Data Evaluation

Introduction

VI Framework

VI Receptor Evaluation (Stage 1)

VI Investigation (Stage 2)

Break

MLE & Data Evaluation

Petroleum Hydrocarbon

Mitigation (Stage 3)

OMM (Stage 4) & Termination (Stage 5)

Data Evaluation

Topics to be discussed:

Data Usability

Multiple Lines of Evidence

- Primary Factors
- Secondary Factors

Background Investigations

- Indoor Air
- Ambient (outdoor Air)

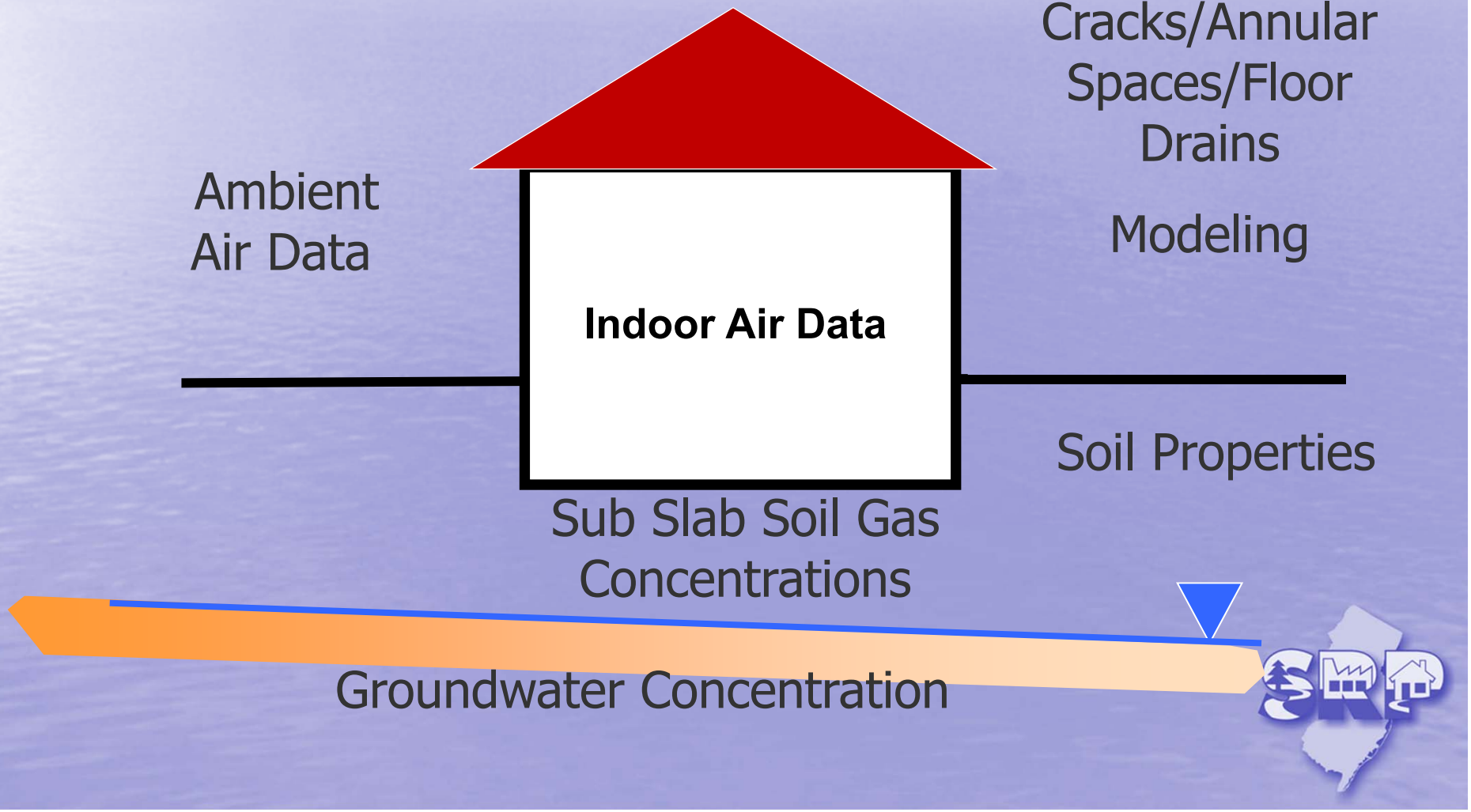
VI Scenarios

Data Usability

Valid and Representative Data

- Appropriate sampling approach?
- Proper sample collection?
- Equipment not tampered with?
- Were the data reviewed?
- Was background considered?
- Were issues that might impact usability addressed?

Lines of Evidence



Multiple Lines of Evidence (MLE) Approach

Principle Concern: Is the VI Pathway from a Discharge to a Potentially Exposed Person Complete?

MLE Primary Factors:

- Indoor Air (and Background)
- Groundwater Data
- Site-Specific Contaminants of Concern
- Sub Slab Soil Gas Samples
- Ambient (outdoor) Air

Multiple Lines of Evidence (MLE) Approach

MLE Secondary Factors:

- Building Survey
- Building Characteristics
- Exterior Soil Gas Samples
- Soil Properties
- Modeling

Use these primary and secondary factors to refine your Conceptual Site Model

Background Sources

- Consumer activities
- Household Products
- Building materials and furnishings
- Laboratory contaminants
- Others?

Indoor Air Sources: Appendix H

Paints

Gasoline Powered Equipment

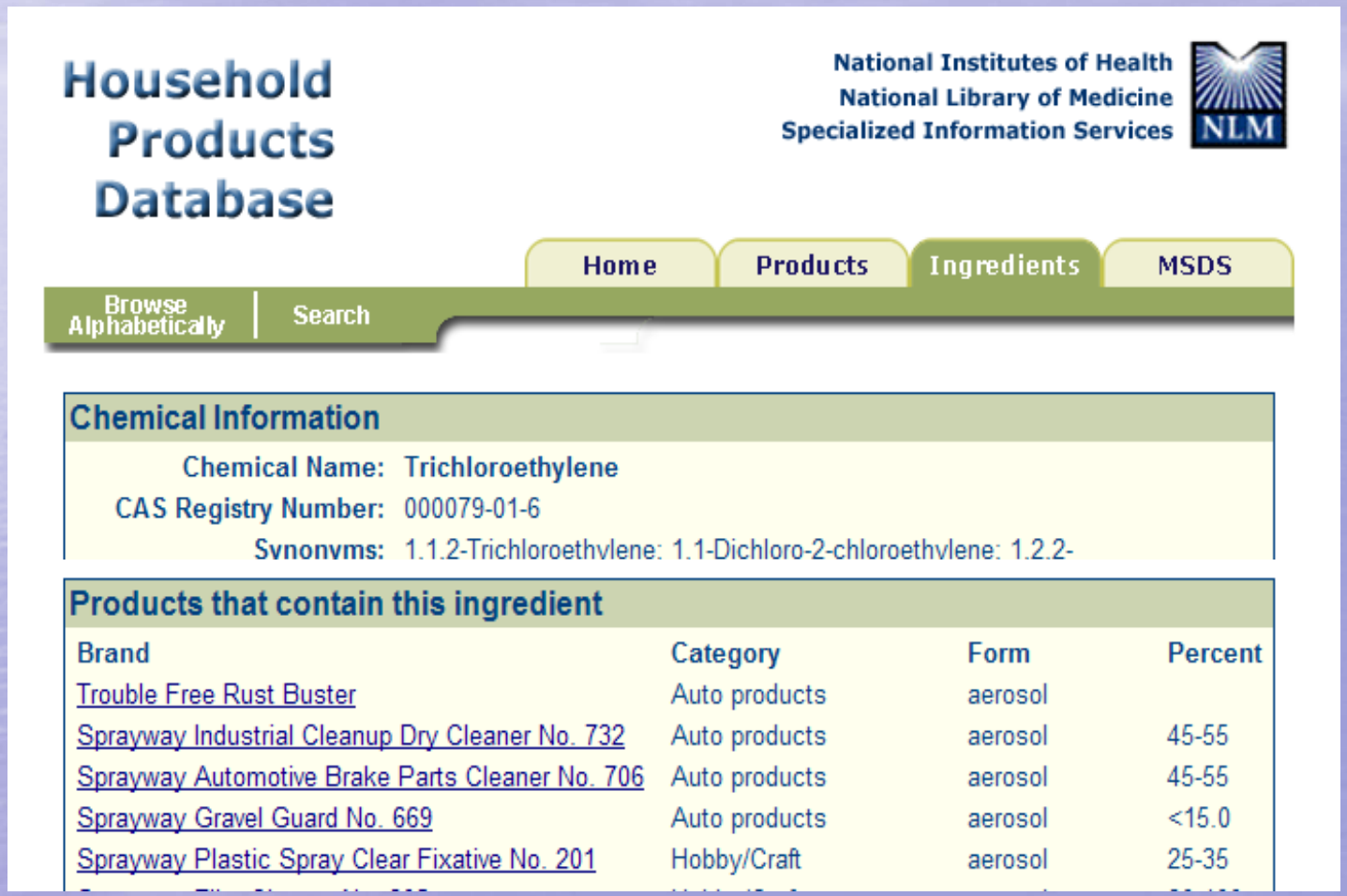
Tobacco Smoke

Glues/Adhesives

Dry Cleaning

Cleaners/ Solvents

Chemicals in Household Products



http://hpd.nlm.nih.gov/

Background Levels of VOCs in NJ Homes: Appendix G

Table G-4
Summary of Ambient Indoor Levels and New Jersey Median Background Concentrations of Volatile Contaminants in Homes (µg/m3)[a]

Chemical	CAS No.	Range of median values	Representative median indoor air concentrations	Range of 90th percentile values
Acetone (2-Propanone)	67-64-1	6-34	34	62-110
Benzene	71-43-2	<1.6-3.1	2	5.2-15
Bromodichloromethane (Dichlorobromomethane)	75-27-4	<RL		<RL
Bromoethene (Vinyl bromide)	593-60-2	<RL		<RL
Bromoform	75-25-2	<RL		<RL
Bromomethane (Methyl bromide)	74-83-9	<RL		0.6[c]
1,3-Butadiene	106-99-0	<RL		1.6[b]
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	1.5[b];2.7-3.5[d]	4	6.7[b];9.6-16[d]
Carbon disulfide	75-15-0	0.13[b]		0.86[b]
Carbon tetrachloride	56-23-5	<0.25-0.6	0.6[f]	0.8-0.9
Chlorobenzene	108-90-7	<RL		<RL
Chlorodibromomethane (Dibromochloromethane)	124-48-1	<RL		<RL
Chloroethane	75-00-3	<RL		<RL
Chloroform	67-66-3	<0.25-2.4	1	1.4-3.4[d];4.4[b]
Chloromethane (Methyl chloride)	74-87-3	0.5-1.4	1	1.8-3.3
3-Chloropropene (Allyl chloride)	107-05-1	<RL		<RL
2-Chlorotoluene (o-Chlorotoluene)	95-49-8	<RL		<RL
Cyclohexane	110-82-7	0.7-0.8[d];4.5[b]	0.7	2.8-8.1[d];15[b]

The representative median indoor air concentrations are an acceptable line of evidence when evaluating results

Groundwater Data

A delineated groundwater plume (or subsurface soil impacts) may lead to a list of Contaminants of Concern that can be used to evaluate the VI data

- Must include potential degradation products
- Initial round of VI samples should include the full list of parameters
- With appropriate technical justification a reduced COC list can be employed

Proper screened interval?

Perched/clean water lens?

Sub-slab Soil Gas Data

An Important Evaluation Data Set

Compare to IA Samples

- Same COCs? If yes - path may be complete
- Concentration Gradient? Are concentrations in indoor air lower that SSSG? Look for attenuation.
- Same relative ratios of COCs in IA and SSSG?
- Are there preferential pathways?

Background Air Data

Ambient (Outdoor) Air Samples

Collect one sample during Indoor Air Sampling

- Evaluate for potential impacts of indoor air from outside air
- Mitigation not required when Ambient > Indoor Air

Indoor Air Background

Refer to data available in Appendix G

- Do not subtract background from IA data to determine compliance

Building Characteristics

Review the Building Survey

- Potential Background Sources
- Potential Preferential Pathways
- HVAC and other building operational issues
  - Positive Air Pressure may minimize VI
  - Dirt Floors/Crawl Spaces
  - Ventilation Fans/Open doors
  - Sump pumps

Preferential Pathways

Foundation Cracks

Fractured Soil or Rock

Soil Properties

Soil permeability

- Most important factor in movement of vapor through soil
- Generally, smaller the grain size the less permeable the soil unless secondary porosity (i.e., fractured clays) increases permeability

Soil moisture content

- Presence of moisture in soil decreases the rate of vapor intrusion by decreasing the soil air space which inhibits vapor movement

Vapors migrate fastest through coarse dry materials

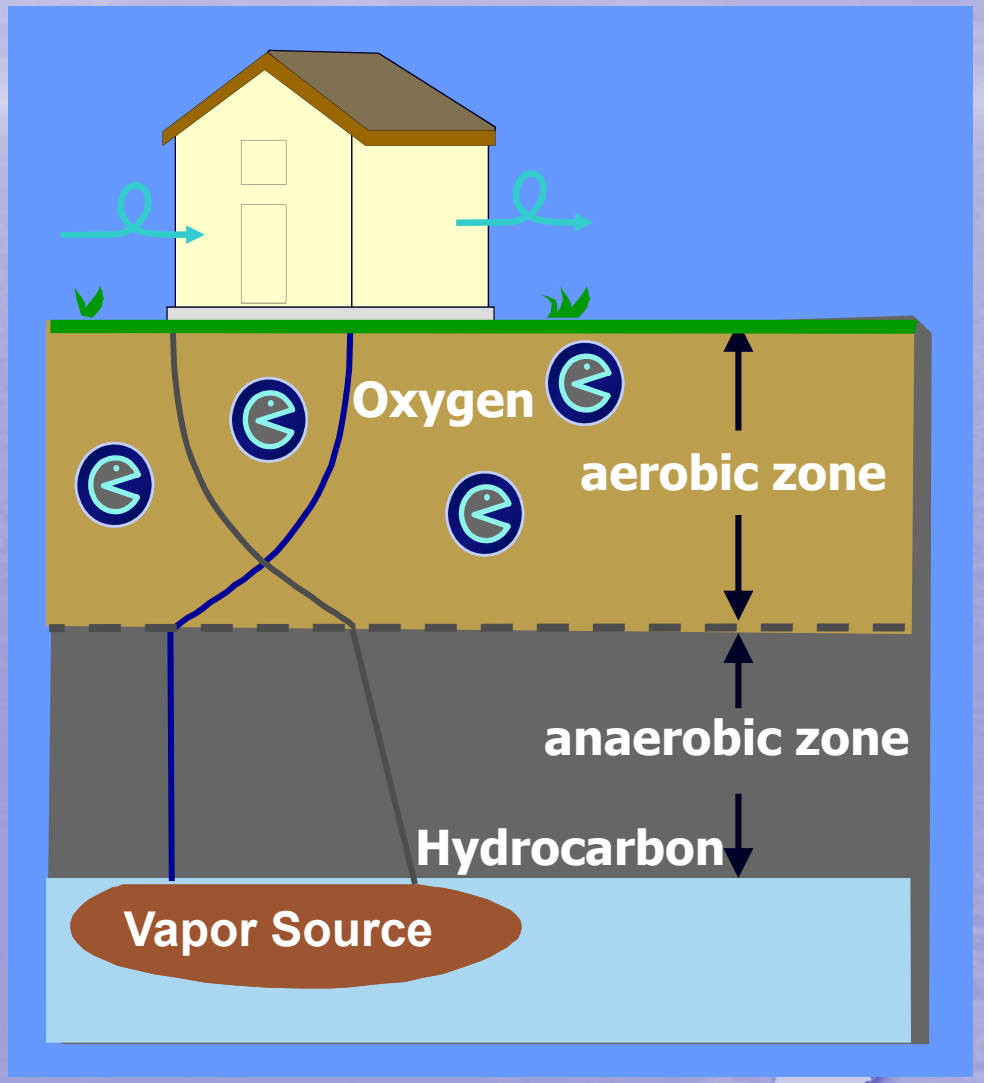
Vapor Intrusion Modeling Overview

Advantages:

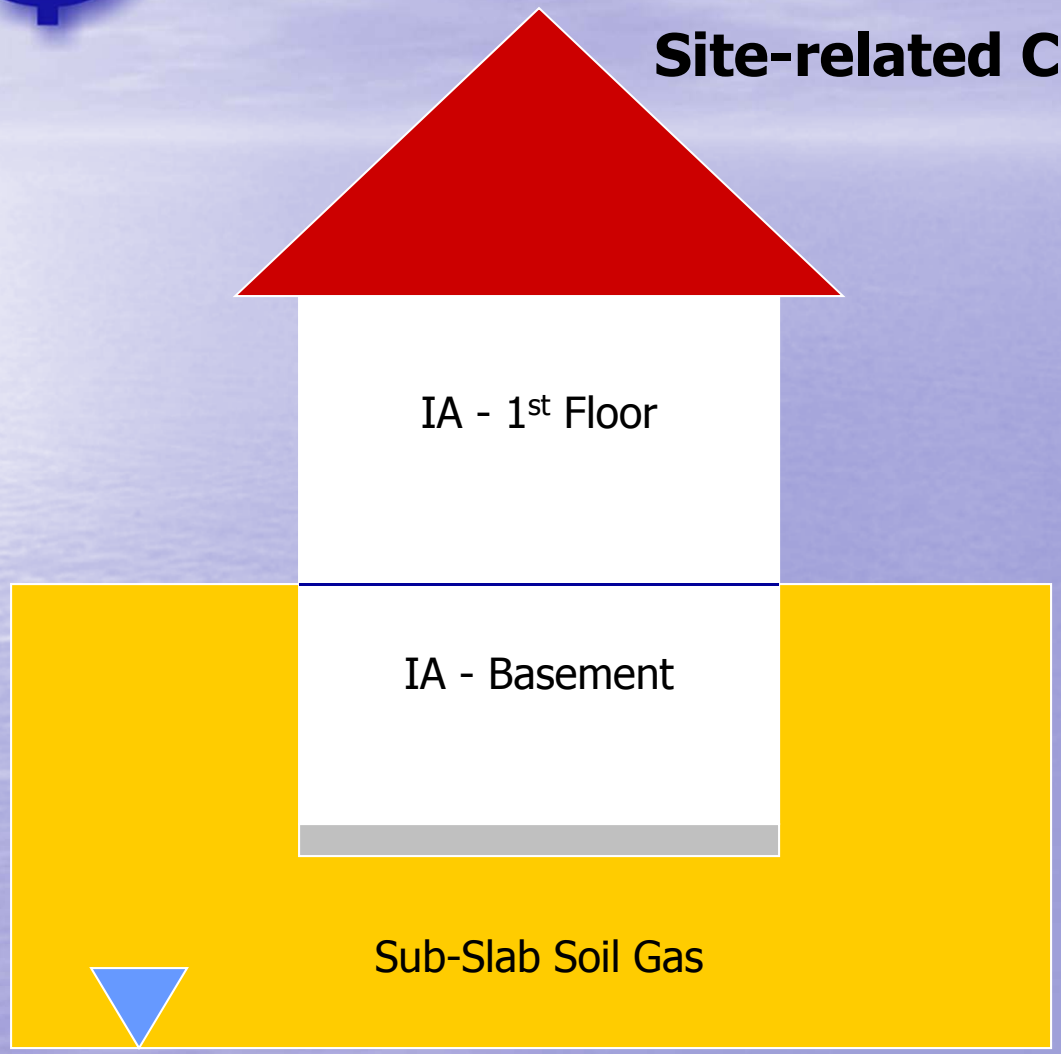
- Inputs are groundwater, soil, soil gas, NAPL data
- Relatively easy

Disadvantages:

- Which Version to Use?
- No Validation – Erroneous Conclusions
- Often Too Restrictive
- Very user definable to a potential fault



Vapor Intrusion Scenarios



Site-related Contaminants of Concern

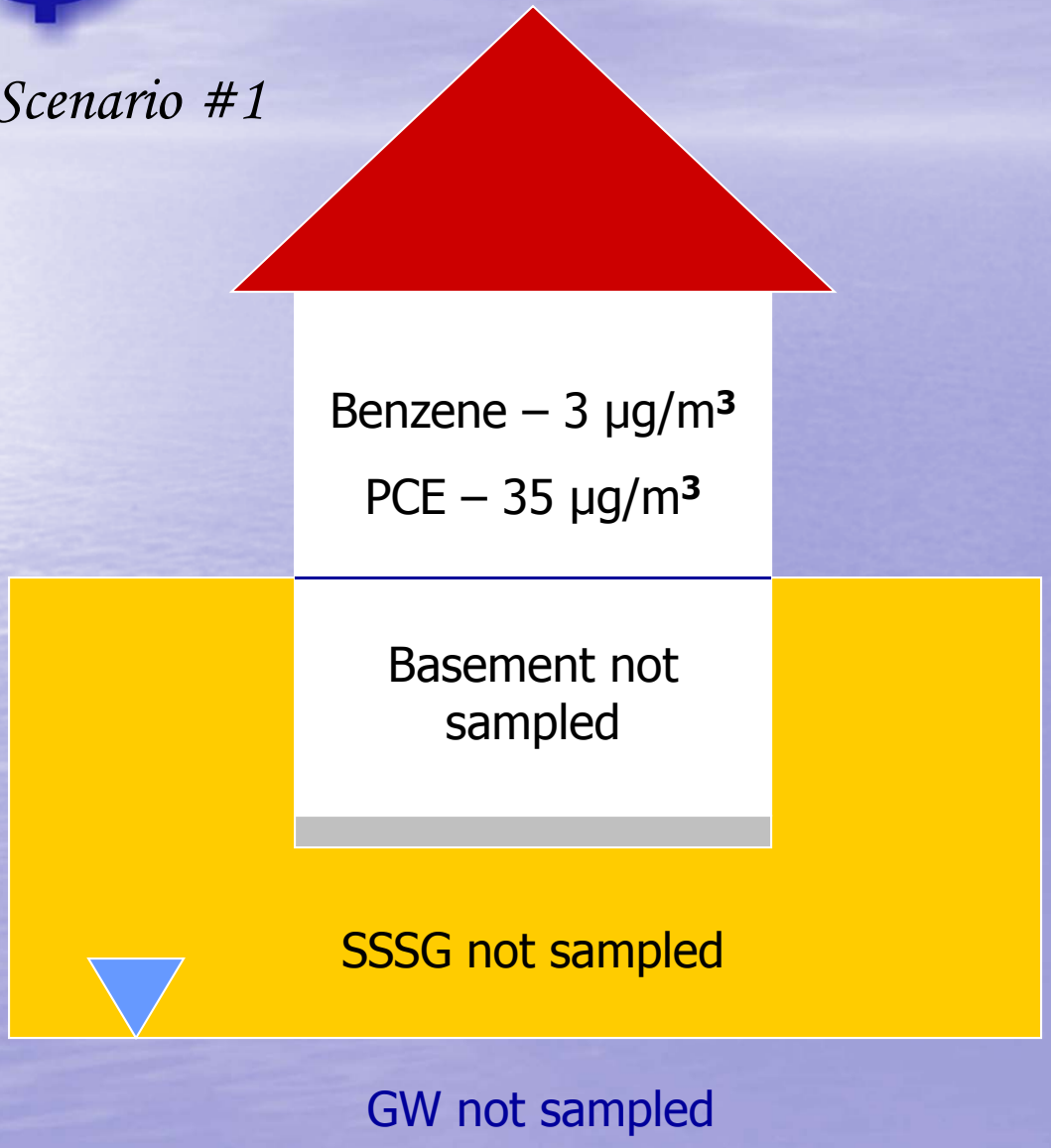
- Tetrachloroethene (PCE)
  - GWSL – 1 µg/L
  - SGSL – 34 µg/m^3
  - IASL – 3 µg/m^3
  - RAL – 30 µg/m^3
- 1,1,1-Trichloroethane
  - GWSL – 2,300 µg/L
  - SGSL – 51,000 µg/m^3
  - IASL – 1,000 µg/m^3
  - RAL – N/A

Non-COC

- Benzene
  - GWSL – 15 µg/L
  - SGSL – 16 µg/m^3
  - IASL – 2 µg/m^3
  - RAL – 14 µg/m^3

What Would the LSRP Do?

Scenario #1



ISSUES:

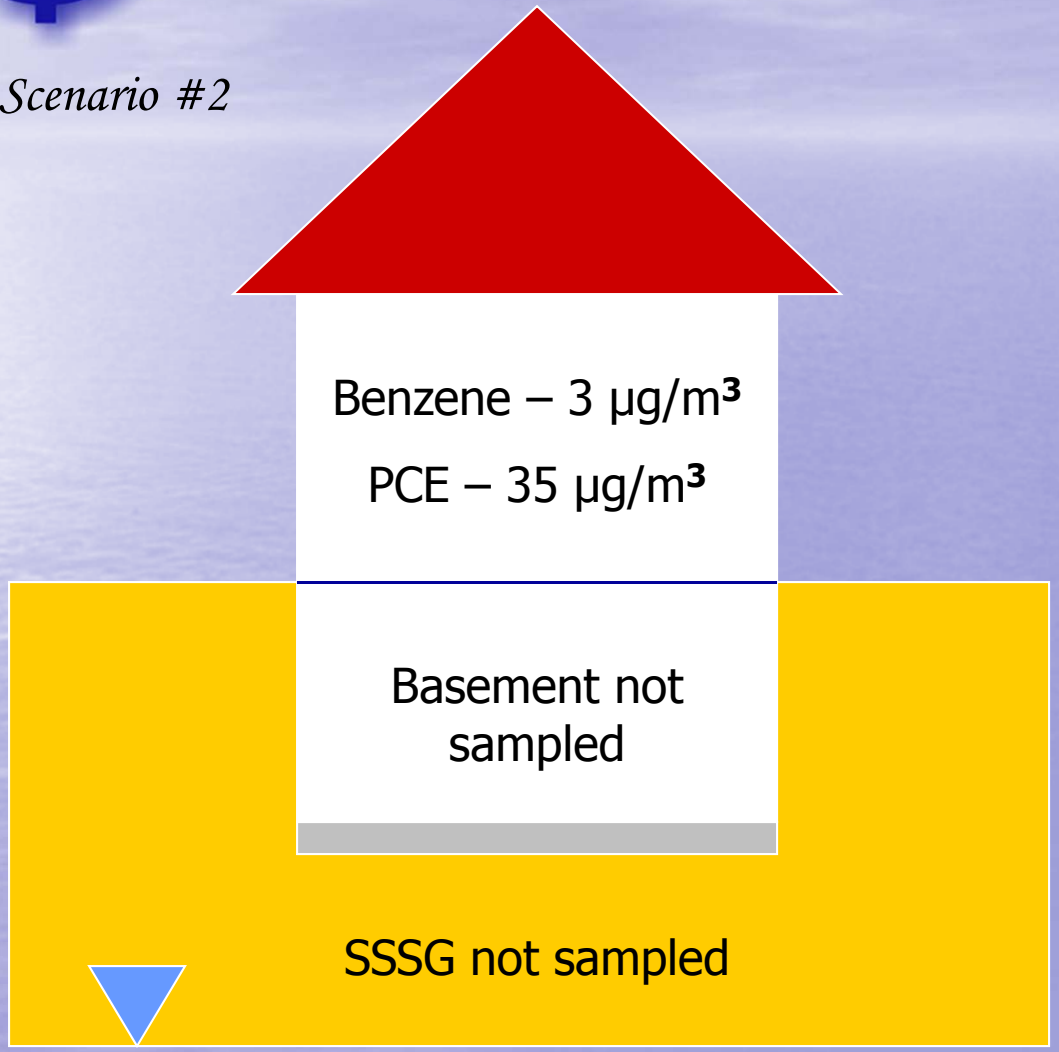
- IA COC > RAL
- IA non-COC > IASL
- SG & GW not sampled
- Status of VI Pathway unknown

ANSWER:

Investigate

What Would the LSRP Do?

Scenario #2



ISSUES:

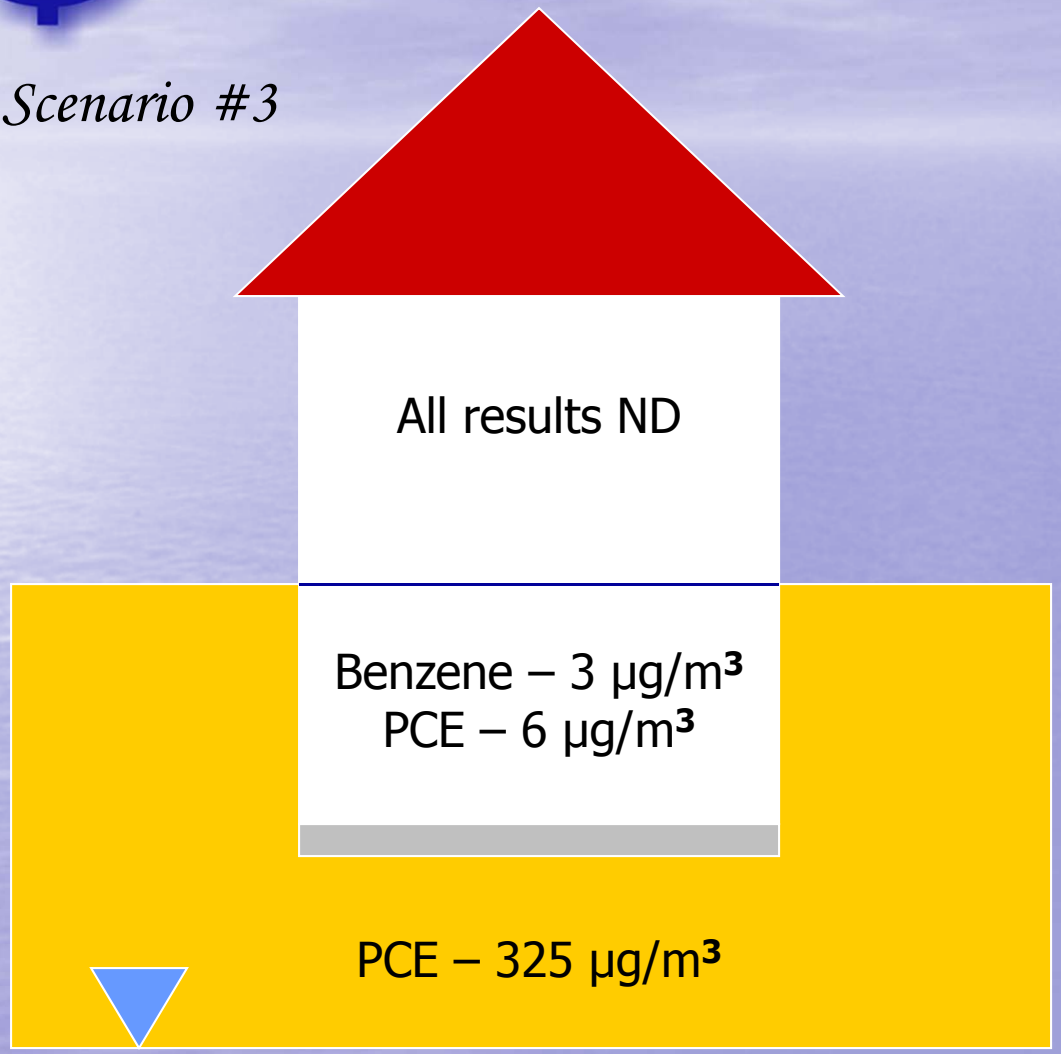
- IA COC > RAL
- IA non-COC > IASL
- GW COC > GWSL
- Status of VI Pathway still unknown

ANSWER:

Investigate

What Would the LSRP Do?

Scenario #3



ISSUES:

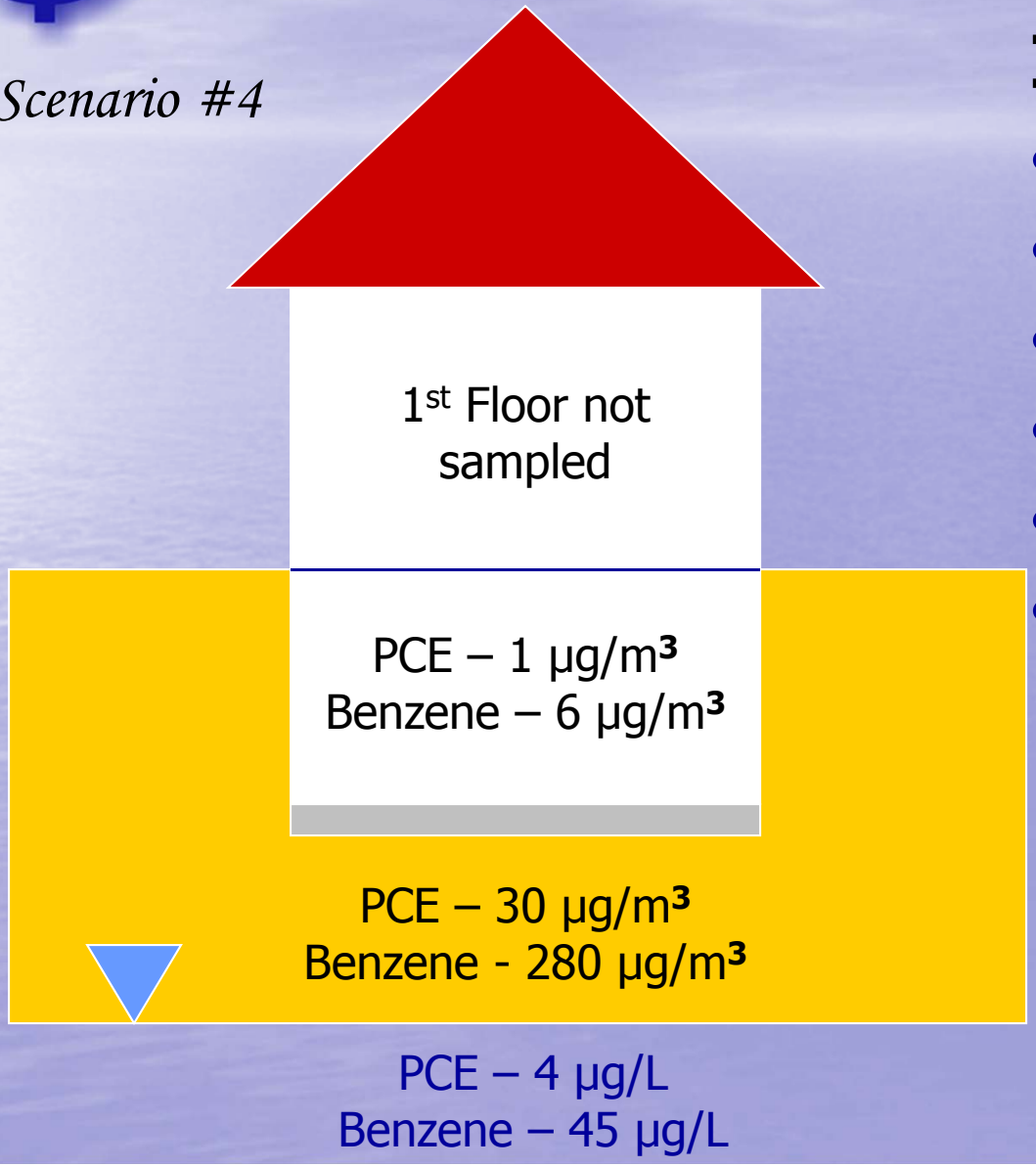
- IA COC > IASL
- IA non-COC > IASL
- 1st Floor IA results ND
- SSSG COC > SGSL
- GW COC > GWSL
- VI Pathway complete

ANSWER:

VC

What Would the LSRP Do?

Scenario #4



ISSUES:

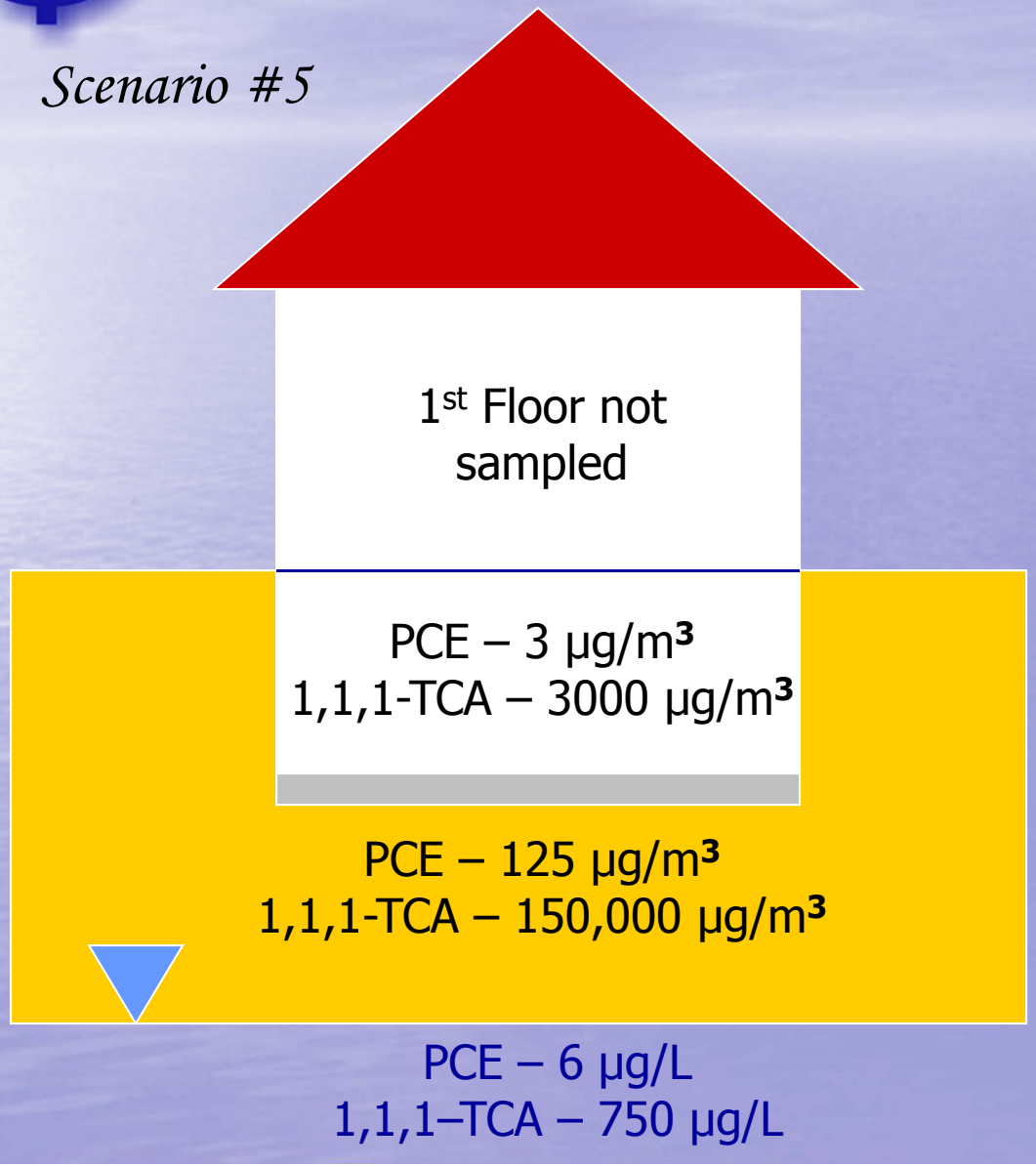
- IA COC < IASL
- IA non-COC > IASL
- SSSG Non-COC > SGSL
- GW Non-COC > GWSL
- COCs well documented
- VI Pathway complete

ANSWER:

VC, but . . .

What Would the LSRP Do?

Scenario #5



ISSUES:

- IA COC > IASL
- SSSG COC > SGSL
- GW COC > GWSL
- RAL?

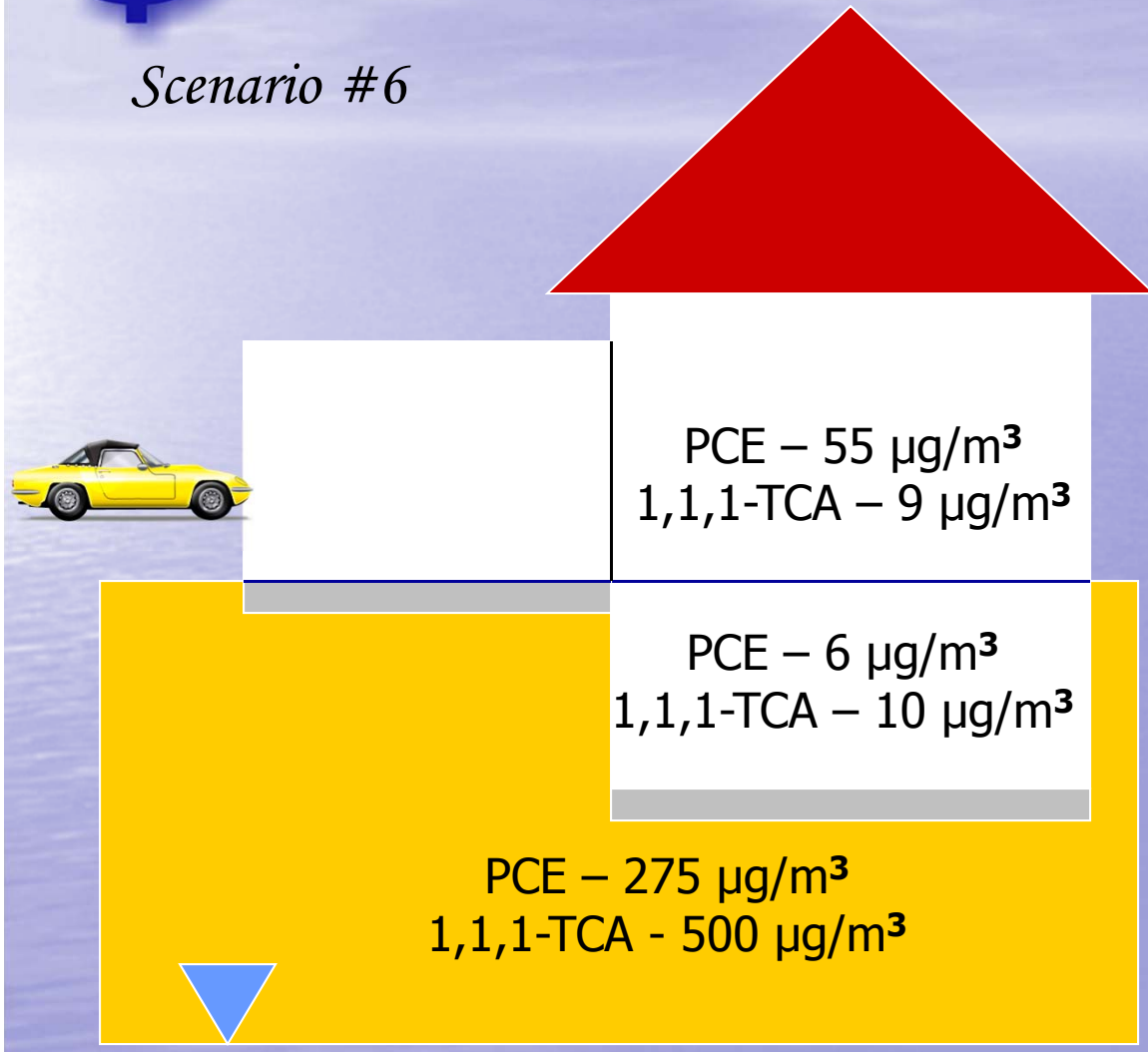
ANSWER:

Request

RAL

What Would the LSRP Do?

Scenario #6



ISSUES:

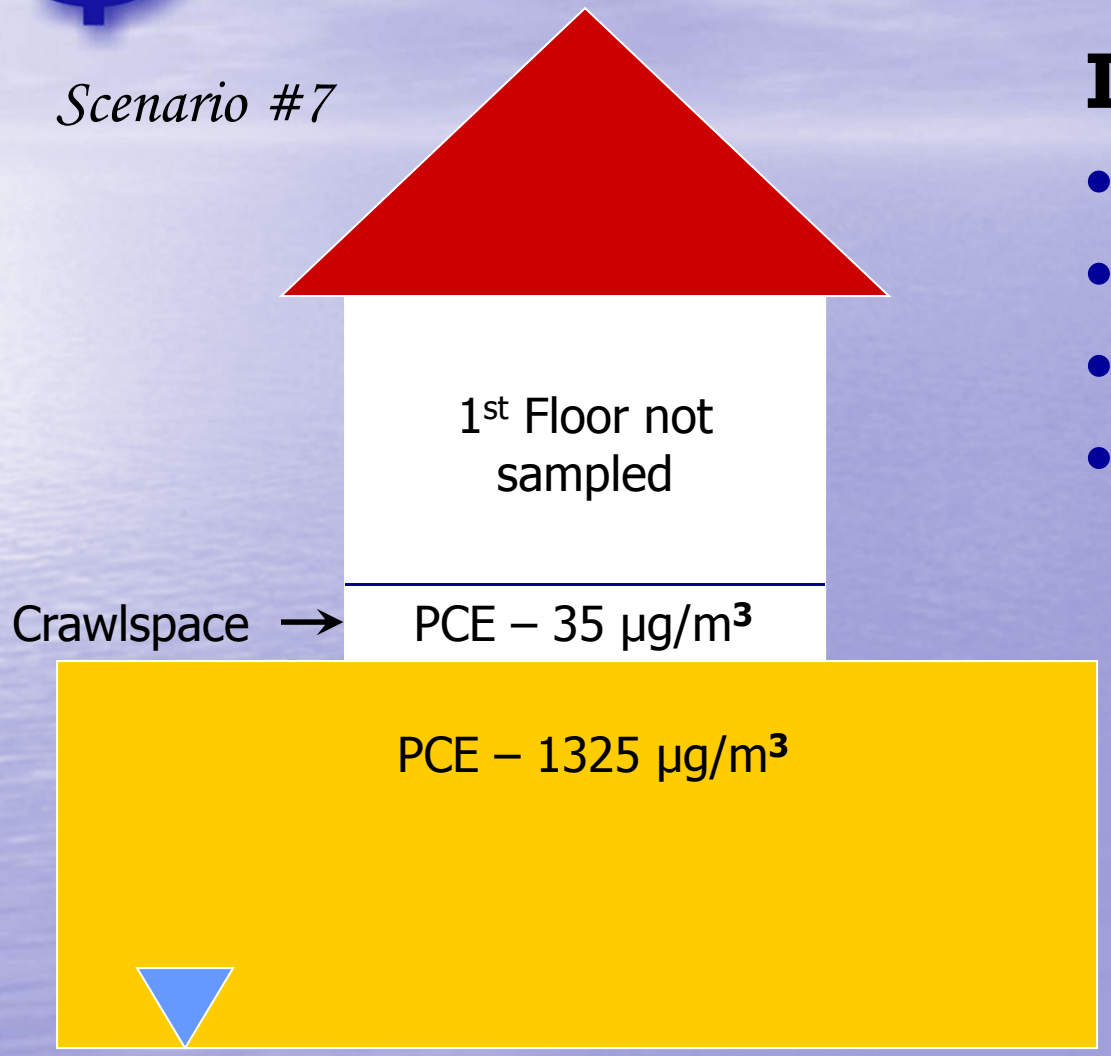
- 1st Floor IA COC > RAL
- SSSG COC > SGSL
- GW COC > GWSL
- VI Pathway complete?
- Background sources?
- MLE

ANSWER:

VC

What Would the LSRP Do?

Scenario #7



ISSUES:

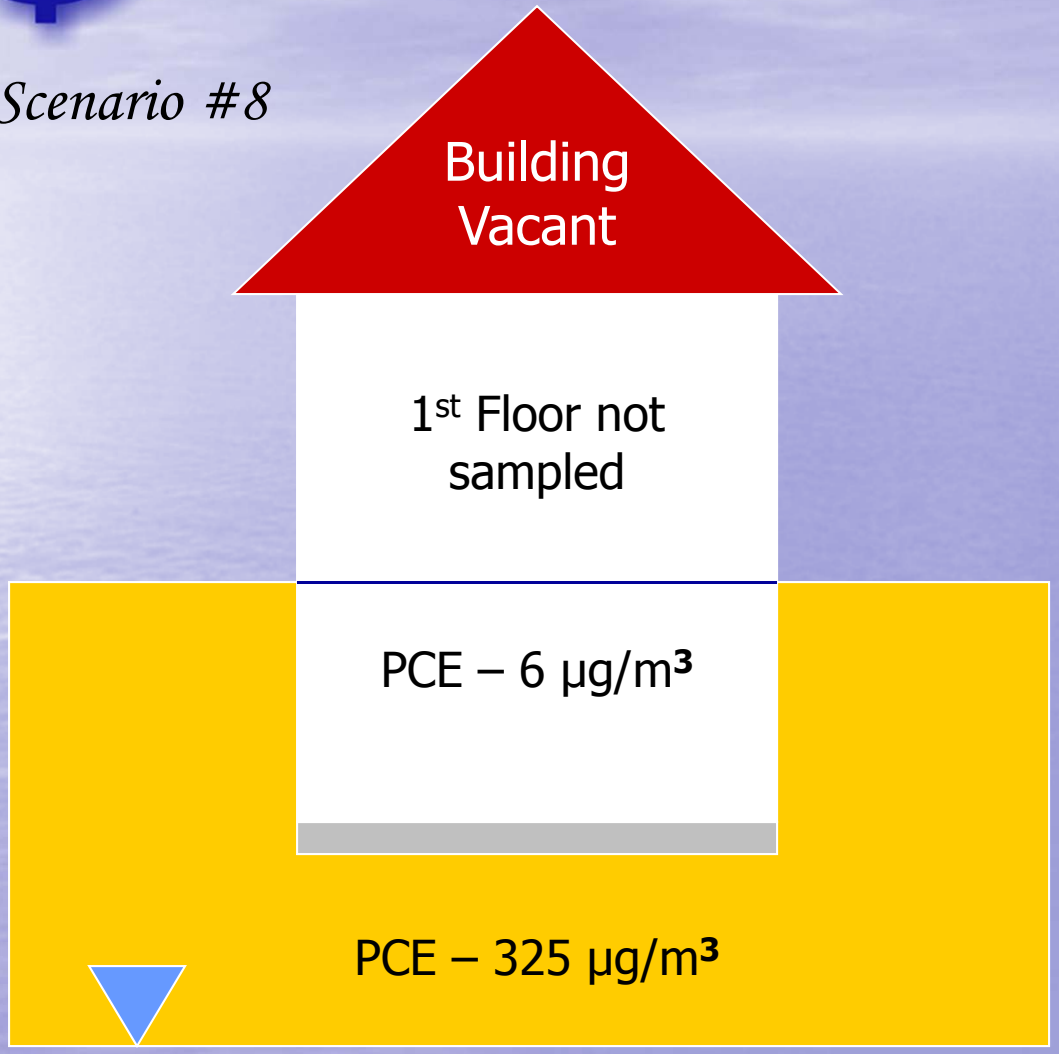
- Crawlspace air > IASL
- 1st floor IA not sampled
- SSSG & GW COC > SLs
- VI Pathway unknown

ANSWER:

Investigate

What Would the LSRP Do?

Scenario #8



ISSUES:

- IA COC > IASL
- SSSG & GW COC > SLs
- VI Pathway complete
- How to monitor future use?
- Off-site vs. onsite
- Mitigation warranted

ANSWER:

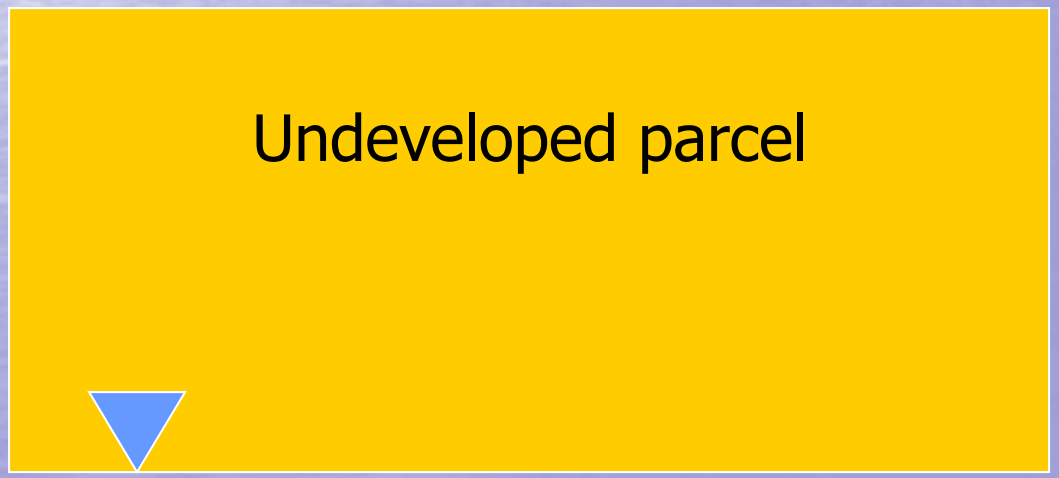
VC

What Would the LSRP Do?

Scenario #9

ISSUES:

- Future use?
- VI investigation warranted if use changes



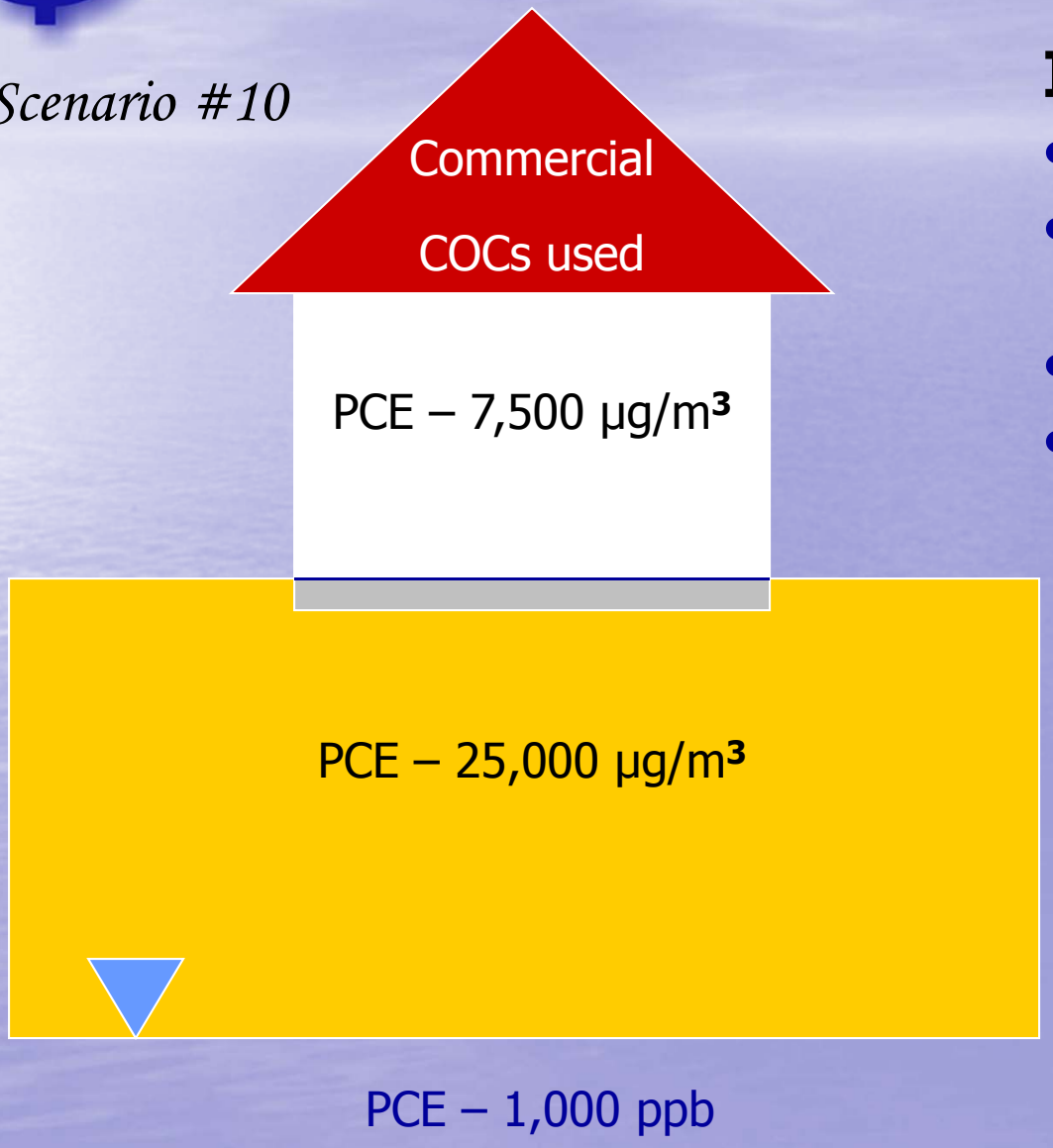
PCE – 1,000 ppb

ANSWER:

??

What Would the LSRP Do?

Scenario #10



ISSUES:

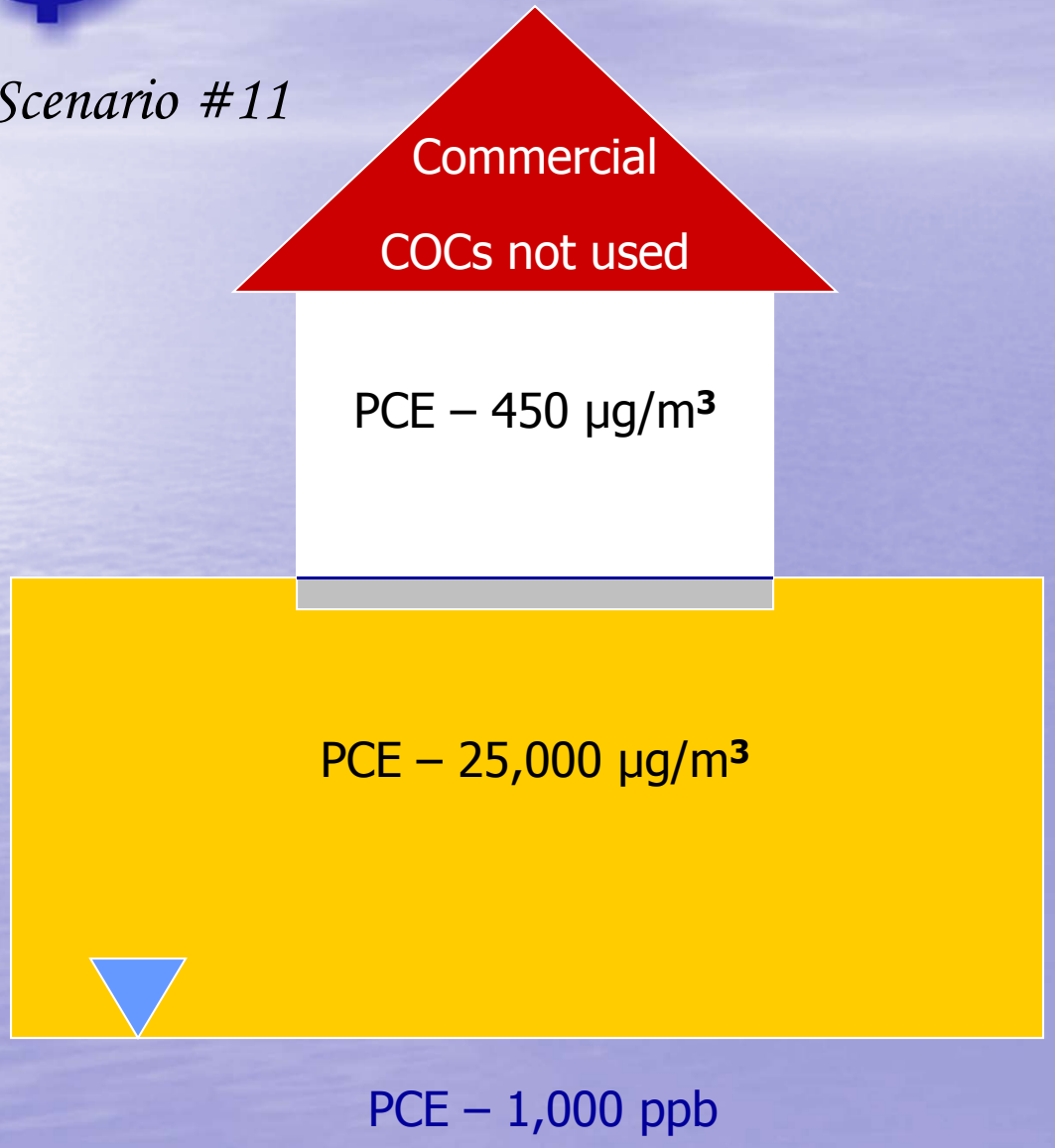
- IA COC > RAL
- Status of VI Pathway likely complete
- OSHA applicable
- Future use?

ANSWER:

NFI

What Would the LSRP Do?

Scenario #11



ISSUES:

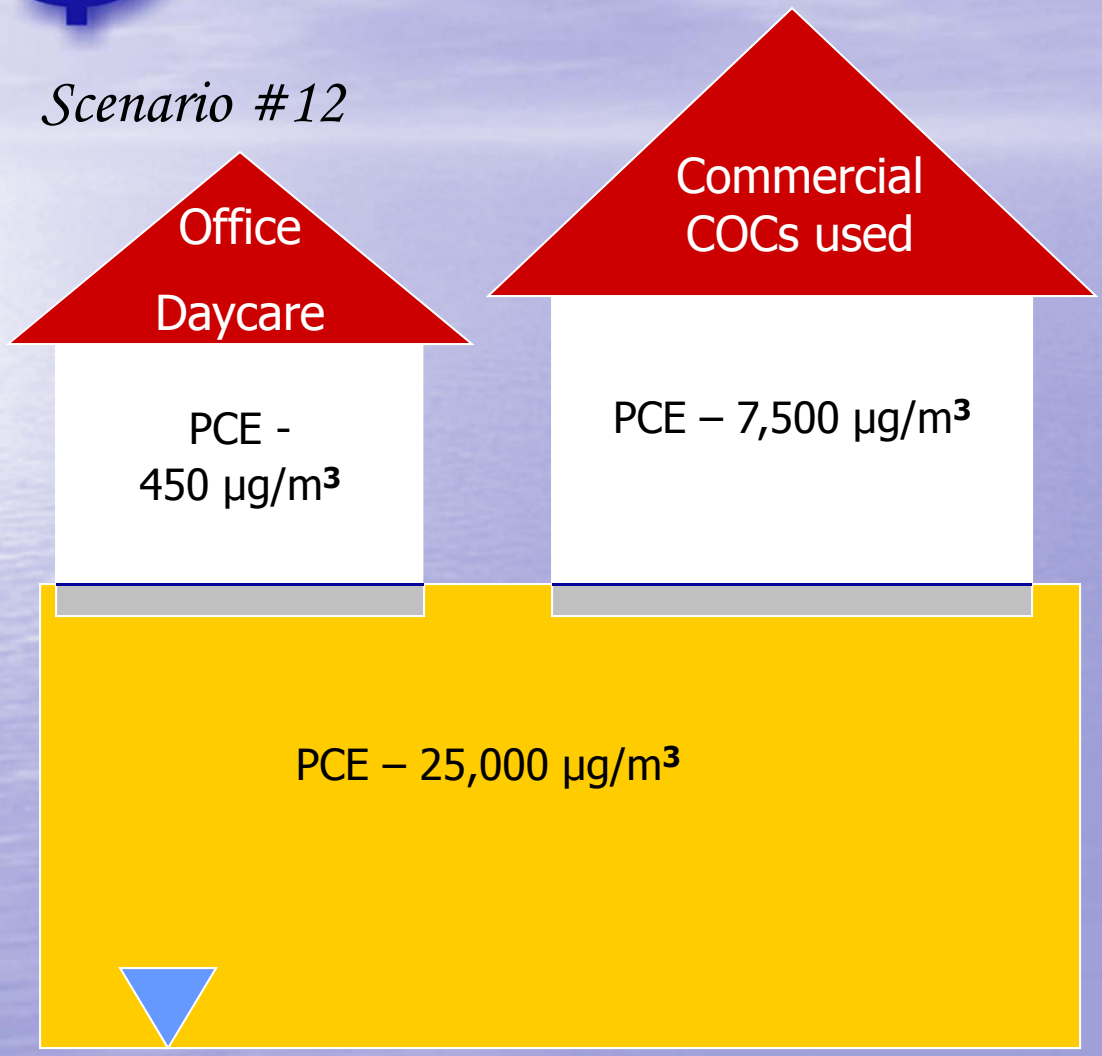
- IA COC > RAL
- Commercial Building
- Don't utilize COC in current operations
- VI Pathway complete

ANSWER:

IEC

What Would the LSRP Do?

Scenario #12



ISSUES:

- IA COC > RAL
- Commercial & Office Buildings on site
- Utilize COC in current factory operations
- Don't utilize COC in office
- Future use?

ANSWER:

IEC & NFI

Petroleum Hydrocarbons

Introduction

VI Framework

VI Receptor Evaluation (Stage 1)

VI Investigation (Stage 2)

Break

MLE & Data Evaluation

Petroleum Hydrocarbons

Mitigation (Stage 3)

OMM (Stage 4) & Termination (Stage 5)

Petroleum Hydrocarbons

Petroleum Hydrocarbons of interest to VI include:

- gasoline, diesel fuel, No.2 Heating Oil, Kerosene, and aviation fuels.

VI critical distance criteria (N.J.A.C.7:26E-1.18):

- Free product located or suspected within 100 feet of a building
- Petroleum-related compounds in groundwater in excess of the GWSL within 30 feet of a building

Gasoline discharges represent a significant portion of the petroleum–related VI investigations in New Jersey.

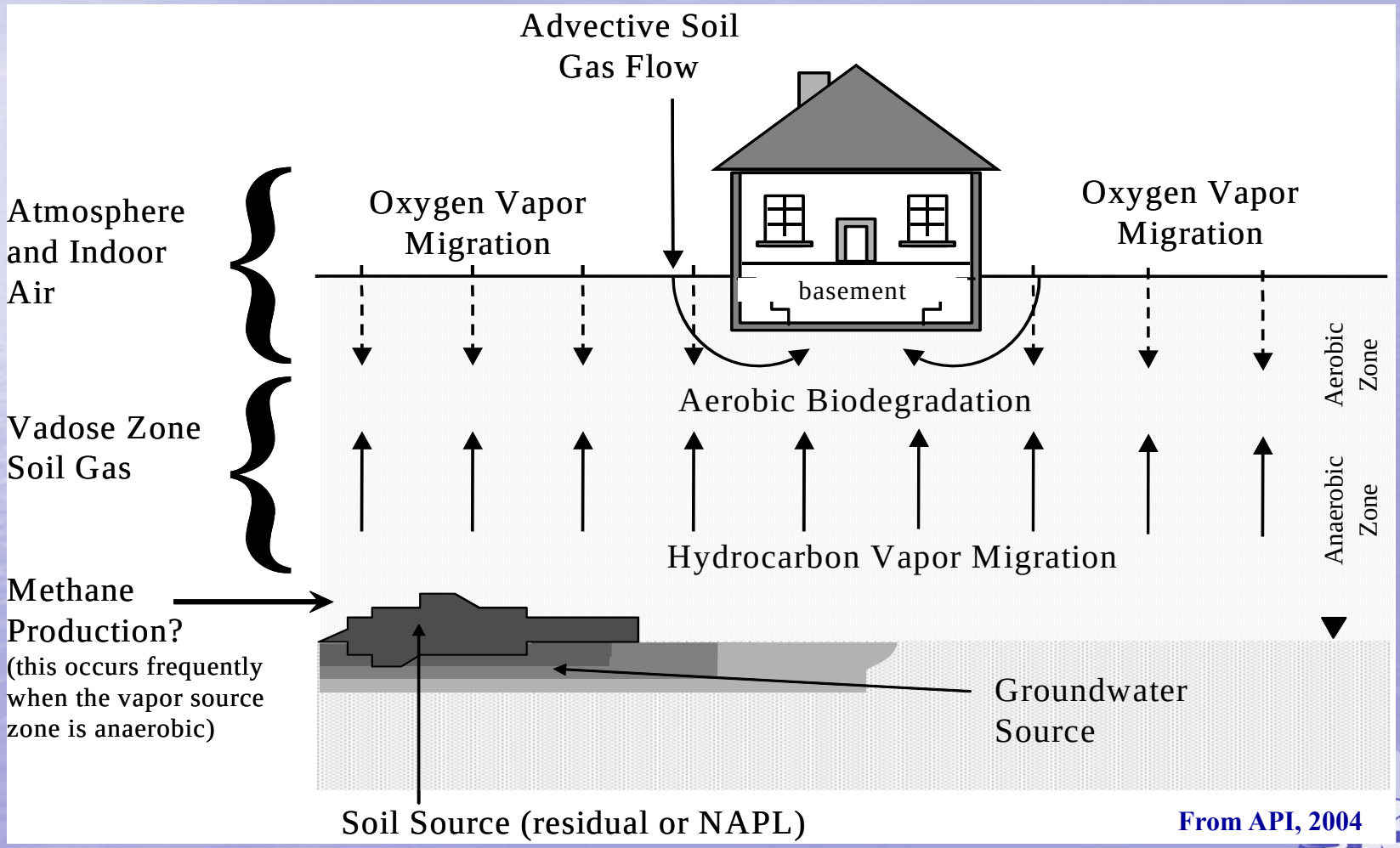
Petroleum- Biodegradation

Research over the last decade has demonstrated that petroleum-related compounds can biodegrade in the vadose zone.

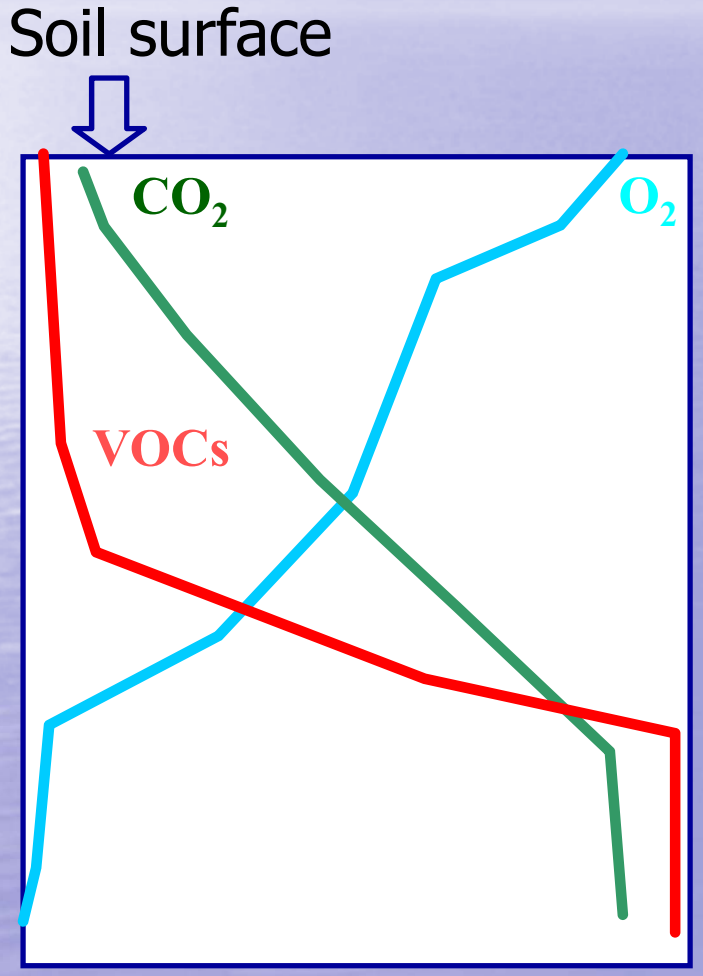
General requirements include:

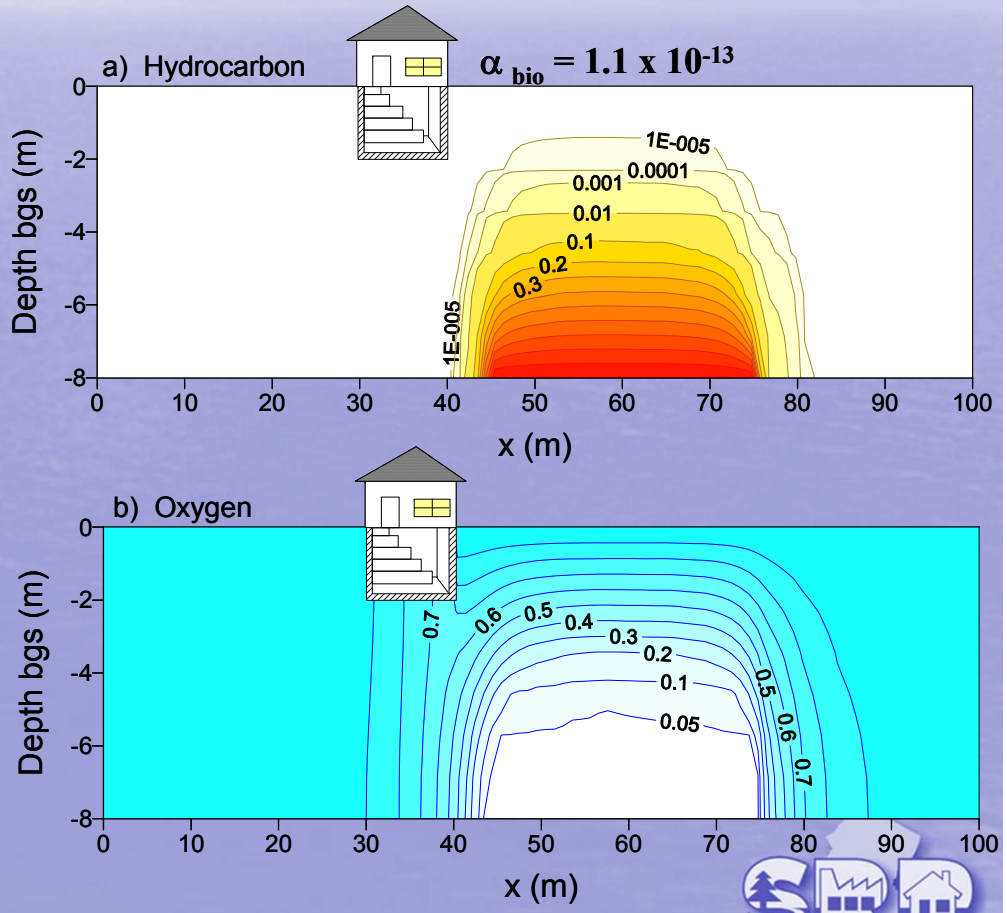
- Microorganisms
- Oxygen
- Nutrients
- Moisture

Petroleum- Conceptual Model



Petroleum- Biodegradation



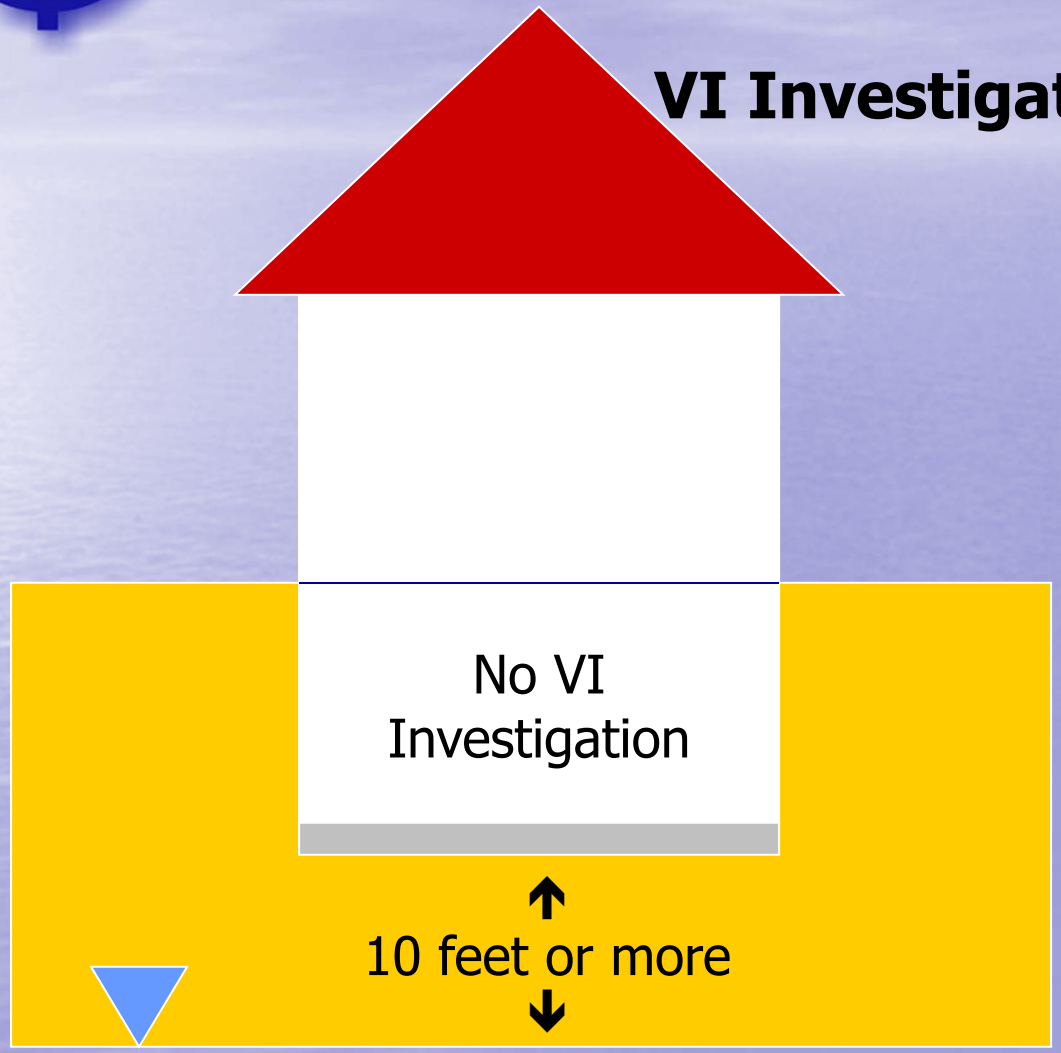


(Abreu and Johnson, 2005, 2006)

Gasoline Exclusion Criteria

For gasoline discharges (ONLY) <u>benzene is the exclusive trigger</u> and the following three specific scenarios apply:

Gasoline Exclusion Scenario #1



VI Investigation not required when:

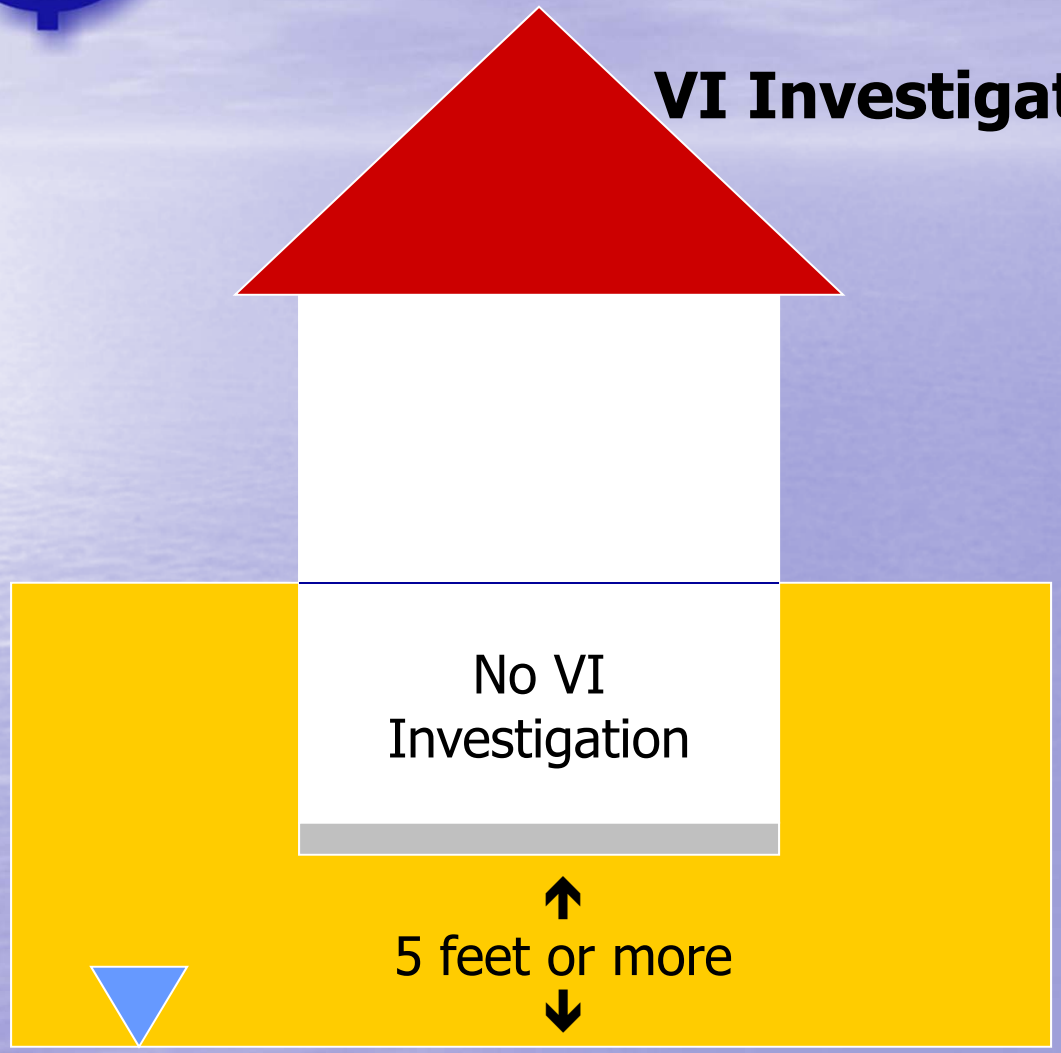
- ≥10 ft between seasonal water table and foundation and benzene in GW is ≤1,000 µg/L

Benzene – < 1,000 µg/L

Gasoline Exclusion Scenario #2

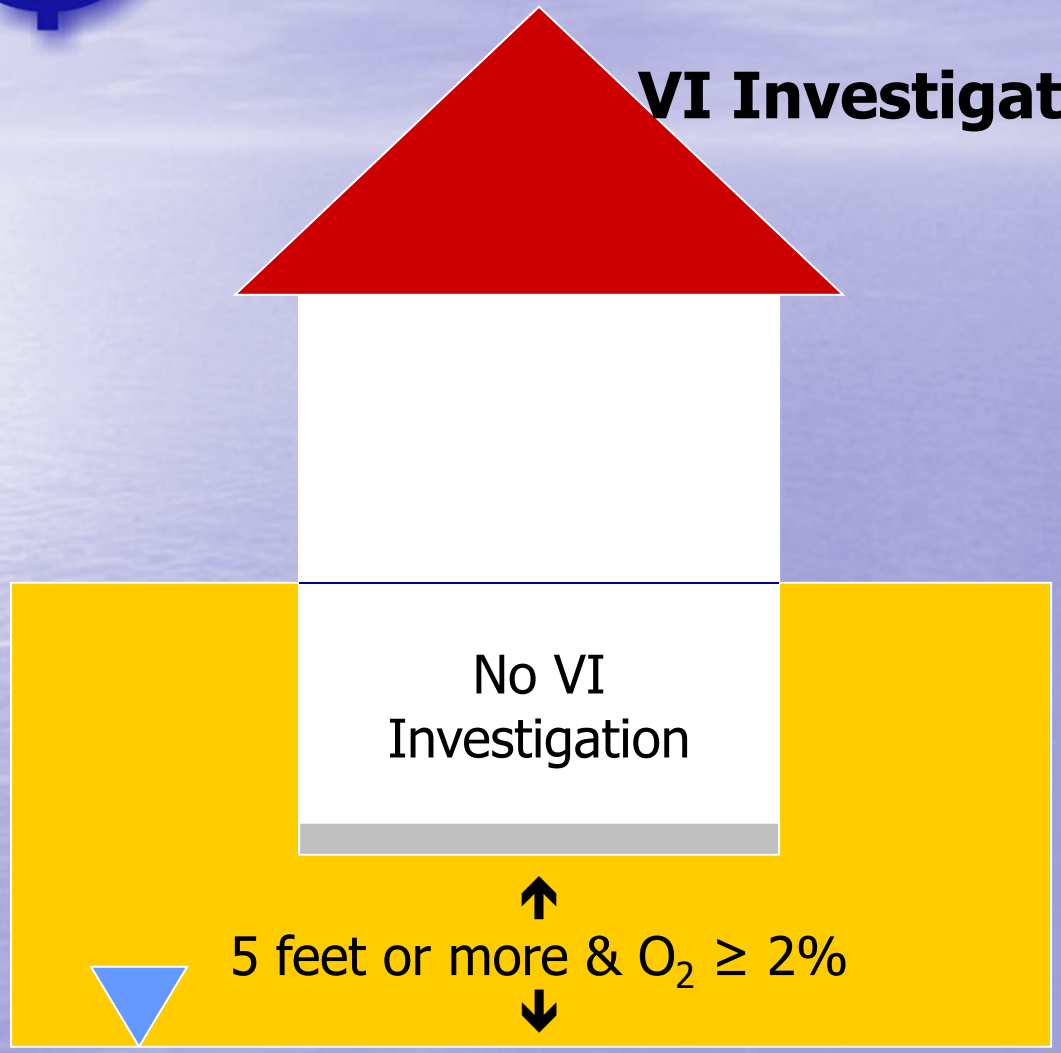
VI Investigation not required when:

- ≥5 ft between seasonal high water table and benzene in shallow GW is ≤100 µg/L



Benzene – < 100 µg/L

Gasoline Exclusion Scenario #3



VI Investigation not required when:

- ≥5 ft between seasonal high water table and foundation, oxygen levels measured at ≥2% (v/v), and benzene in shallow GW is ≤1,000 µg/L.

Benzene – < 1,000 µg/L

Gasoline Exclusion Conditions

Four Conditions for the application of the Gasoline Exclusion Criteria:

1. Detached building; single family home or duplex (small building size)
2. Area around the building is not extensively paved, allowing for air/oxygen infiltration.
3. Clean soil exists beneath the building to the water table (no source area).
4. NAPL is not present within 30 feet of the building.

No. 2 Fuel and Heavier PHCs

- VI investigation not required based exclusively on a discharge of No. 2 fuel oil or diesel (N.J.A.C. 7:26E-1.18(a)3)
- BUT triggers contained in N.J.A.C. 7:26E-1.18(a)1 & 4 can still necessitate a VI investigation
- If free product (soil and/or water table) is removed within 6 months, GW investigation to assess VI can be delayed until remedial action completed (UHOT provision)
- Naphthalene and 2-methyl naphthalene (in addition to benzene) are the exclusive triggers for VI investigation (full parameter analysis still necessary)
- Current modifications limited to diesel and No. 2 fuel oil

Petroleum- Additional Guidance

If a VI investigation is required for an active gasoline service station:

- Indoor air samples should not be collected due to vapors from operations
- Subsurface Soil Gas samples should be collected in consideration of potential reuse of the property in the future.
- If sampling shows concentrations greater than the SGSL, an institutional control should provide for additional investigation of VI if the land use changes.

Vapor Intrusion Mitigation (Stage 3)

Introduction

VI Framework

VI Receptor Evaluation (Stage 1)

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Break

MLE & Data Evaluation

Petroleum Hydrocarbons

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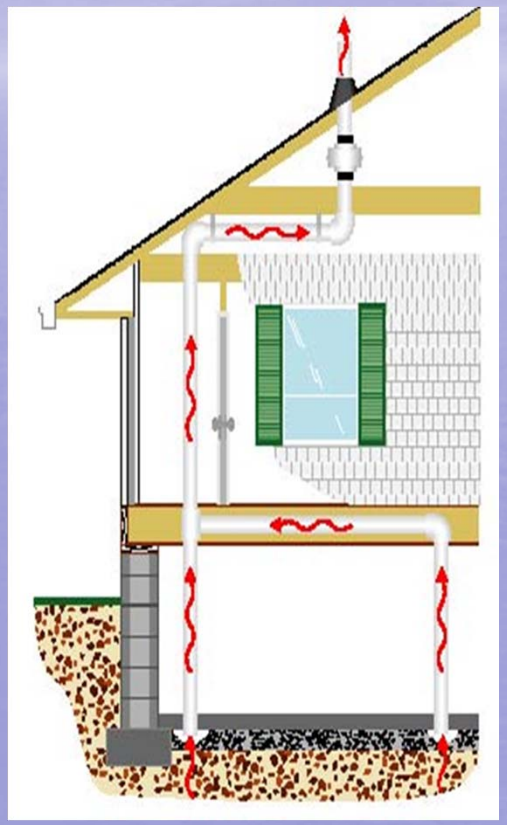
OMM (Stage 4) & Termination (Stage 5)

Vapor Intrusion Mitigation

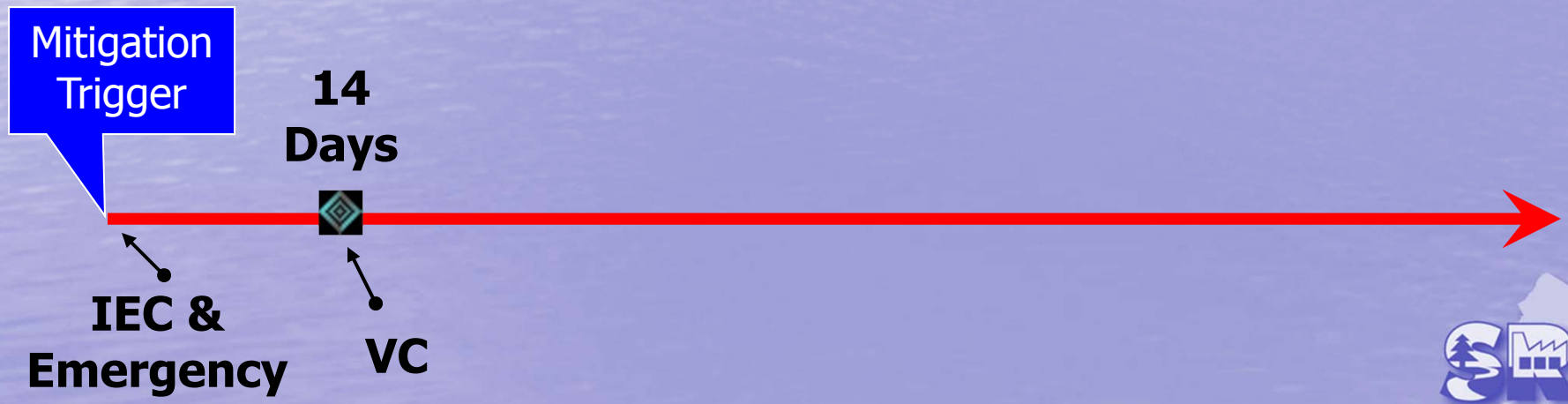
- Preference for Active Systems (existing buildings)
- Passive systems for new construction
- Must consider Presumptive Remedy
- Specification for Active Systems
  - 0.004 inches of water
- Operation, Maintenance, and Monitoring



Response Action Timeframes

Notification Requirements:

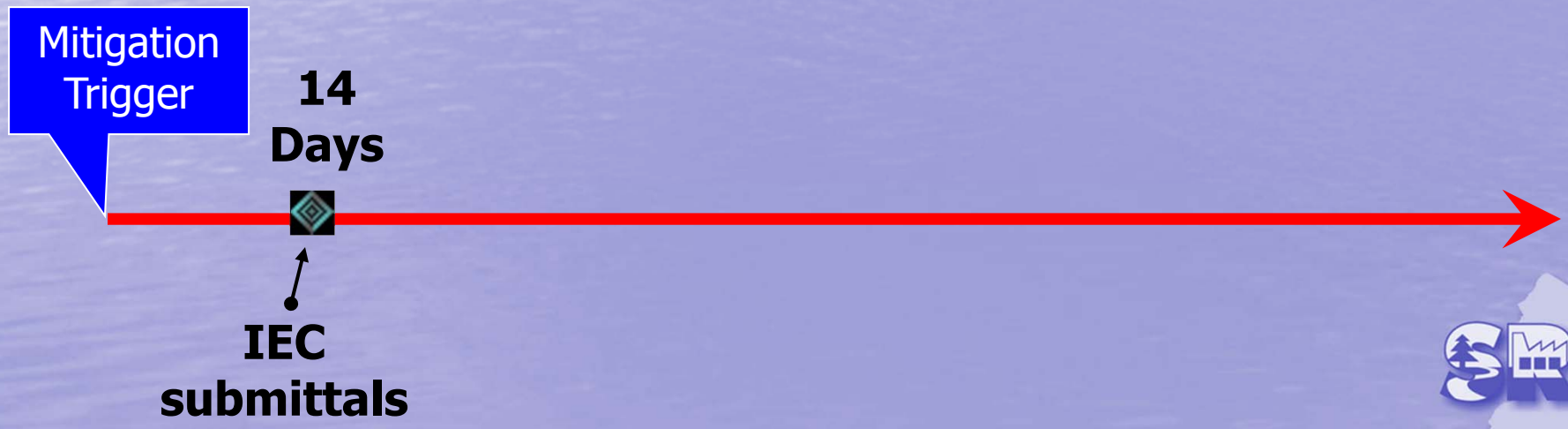
- VC – 14 days by submitting *VC Response Action form*
- IEC – immediately by calling CM or Department Hotline
- Emergency – immediately by calling 911, NJDEP & NJDHSS



Response Action Timeframes

IEC submittals within 14 days of mitigation trigger:

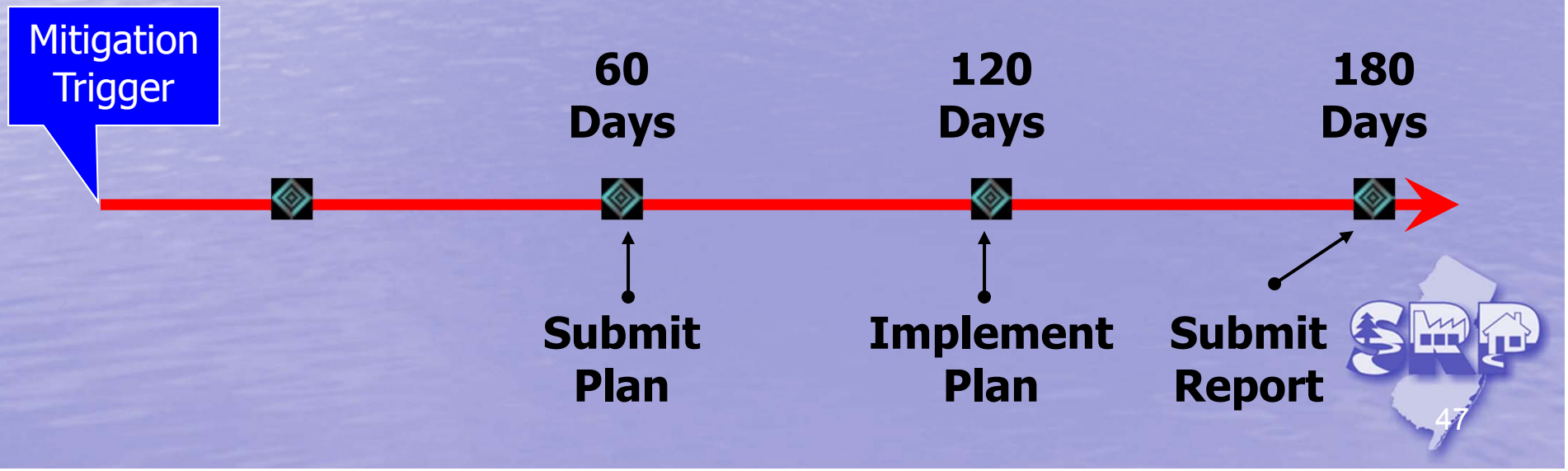
- *IEC Response Action* form – notification and interim response actions
- IEC site sampling map & *IEC VI Reporting* spreadsheet
- Result letters/tables to building owner/occupants with copies to appropriate officials



Engineered System Response Action

VC Response Action:

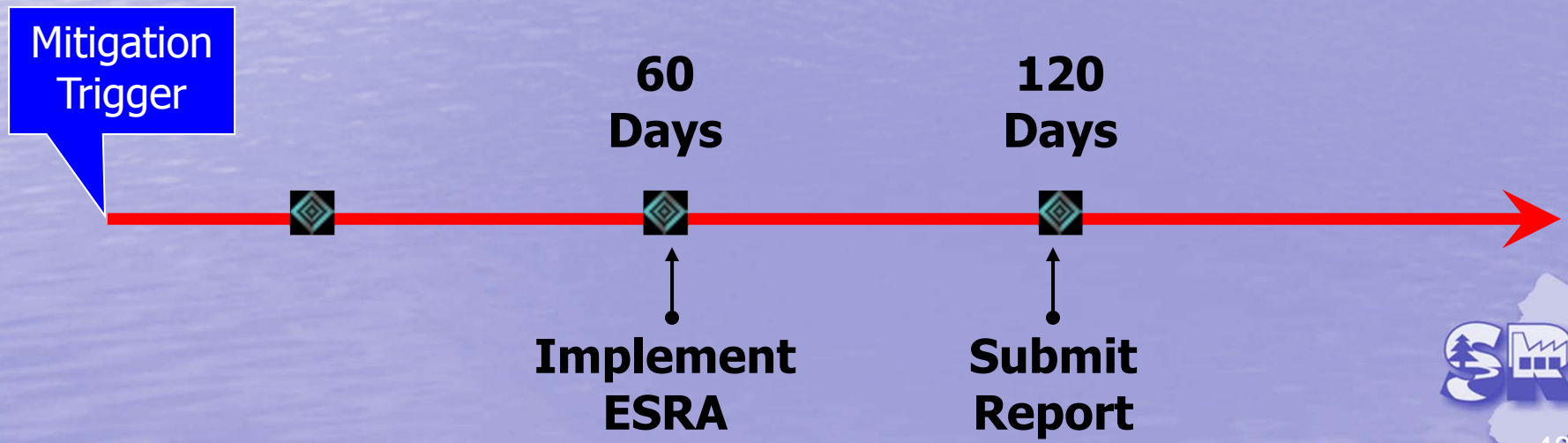
- VC Mitigation Plan – 60 day submittal with updated *VC Response Action form* (Department approval not required)
- Implement VC Mitigation Plan – 120 days
- VC Mitigation Response Action Report – 180 day submittal with updated *VC Response Action form*



Engineered System Response Action

IEC Response Action:

- Implement ESRA (Mitigation) – 60 day submittal
- IEC Engineered System Response Action Report – 120 day submittal with updated IEC *Response Action form*



Decision Flowchart

Mitigation Decision Matrix - Stage 3

		Indoor Air Concentrations (for COCs)	
		< IASL	>IASL
Sub-Slab Soil Gas Concentrations (for COCs)	<SGSL	No Action	No Action * (if no other subsurface source)
	>SGSL to 10X SGSL	Monitor	Mitigate
	>10X SGSL	Monitor / Mitigate	Mitigate

Notes:

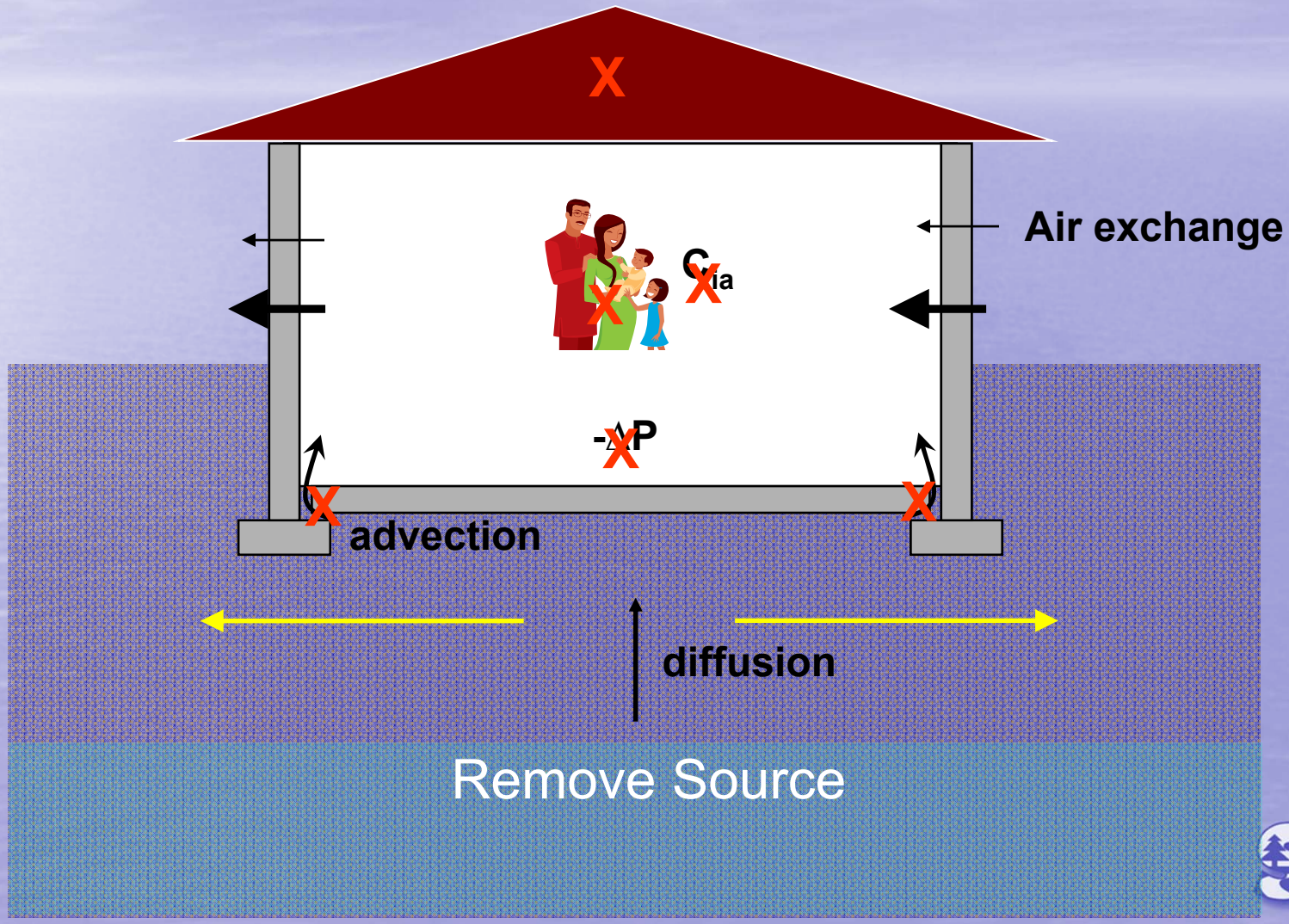
* Investigator should consider the potential for vadose zone (soil) contamination and/or preferential pathways as part of the assessment of vapor intrusion before concluding "no further action"

Interim Response Actions

Initial mitigation steps conducted to protect receptors within 14 days of the IEC trigger

- Sealing major openings and cracks
- Repairing compromised areas of the slab
- Covering and sealing exposed earth
- Covering and sealing sump pits
- Utilizing carbon IA filtration fan units
- Implementing selective or natural ventilation
- Adjusting HVAC settings (e.g., positive pressure, balance)
- Limiting access to building or area of interest
- Evacuating occupants

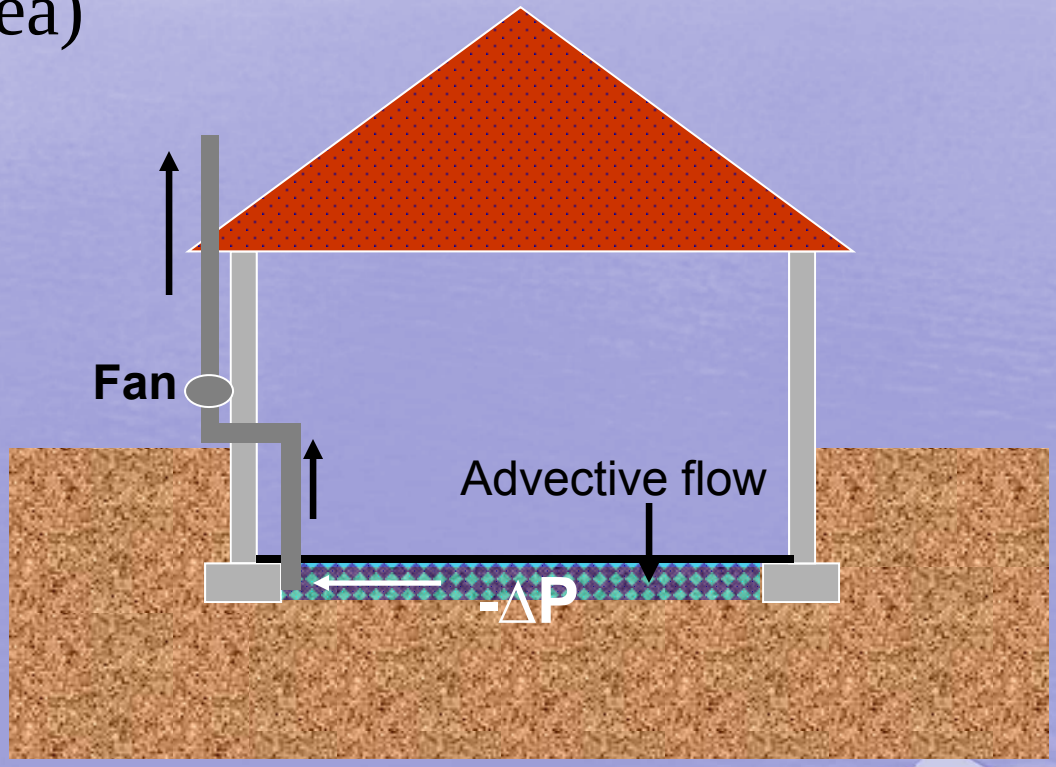
Mitigation Concepts



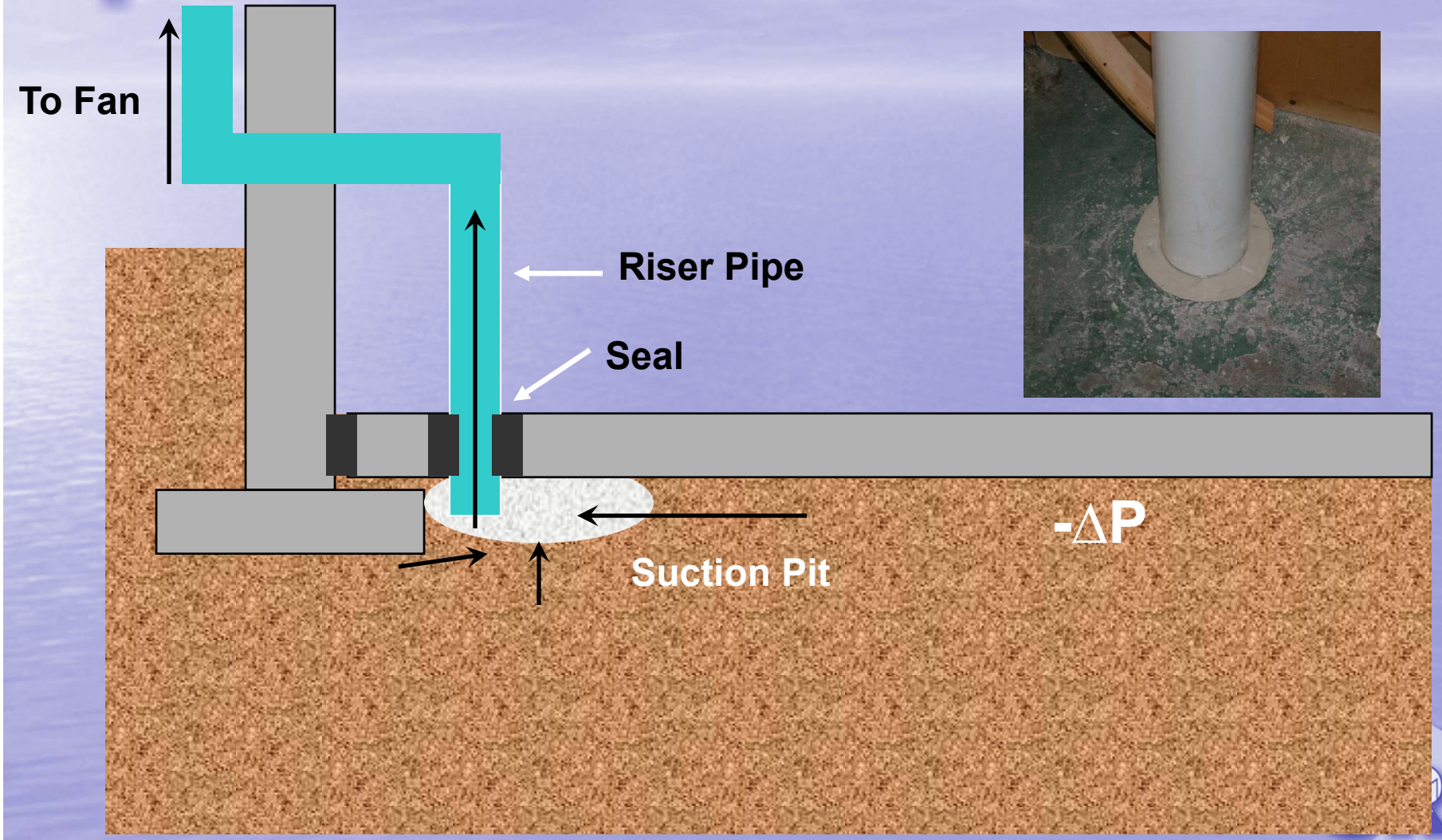
Courtesy of David Folkes, EnviroGroup Limited

Active SSDS

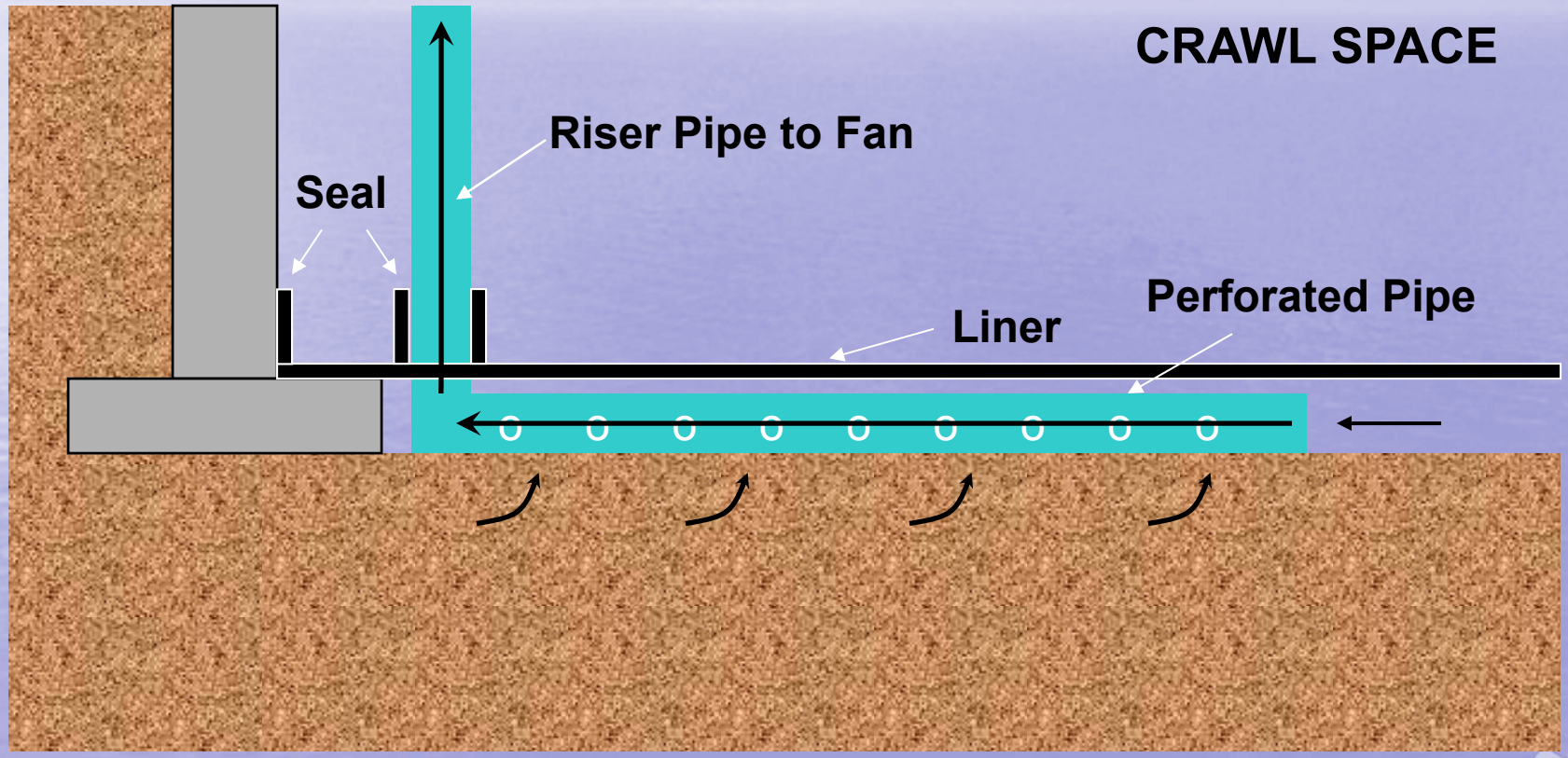
Active SSDS rely on fans to create suction (i.e., depressurize sub-slab area)



Active SSDS in Existing Building

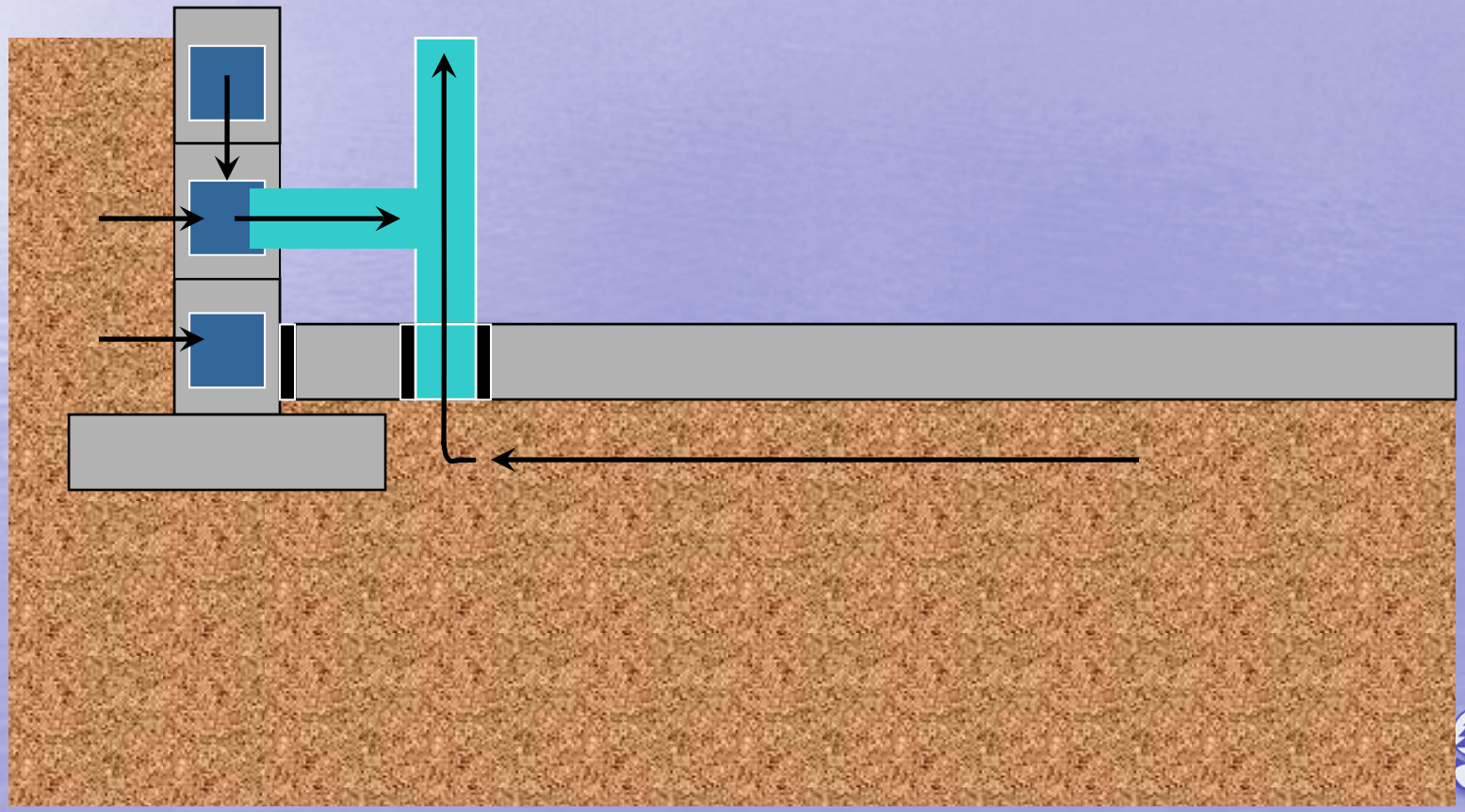


Sub-Membrane Depressurization



Block Wall Depressurization

Cinder block foundation wall

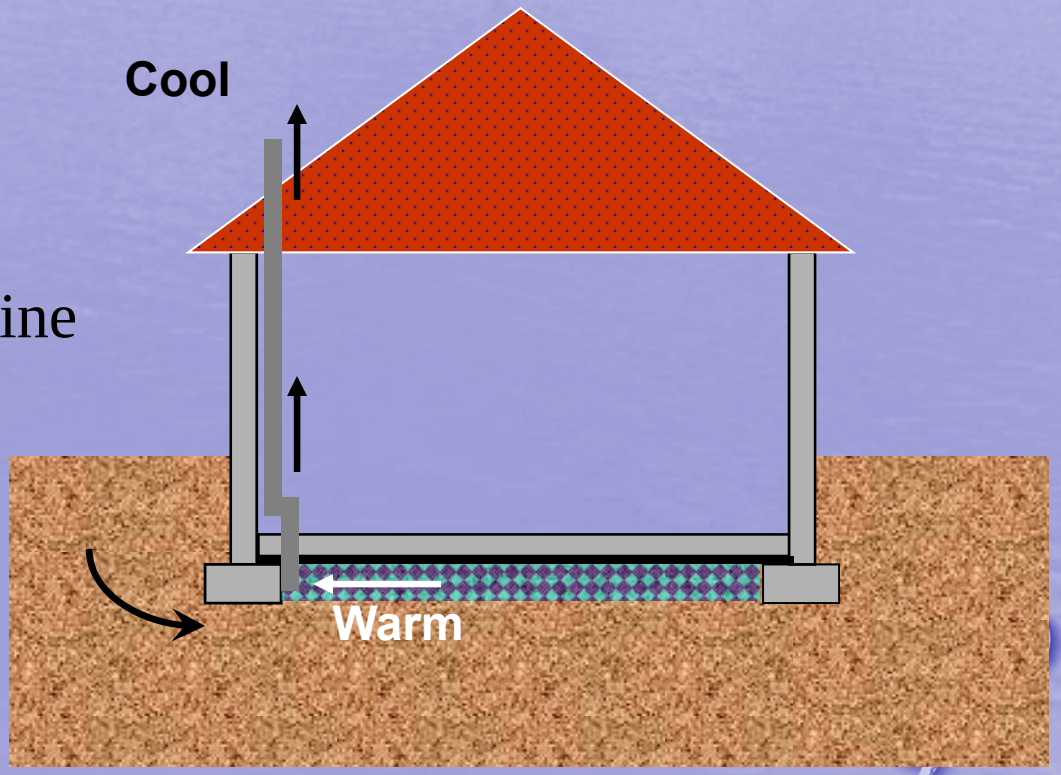


Foundation Drain Depressurization

Passive SSDS Mechanism

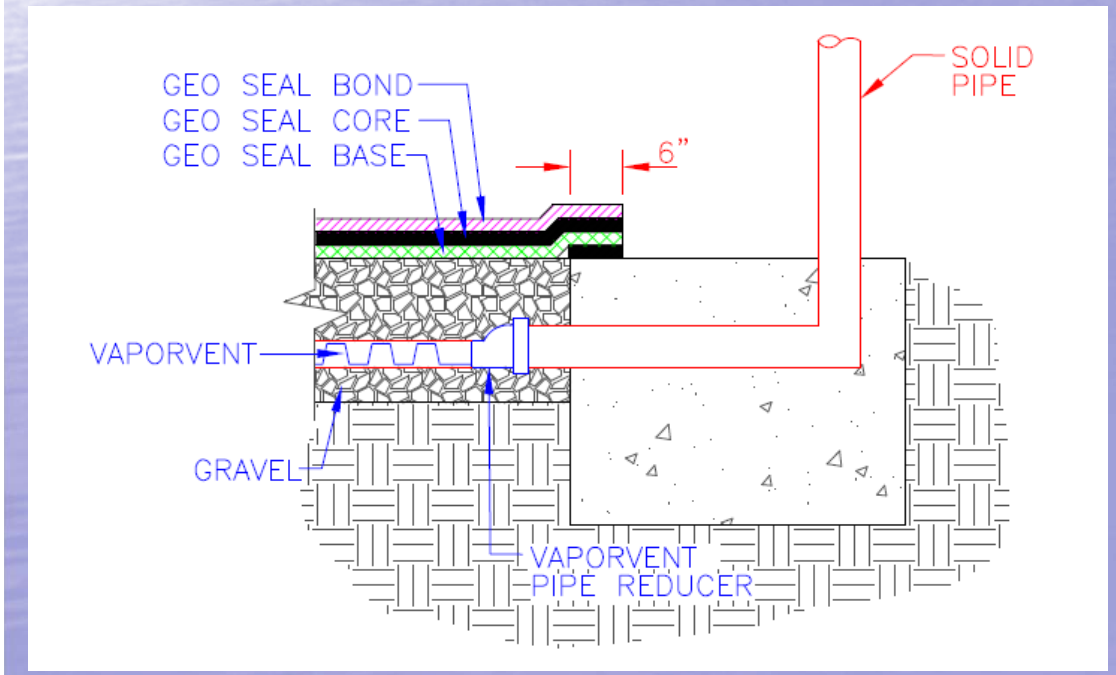
Passive SSDS rely on diffusion and natural pressure gradients

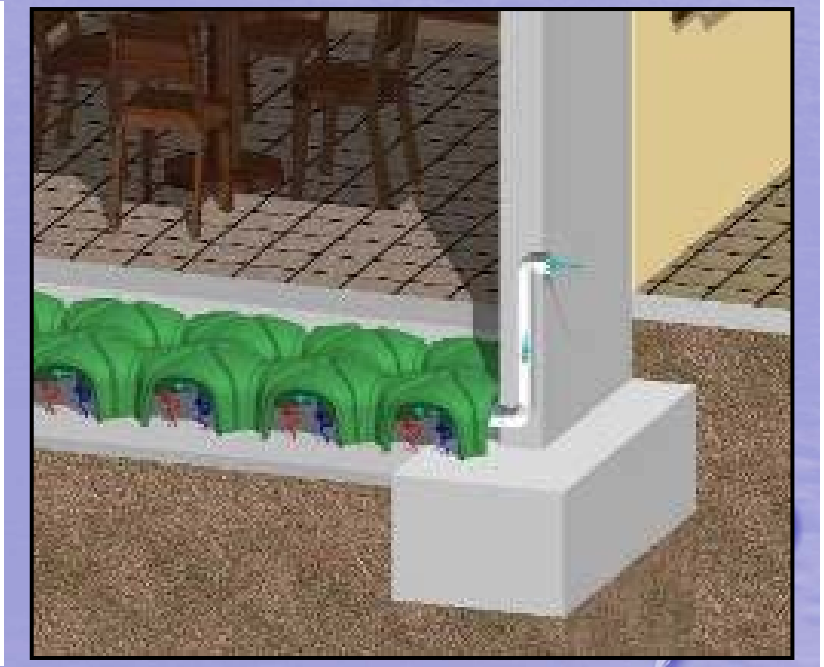
- Thermal-induced pressure gradient
- Wind-induced pressure gradient
- Augment with wind turbine



Components of a Passive SSDS

- Venting layer
- Lateral perforated piping (unless void space technology used)
- Gas vapor barrier
- Vertical exhaust pipe running through heated building space
- Electrical service near vent pipes in unoccupied space (attic)

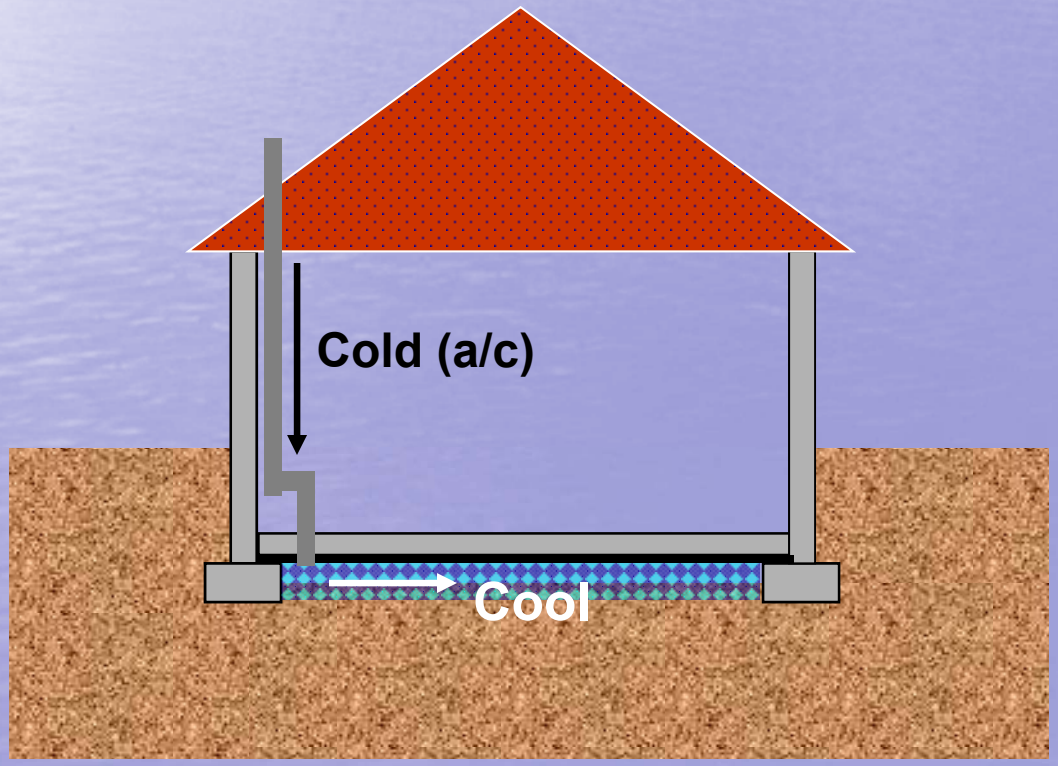




Passive SSDS - Problems

<u>Passive</u> venting may not occur naturally all the time

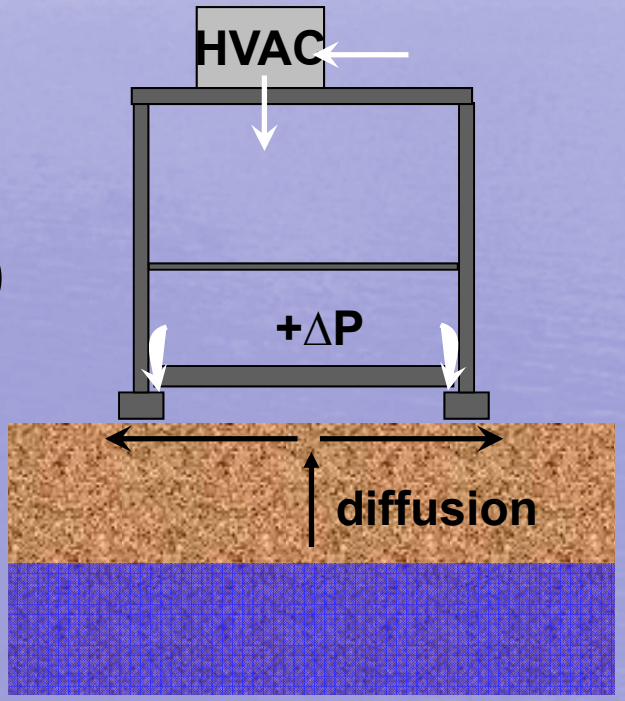
- Potential reverse stack effect
- 10-50% as effective as active SSDS



Alternative Mitigation Methods

When SSDS is not appropriate . . .

- Active HVAC modifications (not for residential buildings)
- Passive SSDS (existing buildings)
- Spray on barriers (supplemental only)
- Soil vapor extraction (SVE)
- Aerated floor systems
- Subsurface pressurization
- Heat recovery ventilator
- IA treatment (temporary use only)
- Limit or prohibit access
- Immediate removal of source



Design & Installer Qualifications

For design & installation of a vapor mitigation system, utilize:

- NJ Certified Radon Mitigation Contractor
- Licensed Site Remediation Professional *
- Licensed Professional Engineer *

* *with specific experience in VI or radon building mitigation*

- ✓ Don't forget local building codes
- ✓ Licensed electrician will be needed
- ✓ Asbestos materials may be present

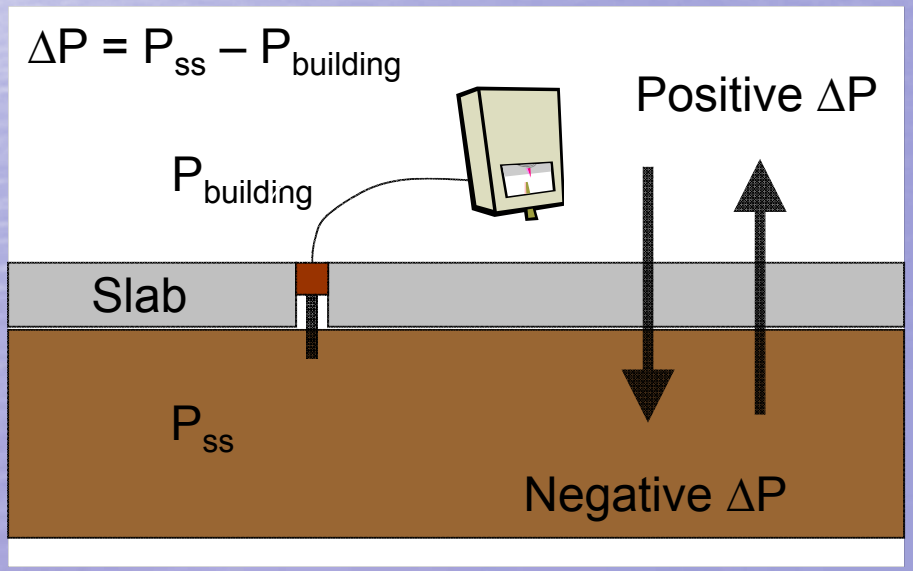
Pre-Mitigation Design

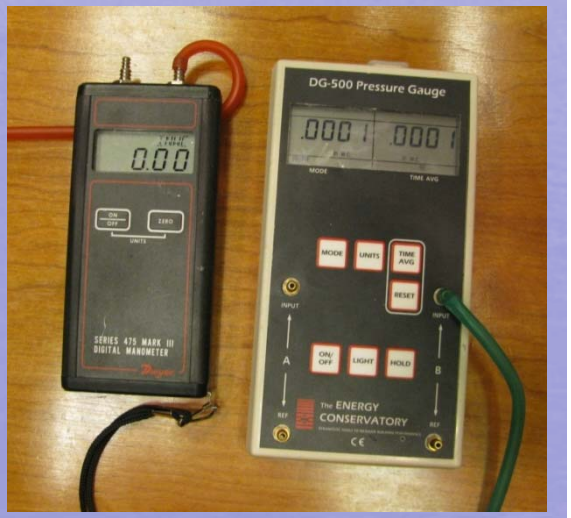
- Visual inspection
- Backdraft testing
- Stack effects
- Communication Test
- Permanent Sub-slab soil gas probes
- Condensation
- Alarms
- Sealing vapor entryways
- Construction and electrical permits

Communication Test

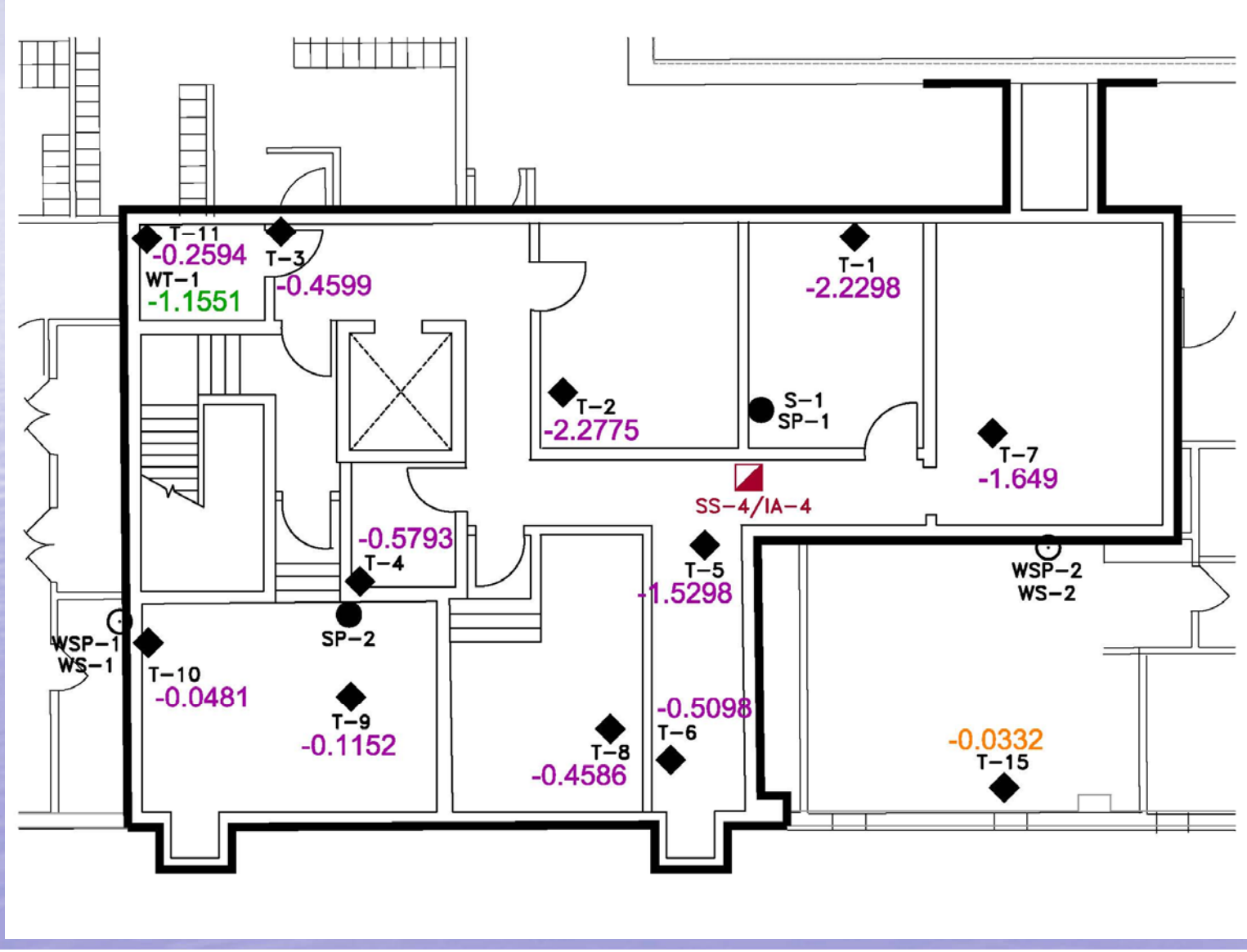
Critical step in proper design of active SSDS

- Extent of depressurization field (suction) under slab
- Determines the number and locations of suction point(s) and fan size(s)
- Minimum 0.004 inches water column (wc)



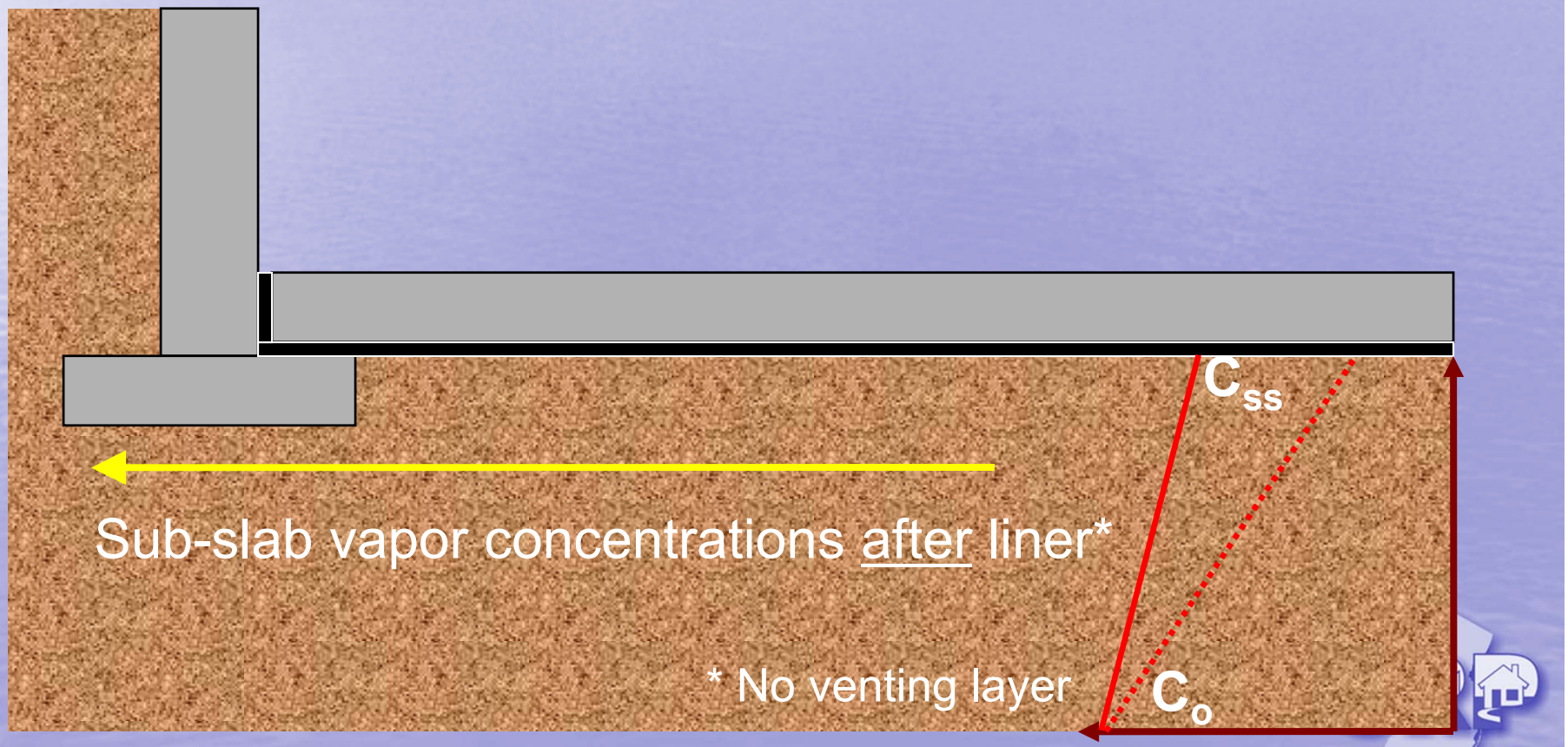


Communication Test



Gas Vapor Barrier Concept

Vapors must diffuse or flow laterally



Gas Vapor Barriers Provisions

Three types of gas vapor barriers:

- Sheet (e.g., HDPE, LLDPE, EPDM)
- Spray on liquid (e.g., Liquid Boot®)
- Composite (e.g., Geoseal™)

Appropriate Gas Vapor barriers based on:

- thickness
- resistance to water vapor transmission
- solvent vapor transmission
- chemical resistance
- resistance to puncture
- tensile strength

Unit Conversions (Table 6-1)

Unit	Multiplied by	To Obtain
Inches of water	249.1	Pascal
Inches of water	7.355×10^{-2}	Inches of mercury
Liter	3.531×10^{-2}	Cubic feet
Liter	1,000	Cubic meter
^{o}F	$5/9 (^{o}F-32)$	^{o}C
^{o}C	$9/5\ ^{o}C+32$	^{o}F
$\mu g/m^3$	24.45/MW	ppbv
ppbv	MW/24.45	$\mu g/m^3$
Pascal	0.004	Inches of water

All analytical results are to be reported in units of $\mu g/m^3$

System Commissioning

- Visual inspection of mitigation system
- Comparison to *Vapor Intrusion Mitigation System Inspection Checklist* (Appendix M)
- Establishment of operational baseline from appropriate system diagnostic parameters based on type of vapor mitigation system
- System assessment for alterations or augmentations
- Trouble-shoot any problems (noise, vibration, complaints)
- Backdraft testing
- Explanation of system components to building owner/occupant

System Diagnostic Parameters

System diagnostic values are used during OMM to confirm steady state operational conditions.

Active systems (SSDS):

- Vacuum (pressure differential)
- Air flow measurements

Passive & Alternative systems:

- IA sampling
- Air flow measurements
- Sub-slab SG sampling event

Verification Sampling (VS)

- Collect indoor and ambient air samples to verify the effectiveness of the vapor mitigation system
- Samples collected immediately following system commissioning (usually 30-45 days after system start-up)
- Minimum of one round of sampling during the heating season
- VS samples collected irrespective of the vapor mitigation system installed
- Background sources of COCs can complicate review of VS results
- Always use MLE when assessing system effectiveness

VI Mitigation Verification (Table 6-2)

	Active SSDS or SSVS	Passive SSDS or SSVS	Alternative VI Mitigation Systems
Recommend Use	**Existing buildings and IRA**	**New building construction only**	**When technically justified based on site-specific features (Section 6.2.4)**
Commission Timeframe	**30 - 45 days after system startup**		
System Commission Parameters	**IA samples, sub-slab negative pressure field measurements, system air flow measurements, pressure measurements**	**1) IA samples 2) SSSG (or void space) samples 3) Air flow measurements for SSVS**	**1) IA samples 2) SSSG or void space samples, sub-slab negative pressure field measurements and/or other system-specific parameters selected**
Verification Samples	**Perform immediately following system commissioning. Minimum one round of IA samples in heating season. Collect appropriate system diagnostic measurements to establish baseline values.**	**Perform immediately following system commissioning. Minimum one round of IA samples in heating season. In addition, collect appropriate number of sub-slab (or void space) soil gas samples to establish baseline values.**	**Perform following system commissioning. Minimum one round of IA samples in heating season. In addition, collect appropriate number of sub-slab (or void space) soil gas samples and/or system diagnostic measurements to establish baseline values.**

OMM & Termination (Stages 4 & 5)

Introduction

VI Framework

VI Receptor Evaluation (Stage 1)

VI Investigation (Stage 2)

Break

MLE & Data Evaluation

Petroleum Hydrocarbons

Mitigation (Stage 3)

OMM (Stage 4) & Termination (Stage 5)

OMM (Table 6-2)

	Active SSDS or SSVS	Passive SSDS or SSVS	Alternative VI Mitigation Systems
OMM	**First year OMM**: 1) Quarterly inspection of system[3]. 2) Verify the commissioning values[3] **Second year OMM & beyond**: 1) Annual inspection of system[3] 2) Annual collection of appropriate system diagnostic measurements and verify onsistency[3].with baseline values	**First year OMM**: 1) Quarterly system[3] inspection. 2) Sampling of IA and SSSG (or void space) during heating season[1] following VS sampling. **Second year OMM**: 1) Semi-annual inspection of system[3] 2) SSSG (or void space) sampling during heating season[1] **Third year and beyond:** 1) Annual inspection of system[3] 2) IA and SSSG (or void space) sampling during heating season[1] every year until the results are consistent; THEN 3) IA sampling during the heating season every 5 years.	**First and second year OMM**: 1. Quarterly inspection of system[3]. 2. Annual sampling of IA during heating season [1]. 3. Annual SSSG (or void space) sampling (when appropriate). 4. Quarterly collection of commissioning measurements and verify consistency[2]. **Third year OMM & beyond**: 1. Annual inspection of system[3]. 2. Annual collection of appropriate commissioning parameters and verify consistency[2,3]. 3. SSSG (or void space) sampling (when appropriate) and IA sampling during heating season[1] every three years[2]

Corrective Actions (Table 6-2)

	Active SSDS or SSVS	Passive SSDS or SSVS	Alternative VI Mitigation Systems
Corrective actions during VS or OMM	For an exceedance of NJDEP IASL[4] or variation[5] from commissioning values: 1) Check system for malfunctions, modify or augment the system. 2) Re-commission the system. 3) Collect VS & re-start OMM	For an exceedance of NJDEP IASL[4] or variation[5] from commissioning values: 1) Check system for malfunctions, modify or augment the system. 2) Re-commission the system. 3) Collect VS & re-start OMM	For an exceedance of NJDEP IASL[4] or variation[5] from the commissioning values: 1) Check system for malfunctions, modify or augment the system. 2) Re-commission the system. 3) Collect VS & re-start OMM
		Convert to active system if: 1) Second corrective action is required; or 2) Increasing trends in SSSG (or void space) samples that exceed NJDEP SGSLs during OMM (not VS)	Upgrade to active SSDS if: 1) Second corrective action required; or 2) Increasing trends in SSSG (or void space) soil gas results that exceed NJDEP SGSLs during OMM (not VS)

Long Term Monitoring Sampling Designs (Table 6-3)

Sub-Slab Soil Gas >10X NJDEP SGSL	Sub-Slab Soil Gas>NJDEP SGSL and ≤10X NJDEP SGSL
First and second year LTM: **1 Semi-annual inspection of building.** **2. Semi-annual sampling of IA.** **Third year LTM & beyond:** **1. Annual inspection of building.** **2. Annual sampling of IA in heating season.**	**First and second year LTM:** **1 Semi-annual inspection of building.** **2. Annual sampling of IA during heating season.** **Third to sixth year LTM:** **1. Annual inspections of building.** **2. Sampling of IA in years 4 & 6 of LTM.** **After sixth year LTM:** **1. Annual inspection of building.** **2. Sampling of IA every 5 years in heating season.**

Questions?