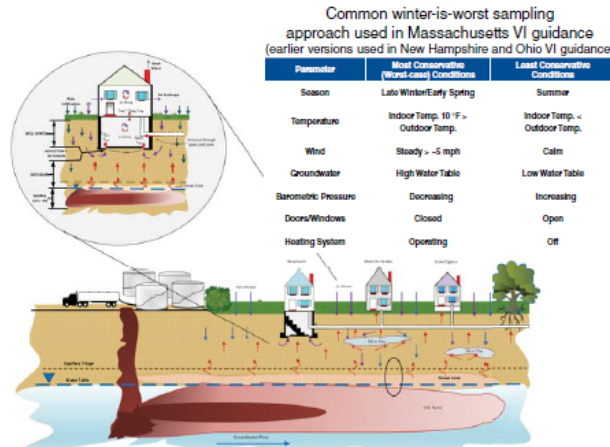
### More Information

The Vapor Intrusion Blog: <https://vapor-intrusion.blogspot.com/>

Use barcode to the left to download a copy of this poster.

Contact: laurent.levy@jacobs.com

### Vapor Intrusion Conceptual Site Model



### State Vapor Intrusion Guidance Documents

Versions of guidance currently available (as of October 2019) and reviewed for this work

State	Most Recent Update	State	Most Recent Update	State	Most Recent Update
Alabama	Guidance (ADEM, February 2015), but no residential guidance	Louisiana	Guidance (SLO/CAJ, 2016 (draft), but no VI guidance)	Ohio	May/August 2014
Alaska	November 2017	Maine	February 2012	Oklahoma	July 2010 (draft)
Arizona	April 2017 (draft accepted)	Maryland	2013/2014 (draft), but no VI guidance	Oregon	March 2010
Arkansas	No VI guidance	Massachusetts	October 2014	Pennsylvania	January 2019
California	October 2014/July 2015 (DTIC), October 2014 (DTIC), but no VI guidance	Michigan	May 2013 (draft), but no VI guidance	Rhode Island	Remediation regulations (November 2015), but no VI guidance
Colorado	September 2016 (draft)	Minnesota	May 2019 (draft), but no VI guidance	South Carolina	No VI guidance
Connecticut	January 2014 (draft), but no VI guidance	Mississippi	Guidance (2017), but no VI guidance	South Dakota	No VI guidance
Delaware	March 2017 (draft)	Montana	Guidance in 2016 (draft)	Tennessee	Guidance (2017), but no VI guidance
Florida	ca. October 2010 (draft)	Nebraska	December 2014 (draft)	Texas	March 2019 (draft accepted)
Georgia	ca. 2015 (drafted workshop)	Nevada	April 2011	Utah	Guidance (2017) (2017), but no VI guidance
Hawaii	December 2017	New Hampshire	October 2012	Vermont	Guidance (2017) (draft), but no VI guidance
Idaho	July 2016/September 2016	New Jersey	February 2013	Virginia	July 2019 (draft)
Illinois	July 2015 (draft), but no VI guidance	New Mexico	January 2019	Washington	October 2019 (draft)
Indiana	July 2015 (draft), but no VI guidance	New York	Guidance (2017), but no VI guidance	West Virginia	Guidance (2017), but no VI guidance
Iowa	Guidance (IJC, September 2016), but no VI guidance	North Carolina	March 2018	Wisconsin	January 2019
Kansas	August 2015	North Dakota	No VI guidance	Wyoming	October 2019 (draft)
Kentucky	Guidance (SLO/CAJ, January 2016), but no VI guidance				

### Is Guidance Adapted to Local Climate?



#### States in Cold/Very Cold Regions (Most Guidance Documents)

- **Alaska** – Sample at least twice during the year (indoor air [IA]) and at least two seasons (subslab vapor [SV]). Increased VI potential when weather is getting colder (as opposed to being cold) and potential worst-case VI conditions in later summer/fall. Guidance recommends collecting IA samples on the basis of indicators, tracers, and surrogates.
- **Colorado** – Winter/summer IA sampling, up to quarterly.
- **Idaho** – Sample SV two to four times during different times of the year. Winter or early spring is often the worst case for IA due to "building depressurization, lack of building ventilation, and frozen ground."
- **Indiana** – Sample SV/IA in at least two distinct seasons: winter heating season (mid-November to March) with minimum 10-degree differential temperature and dry summer season when significant volatile organic compound migration can occur.
- **Maine** – For "small" sites, a single SV/IA sampling event will "usually result in 80% of the VI information about a site"; however, warm/dry weather (e.g., Maine in August) may limit VI compared to heating season conditions.
- **Massachusetts** – At least one to two SV sampling events (two different seasons best) and multiple IA sampling rounds across several seasons, including one under worst-case conditions, which are "generally thought to occur during winter." Also sample IA "when the groundwater elevation is high and during a low pressure event."
- **Michigan** – Four to five SV sampling events to assess seasonal variability. "Consequently collected IA sampling events over at least three seasons."
- **Minnesota** – Collect SV samples at least 30 days apart, during heating season (November to March) and non-heating season (April to October).
- **Montana** – Sample SV/IA during worst-case conditions (winter in Montana "when the ground is frozen") and, if appropriate, during the season with shallowest groundwater table ("spring or early summer," "rainy season").
- **New Hampshire** – SV/IA sampling should be conducted during the winter to evaluate potential worst case conditions. Multiple events may be needed to evaluate variability of SV.
- **New Jersey** – Sample IA during the heating season (November to March), which generally is the worst-case condition. For both IA and SV, a single event may be enough depending on available lines of evidence.
- **New York** – More than one sampling round to evaluate seasonal effects and building operation conditions, with SV and IA typically collected during heating season (mid-November to March).
- **Ohio** – Quarterly sampling may be needed for SV/IA, with late winter/early spring most desirable.
- **Pennsylvania** – Collect a minimum of two rounds of SV/IA at least 45 days apart, with IA sampling during the heating season at a time when differential temperature is greater than 15°F.
- **Wisconsin** – Sample SV/IA two to three times, with at least one sampling event in the winter.

#### States in other regions

- **California** – Conduct at least two SV sampling events to evaluate seasonality. Numerous IA sampling events may be needed, with sampling obtained over at least two seasons (late summer/early fall and late winter/early spring).
- **Hawaii** – Multiple SV and IA sampling events generally needed with timing and frequency dependent upon seasonal changes in weather and water table (dry/wet season) and building HVAC operation (for IA).
- **Kansas** – Sampling frequency depends on lines of evidence. Multiple IA sampling events may be necessary.
- **North Carolina** – More than one SV/IA round is recommended, particularly if initial samples are collected outside of winter or summer (when windows are closed with HVAC on); however, HVAC off (mild weather) may be worse.
- **Oregon** – Target "seasonal maximum (worst-case) concentrations"; a SV single event may not suffice (and winter not necessarily worst). For IA, conduct two sampling events in late summer/early fall and late winter/early spring.
- **Washington** – At least one SV/IA sampling event during worst-case conditions, which is when building is depressurized, barometric pressure is falling, and differential temperature is high (often winter heating season).

#### US EPA (2015 Guidance)

- Several SV and IA sampling rounds to understand variability.
- In many regions, IA sampling during the heating season may yield higher concentrations than at other periods due to stack effects.