Vapor Intrusion Guidance

MassDEP/LSPA 2014 MCP Regulatory Reform Initiative Training

Gerard Martin, Catherine Wanat
Massachusetts Department of Environmental Protection

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Purpose of VI Guidance

- Clarify when evaluation of the vapor intrusion pathway is required pursuant to the MCP;
- Provide guidance on conducting assessments to determine if the vapor intrusion pathway at a site is complete and likely to be of concern;

Purpose of VI Guidance

- Provide guidance on conducting exposure and risk assessments at sites where the vapor intrusion pathway has been determined to be complete;
- Recommend vapor intrusion mitigation strategies; and
- Outline the MCP requirements relative to sites at which a potential or known vapor intrusion pathway exists.

What We Will Cover

- Review of vapor intrusion pathway
- When and how to look for the pathway
- Conceptual Site Models
- Multiple Lines of Evidence
  – sampling recommendations
- Multiple Lines of Evidence – evaluation
- Critical Exposure Pathways
- Closure
- Along the way – highlight reg revision changes ★

Vapor Intrusion – Why the Concern?

Exposure & Risk Issues

- People spend most of their time indoors
- Lungs are efficient at mass transfer of contaminants directly to bloodstream
- Although it is possible to avoid contaminated soil and/or groundwater; it is not possible to avoid breathing air in an impacted structure

Complex pathway to evaluate

- Many variables affect the pathway: building characteristics, soil characteristics, season, wind, temperature, pressure, groundwater level, heating systems, preferential pathways…..

Vapor Intrusion Conceptual Site Model

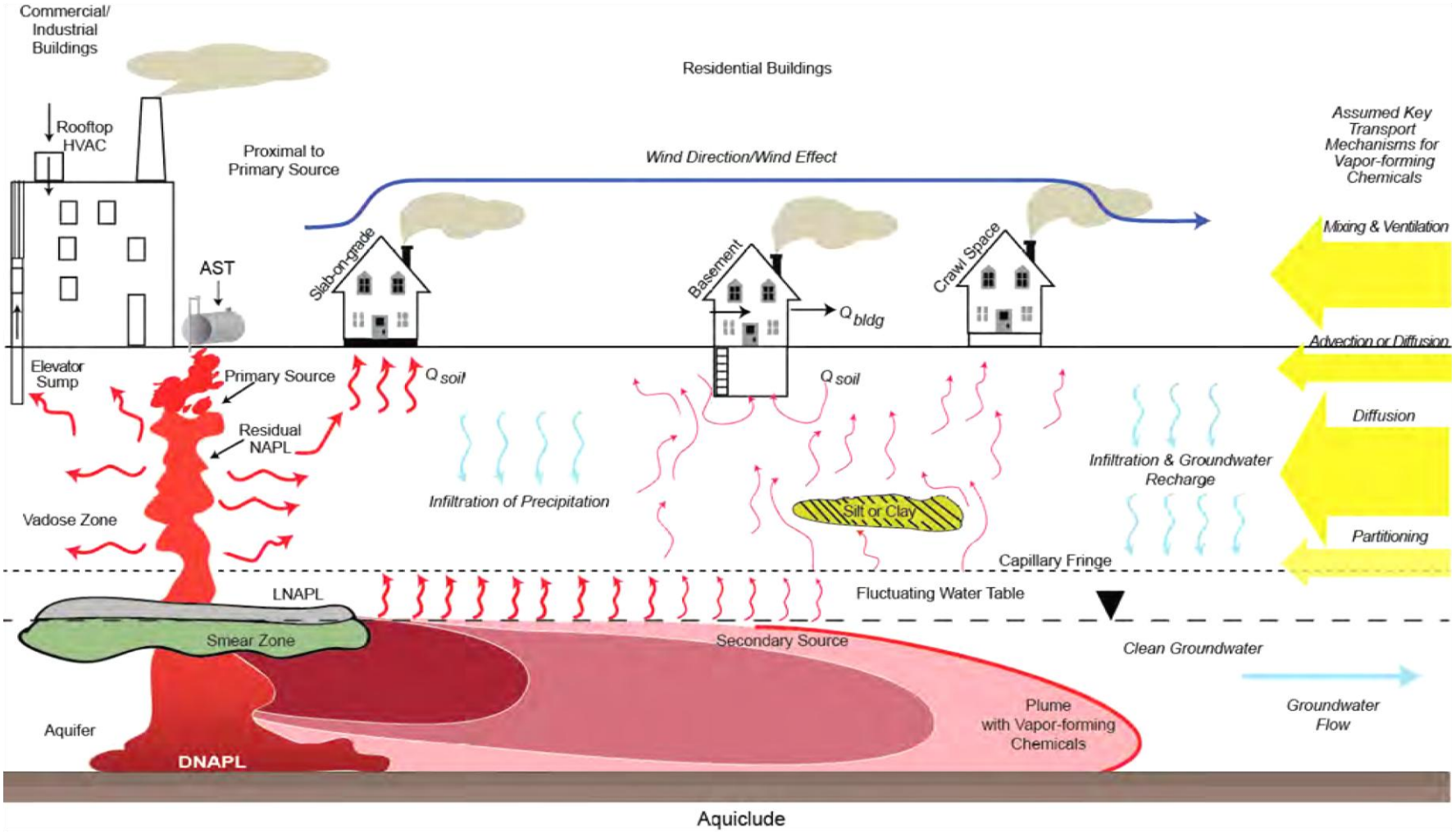
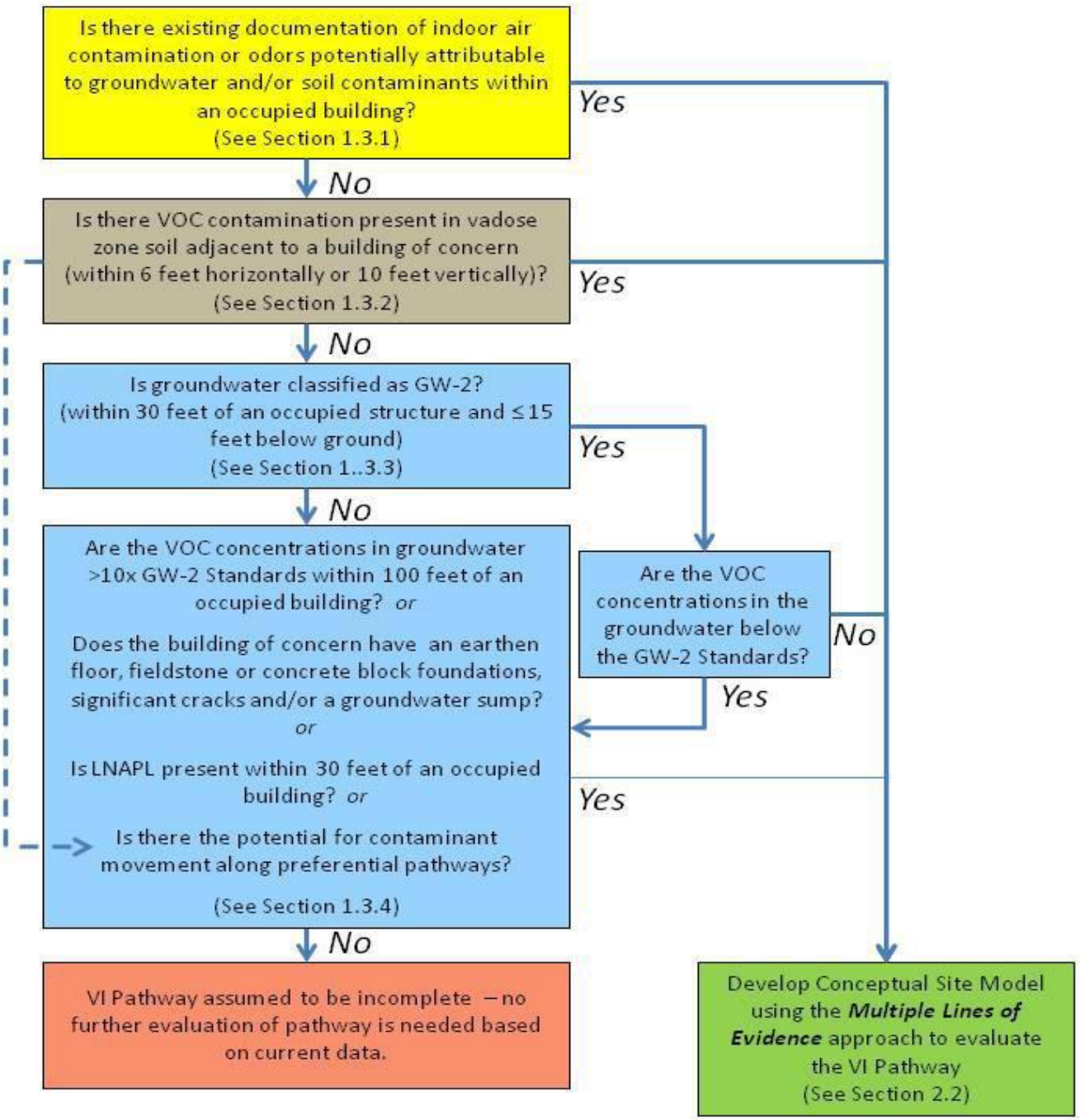


Figure 2-1 from EPA's External Review Draft Vapor Intrusion Guidance (2013)

When to Look

Regulations and Guidance

Evaluation of vapor intrusion potential at sites where VOCs have been released to the environment



New Conditions of SRM for VI at Sensitive Receptors ★

(310 CMR 40.0313(4)(f))

1. Soil or soil gas with VOCs within 6’ (horiz.) and 10’ (vert.) at concentrations likely to discharge vapors into structure
2. VOCs in groundwater > GW-2 within 30’ of structure and aver. annual depth to GW is ≤ 15’
3. Volatile LNAPL in well, excavation, or subsurface depression within 30’ of structure at thickness ≥ 1/8”
4. Evidence of vapor migration along preferential pathways at a location likely to result in the discharge of vapors into the structure

Case Study - Hypothetical

- An assessment was performed at the site of a former metal plating facility that had been converted to condos
- Concentration of TCE in groundwater are below GW-2 Standards
- Subsequent sub-slab soil gas sampling beneath the condos ranged from ND to 1,810 µg/m^3 TCE

Does this represent a Condition of Substantial Release Migration (SRM) or another condition triggering action under the MCP?

Case Study - Hypothetical

Choose all that apply:

A) It depends on the condition of the slab

B) Yes, this represents SRM because soil gas impacted with a VOC is within 10' vertically at concentrations that are likely to discharge vapors into the structure.

C) It depends on the results of indoor air monitoring

How to Look

Start with a good Conceptual Site Model…

Conceptual Site Model

Always part of good practice, now in regulations
(310 CMR 40.0006(12))

Conceptual Site Model or CSM means a site-specific description of how contaminants entered the environment, how contaminants have been and may be transported within the environment, and routes of exposure to human and environmental receptors that provides a dynamic framework for assessing site characteristics and risk, identifying and addressing data gaps and managing uncertainty, eliminating or controlling contaminant sources, developing and conducting response action strategies, and evaluating whether those strategies have been effective in achieving desired endpoints. At sites at which NAPL is or may be present, this includes the body of fundamental scientific principles describing the behavior of fluid flow in porous media necessary to assess NAPL in subsurface strata.

VI Conceptual Site Model - Consider

- Concentrations of VOCs in all media (groundwater, soil, soil gas & indoor air)
- Sources
  - LNAPL or DNAPL
  - Proximity to receptors
- Site hydrogeology
  - Depth to groundwater
  - Soil types
  - Groundwater flow direction and velocity
- Building(s) construction
- The presence of preferential pathways

…Then Apply Multiple Lines of Evidence Approach

- Concentrations of VOCs in groundwater, soil, and sub-slab soil gas
- Concentrations of VOCs in indoor air
- The presence of outdoor sources
- The presence of indoor sources
- Other Lines of Evidence??

Hypothetical

- A commercial building that formerly housed a dry cleaner has been converted to a daycare facility
- Groundwater is classified as GW-2 & GW-3
- Only groundwater sampled - three monitoring wells indicated chlorinated VOCs just over RCs in first round, then just under the Method-1 GW-2 standards

Hypothetical

Recommendations regarding VI evaluation (choose all that apply):

A) None: VI is not an issue since the GW-2 standards are met

B) Do more groundwater monitoring

C) Evaluate sub-slab soil vapors

D) Evaluate potential for soil contamination

E) Perform indoor air monitoring

F) Evaluate potential for preferential pathways

Multiple Lines of Evidence - Sampling Recommendations

Groundwater

- Sampling from at/near water table
- Within 30 feet of structure of concern
- Seasonal data for trends
- No composite sampling
- Groundwater quality profiling

Sampling Recommendations

Soil

- Soil data alone is not a conclusive line of evidence to rule out VI pathway
- Consider history, evaluate full building footprint if OHM was used at building being evaluated

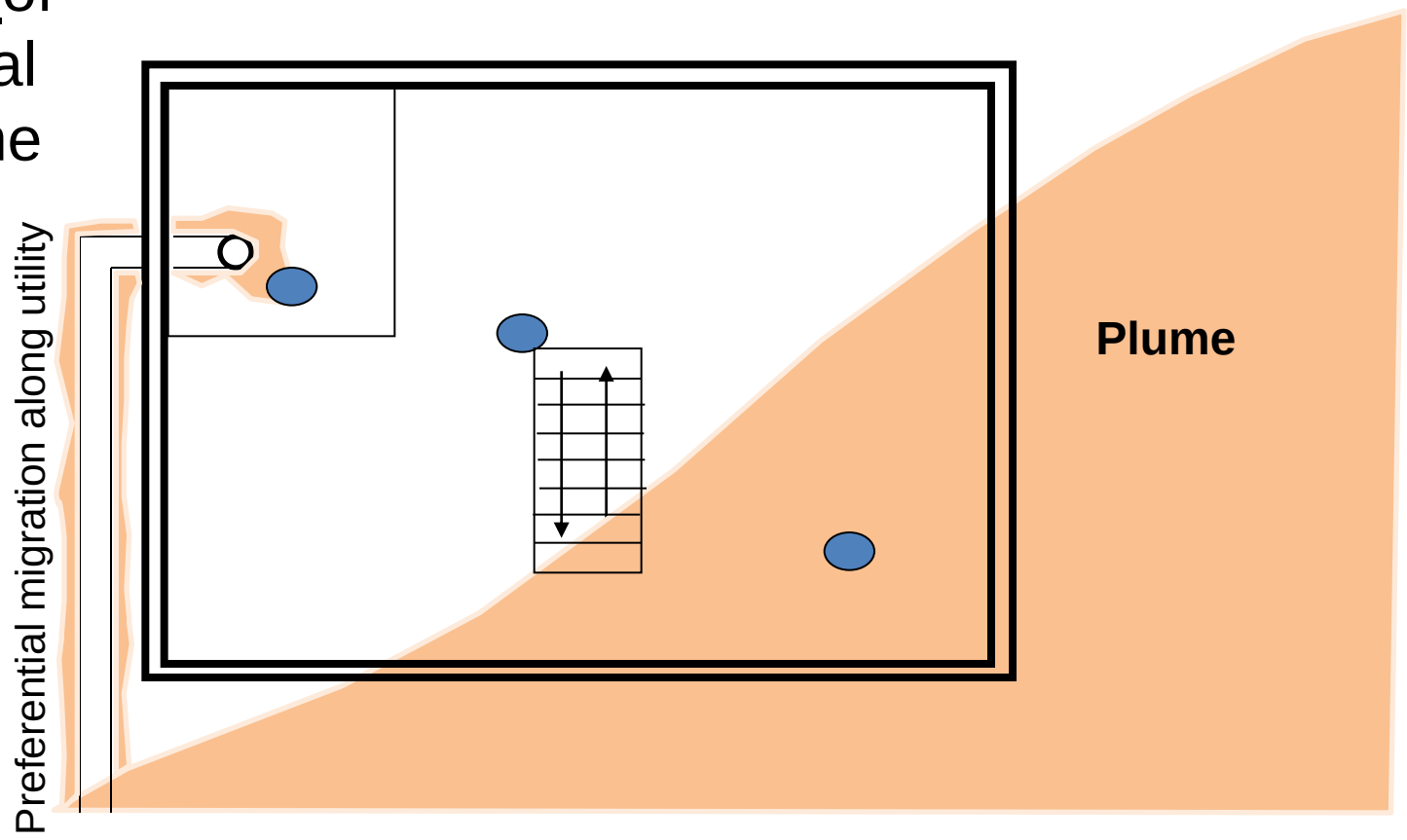
Sampling Recommendations

Soil Gas

- Preference for Sub-Slab Soil Gas for evaluation of the VI pathway
- Number of sub-slab soil gas points depends on size of building & preferential pathway potential
- Recommend at least 1-2 sub-slab soil gas sampling points and sampling events in typical single-family building
- “Open field” soil gas samples may be useful for non-VI applications, such as for extent of contamination

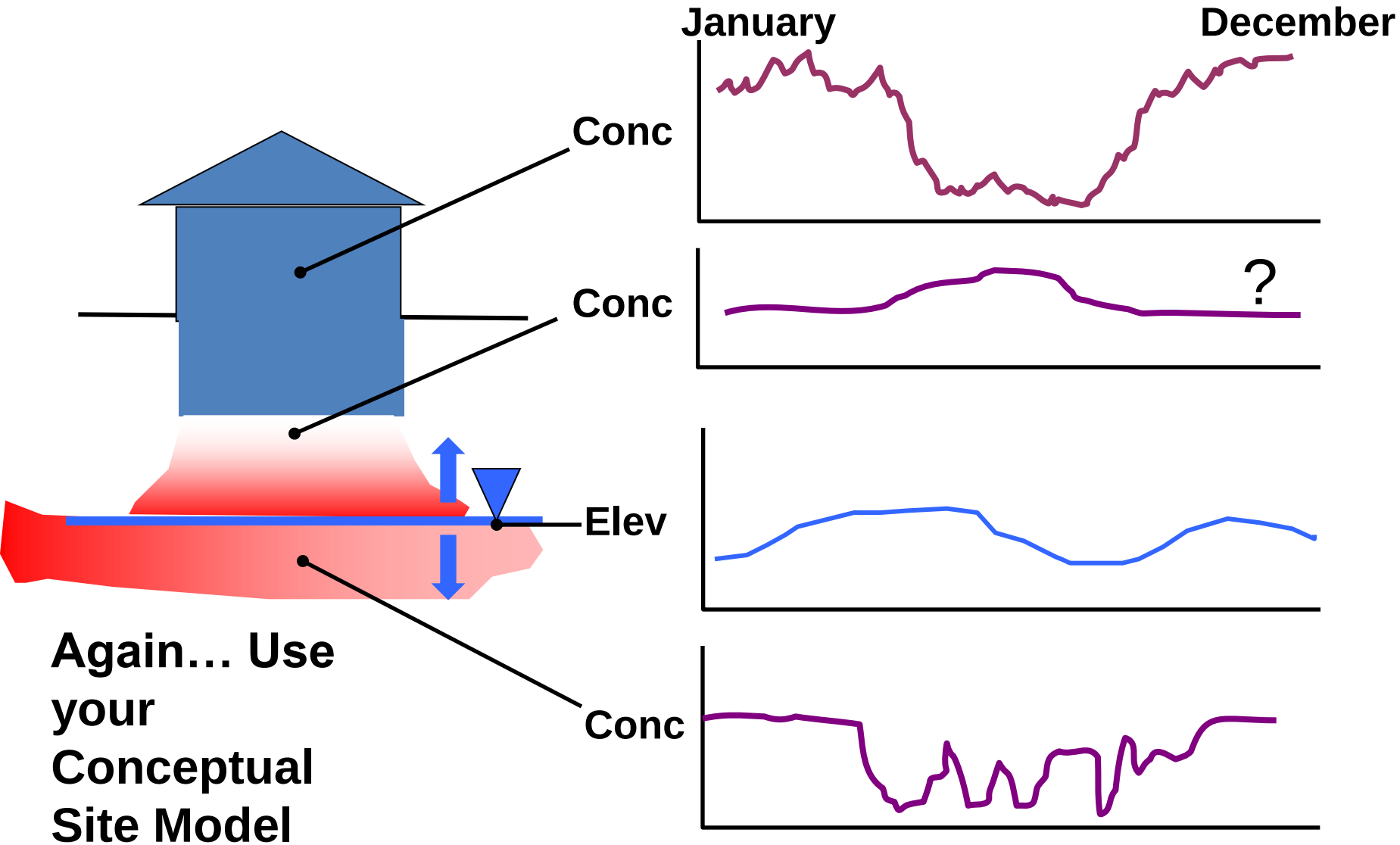
Where to Install Sub-Slab Soil Gas Probes

Minimum of 2 in normal sized home



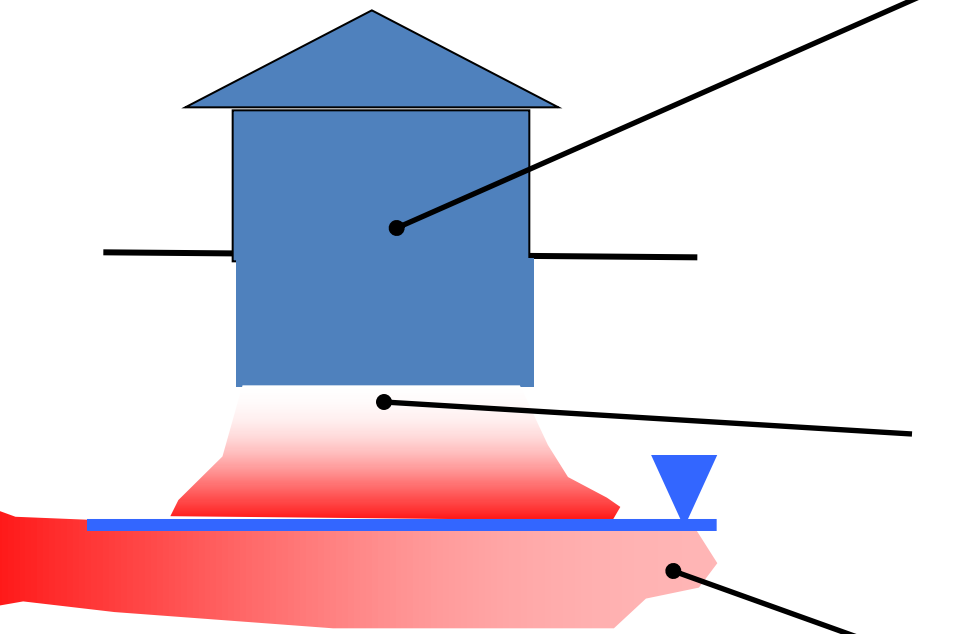
Consider your Conceptual Site Model…

When to Sample



Again… Use your Conceptual Site Model

How to Sample



TO-15 or APH Summa Canister, 24-hour TWA

Consider Outdoor Sample

Grab GC/Summa, Purge 5 probe volumes, Sample rate 100–200 mL/min

Water Table Interface Well 4+/- Rounds

Sampling Recommendations

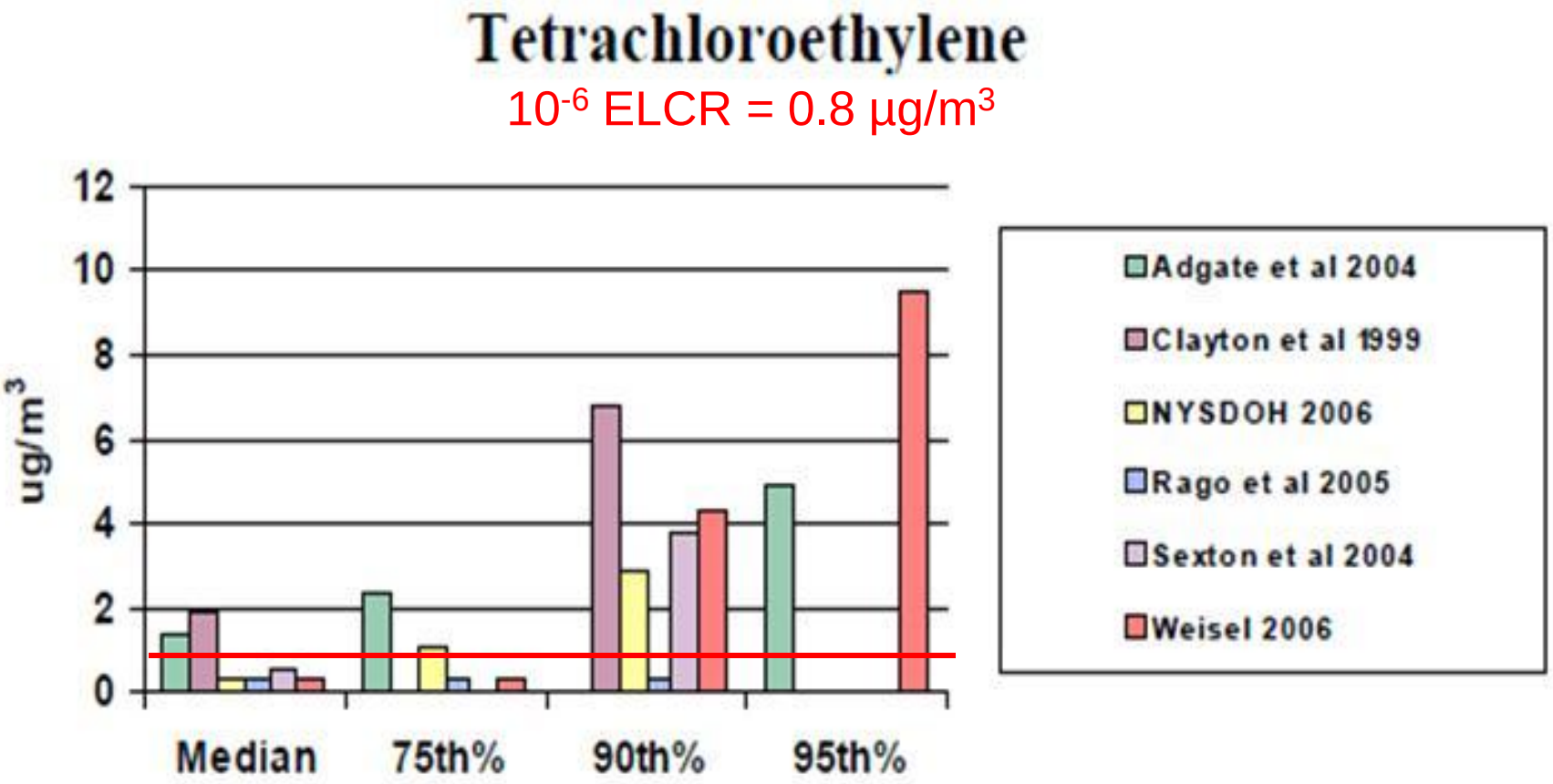
Indoor Air

- Evaluate non-site sources (indoors and out)
- Multiple rounds needed because of variability
- Target conservative conditions
  - late winter/early spring, colder outside than in, steady wind, low outdoor pressure, wet soil, high groundwater table, closed doors/windows, heating system on
- Residential: 24-hour, if possible; Commercial: 8-hour; Minimum: 4-hour

How To Determine if VOCs are from an Indoor Source?

- Unlike soil and groundwater, it is difficult to determine “background” for indoor air
- Indoor air typically has many VOCs from non-site related sources, often above risk-based concentrations
- Pre-sampling building inspection and product removal are critical steps

Could Indoor Sources Really be a Concern?



Typical Indoor Air Concentrations

Multiple Lines of Evidence Data Evaluation Tools: Threshold Values (TVs)

- Based on Typical Indoor Air Concentrations (TIACs – MassDEP 2008) and risk management criteria
- Developed for Residential Use (TV_r) and Commercial/Industrial Use ($TV_{c/i}$)
- If contaminant concentrations in indoor air are less than the applicable TV, vapor intrusion pathway is unlikely under current site conditions and use

More Data Evaluation Tools: Sub-Slab Soil Gas Screening Values

- Developed for Residential Use and Commercial/Industrial Use
- Derived by multiplying the TVs by a general sub-slab soil gas to indoor air dilution factor of 70

Multiple Lines of Evidence Evaluation

Interpreting Lines of Evidence for Presence of Current Exposure Pathways at Commercial/Industrial Locations

LINES OF EVIDENCE						
Groundwater Contaminant Levels	≤ 2x GW-2 AND			> 2x GW-2 OR		
Sub-Slab Soil Gas Contaminant Levels	≤ SG Screening Criteria AND			> SG Screening Criteria AND		
Indoor Air Contaminant Levels	Not Tested	≤ $TV_{c/i}$	> $TV_{c/i}$	Not Tested	≤ $TV_{c/i}$	>TV_r
LIKELY CURRENT PATHWAY OF CONCERN?	No	No	Un-determined	Un-determined	No	Yes

Additional Lines of Evidence: Indoor Air Data

Concentrations
- >Threshold values?
- Use of Chemicals in Building?

Basement vs. upper floors
- Should be higher in lower level(s) unless HVAC Issues or indoor sources

Chemical Forensics
- MtBE – Usually not from GW
- Petro – Check Chromatograms
- Chlorinated VOCs – Degradation Products? Cis-1,2-DCE?

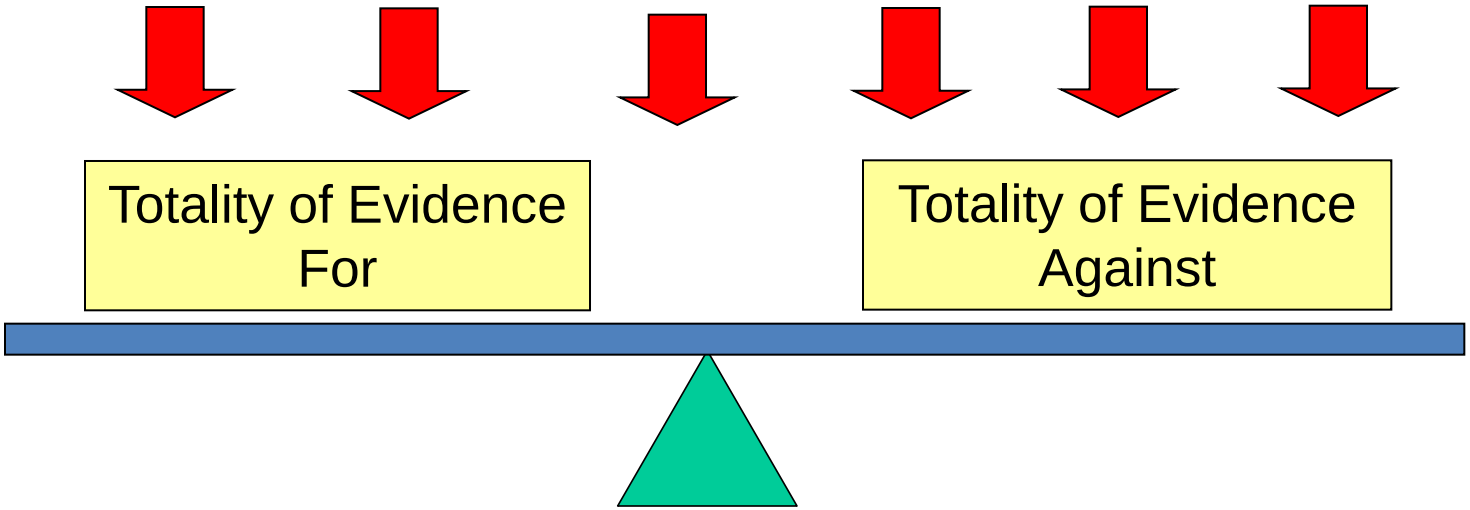
Weighing Lines of Evidence

Assemble as many lines as necessary

Conceptual Site Model

Analytical Data:
Soil
Soil Gas
Groundwater/Soil-Gas Field
Indoor Air
Ambient Air

Chemistry of Air Samples:
- Breakdown products
- In-building sources
- Outdoor air quality
- Fresh vs. weathered petro
- Basement vs. upper floors



Exposure Point Concentrations

- Limits on modeling ★
  - no modeling for indoor air EPCs for future buildings, but can be used to distinguish site-related contamination from interior sources
- Averaging from a given exposure point OK, if there is sufficient data
- In a residence, develop a separate EPC for basement and the 1st floor
- Any basement with at least 7 ft. of head room in an occupied residential dwelling should be considered a potential living or working space
- Basements of any height with evidence of current activity should be considered living or working space if definition met

Critical Exposure Pathway (CEP) Defined

CEPs are those routes by which OHM released at a disposal site are transported, or are *likely* to be transported, to human receptors via:

(a) vapor phase emissions of measurable concentrations of OHM into the living or working space of a pre-school, daycare, school or occupied residential dwelling, or

(b) ingestion, dermal absorption or inhalation of measurable concentrations of OHMs from drinking water supply wells located at and servicing a pre-school, daycare, school or occupied residential dwelling.

New Regulatory Definitions

Living or Working Space ★

Finished & unfinished space

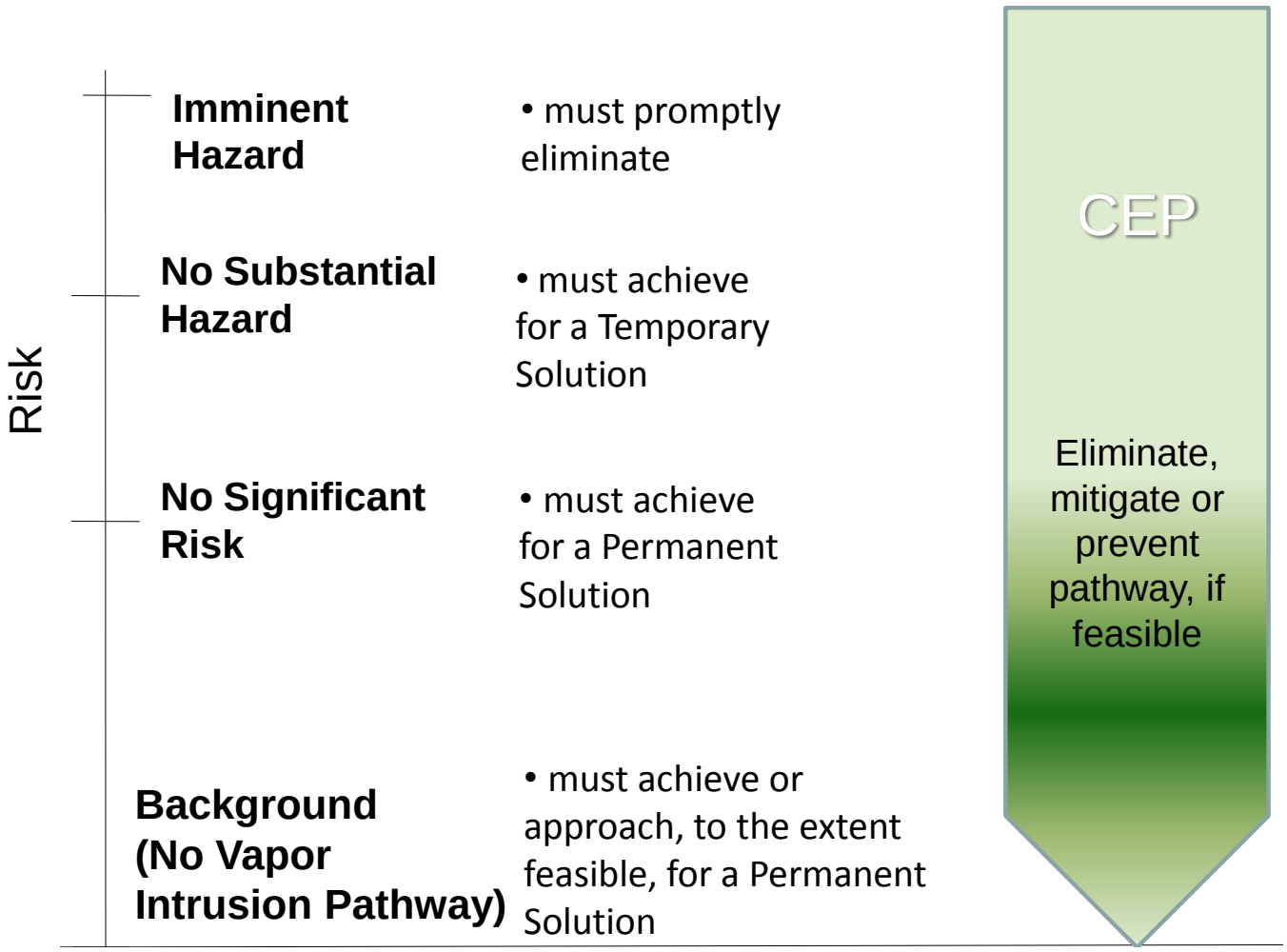
- Within Daycare, Child Care Center, School or Residential Dwelling
- Evidence of potential for use >1 hour at a time

Crawl spaces, basements used for storage or periodic laundry are NOT Living or Working Space

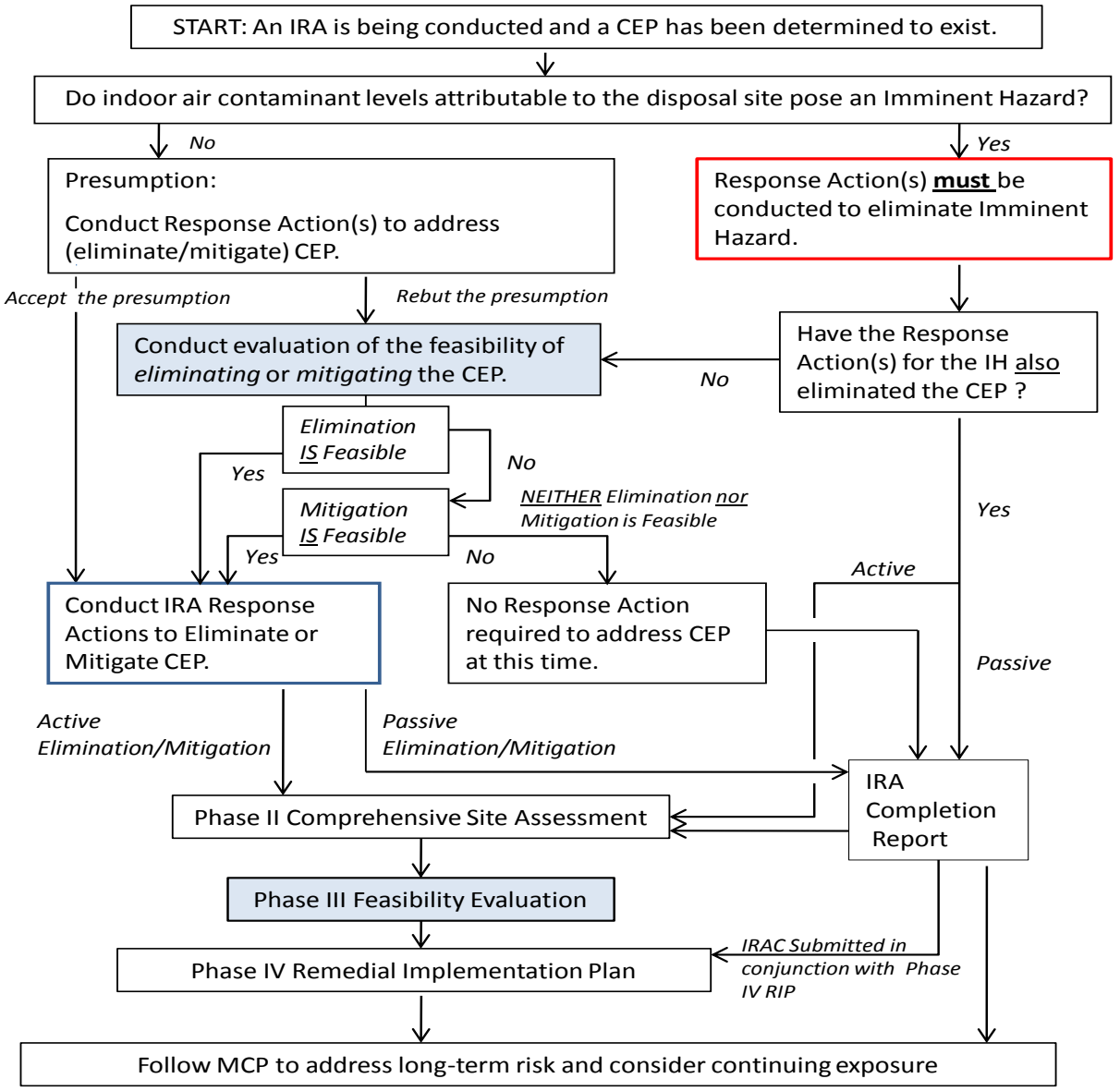
Daycare ★

- Licensed by the state
- Does not include intermittent or sporadic care
- See details at 30.0006(12)

Risk and Required Mitigation



Addressing Critical Exposure Pathways from Vapor Intrusion



CEP Feasibility Evaluations

Expedite consideration of cost-effective measures to eliminate, reduce or prevent exposures in schools, day cares and homes

Generally Feasibly Response Actions to Address CEP

- Installation of an active SSD system

Generally Infeasible Response Actions

- **At owner-occupied residences with a CEP that does not pose a Significant Risk**

  response actions to eliminate or mitigate CEP conditions are infeasible if the owner-occupant will not agree to address CEP conditions

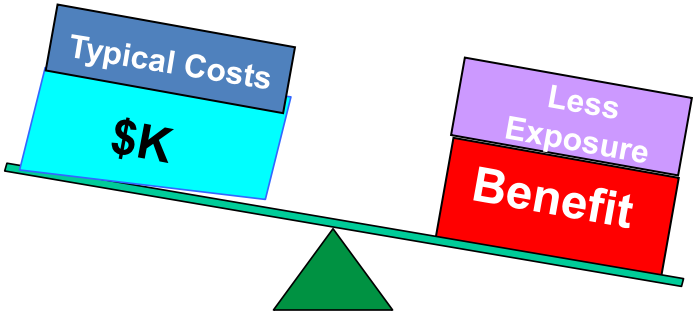
Rebutting the MCP presumption for CEP Elimination/Mitigation

Cost-benefit analysis should consider and balance between risk-reduction benefits:

- Substantial if VI poses Significant Risk
- Consider uncertainty (evaluate amount of existing data)
- Consider toxicity and persistence

and costs:

- SSD system costs are typically relatively low

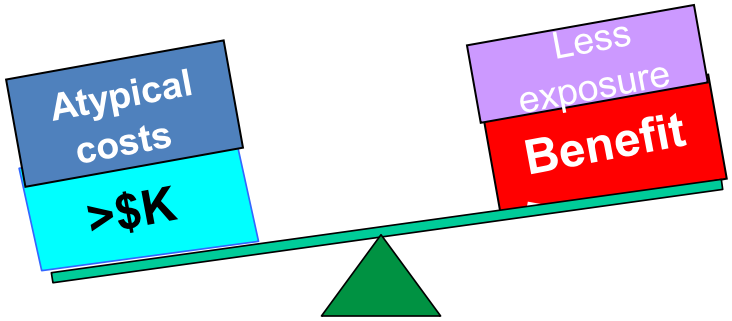


However….

Rebutting the MCP presumption for CEP Elimination/Mitigation

Costs could increase significantly if:

- reconstruction of basement walls or pouring of new slabs,
- installation of raised floor for SSD system installation because of a high groundwater table,
- excessive number of extraction points and fans due to poor sub-slab communication



Clearer Provisions for Closure of IRAs Addressing CEPs (310 CMR 40.0427(1))

- CEP is eliminated using passive measures
- IRA feasibility study concludes addressing CEP not feasible
- Phase III feasibility study concludes addressing CEP not feasible
- When CEP mitigation is incorporated into Comprehensive Response Actions
- When a Permanent or Temporary Solution is achieved – may include AEPMM operation as Permanent Solution with Conditions

Myth Buster: CEP mitigation doesn't mean *forever*.

Hypothetical

- During an assessment-only IRA, VOCs were detected in groundwater and sub-slab soil gas at an occupied residential building.
- Indoor air sampling indicated detectable levels of VOCs in the basement, but not the first floor of the building.

Here is a picture of the basement:

Hypothetical

Which actions would be required under the MCP for this space? Choose all that apply:

A) Feasibility of eliminating/mitigating CEP
B) IH evaluation
C) Phase II risk characterization – current use
D) Phase II risk characterization – future use as laundry/storage area
E) Phase II risk characterization – unrestricted future residential use
F) Reclassification as Tier I ( ?)

Hypothetical

Would your answers change if the basement looks like this?

Vapor Intrusion Mitigation Measures and Closure Monitoring

Vapor Intrusion Mitigation Guidance

- Promotes source control and removal as the best long-term approach to address vapor intrusion
- Promotes use of active sub-slab depressurization (SSD) systems as effective and reliable for vapor intrusion mitigation
- Outlines various available vapor intrusion mitigation approaches
- Provides recommendations for vapor intrusion mitigation monitoring – differences between active systems and passive measures

Recommendations for VI Mitigation System Monitoring

Sampling to Demonstrate Effectiveness

Active Systems	Verify pressure differential across slab Perform at least one round of indoor air sampling during heating season
Passive Measures	Sampling regimen depends on concentrations of contaminants in the groundwater, sub-slab soil gas and/or indoor air PRIOR to system installation

Recommendations for VI Mitigation System Monitoring

Maintenance and Monitoring – in addition to remote telemetry

(Including AEPMM Monitoring for Sites with Permanent Solutions with Conditions, Temporary Solutions or ROS, if applicable)

Active Systems	Differential pressure checks, if differential pressures are at levels verified previously with indoor air monitoring If differential pressure not maintained, perform indoor air monitoring Annual checks for pressure drops and fan operation.
Passive Measures	Perform indoor air sampling at frequency commensurate with contaminant concentrations and observed temporal variability

Recommendations for VI Mitigation System Monitoring

Monitoring to Support Closure

Active Systems

Perform at least 3 indoor-air sampling events over 2 years

at least one round during heating system, at least one round during other worst-case conditions (shallow groundwater)

with system temporarily off for sampling

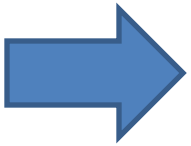
Passive Systems

Perform 3 indoor-air sampling events over 2 years, with one round during the heating season, with exhaust stack capped during sampling

Future Use Considerations for VI Sites

Method 1 GW-2 Standards don't apply in absence of an occupied building or plan for a building

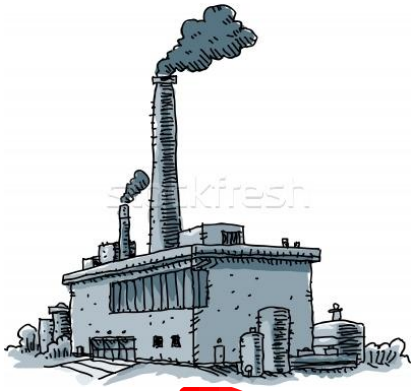
Method 1 Soil Standards are not protective for vapor intrusion



Potential risk of vapor intrusion from post-closure building construction

Closure – Future Use Hypothetical

- Contamination source is eliminated (dry well & soil removal)
- Contaminated soil and groundwater treated with ISCO
- Migration is controlled – plume is stable
- Downgradient property is a vacant lot



Type of MCP closure for vacant lot property

A) Permanent Solution with No Conditions

B) Permanent Solution with Conditions & AUL

C) Permanent Solution with Conditions, No AUL

D) Temporary Solution

PCE plume 60 ug/L

Case Study

- On-site building demolished in October 2005
- 199 tons of soil excavated from source areas
- Up to 6.6 mg/kg PCE detected in post-excavation soil samples (<S-1/GW-2/GW-3)
- Up to 420 ppb PCE in groundwater (< GW-3)
- RAO submitted in January 2006
- New residence built at site post-RAO

Case Study

- Five monitoring wells installed (by MassDEP) to depth of 20 feet in May 2009
- 5.8 – 340 µg/l PCE detected in groundwater
- Indoor air samples collected from basements of two residences in June 2009
- 791 – 2,680 µg/m^3 PCE detected in indoor air
- IRA initiated under new RTN to abate Imminent Hazard

Closure Options

Sub-slab system installed to operate as Active Exposure Pathway Mitigation Measure

- Operating regimen established
- Effective at addressing IH indoor air exposures (OK for 45-day shut-down)
- Remote telemetry

Type of MCP closure 

A) Permanent Solution with No Conditions

B) Permanent Solution with Conditions & AUL

C) Permanent Solution with Conditions, No AUL

D) Temporary Solution

Questions?

Contact Information

gerard.martin@state.ma.us

catherine.wanat@state.ma.us