FET Seminar

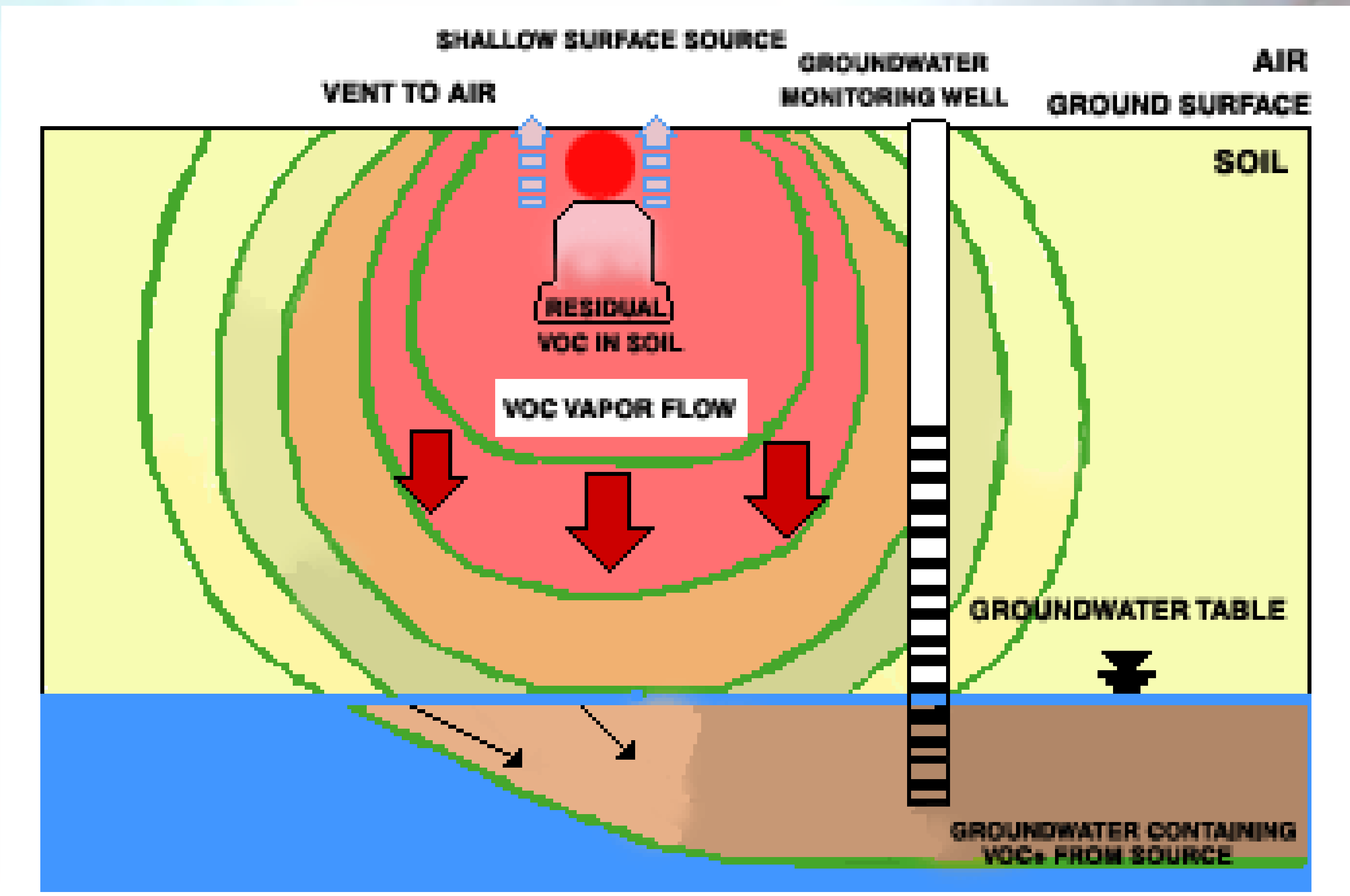
Wisconsin's Vapor Intrusion Guidance

Part 1
Vapor Intrusion Basics

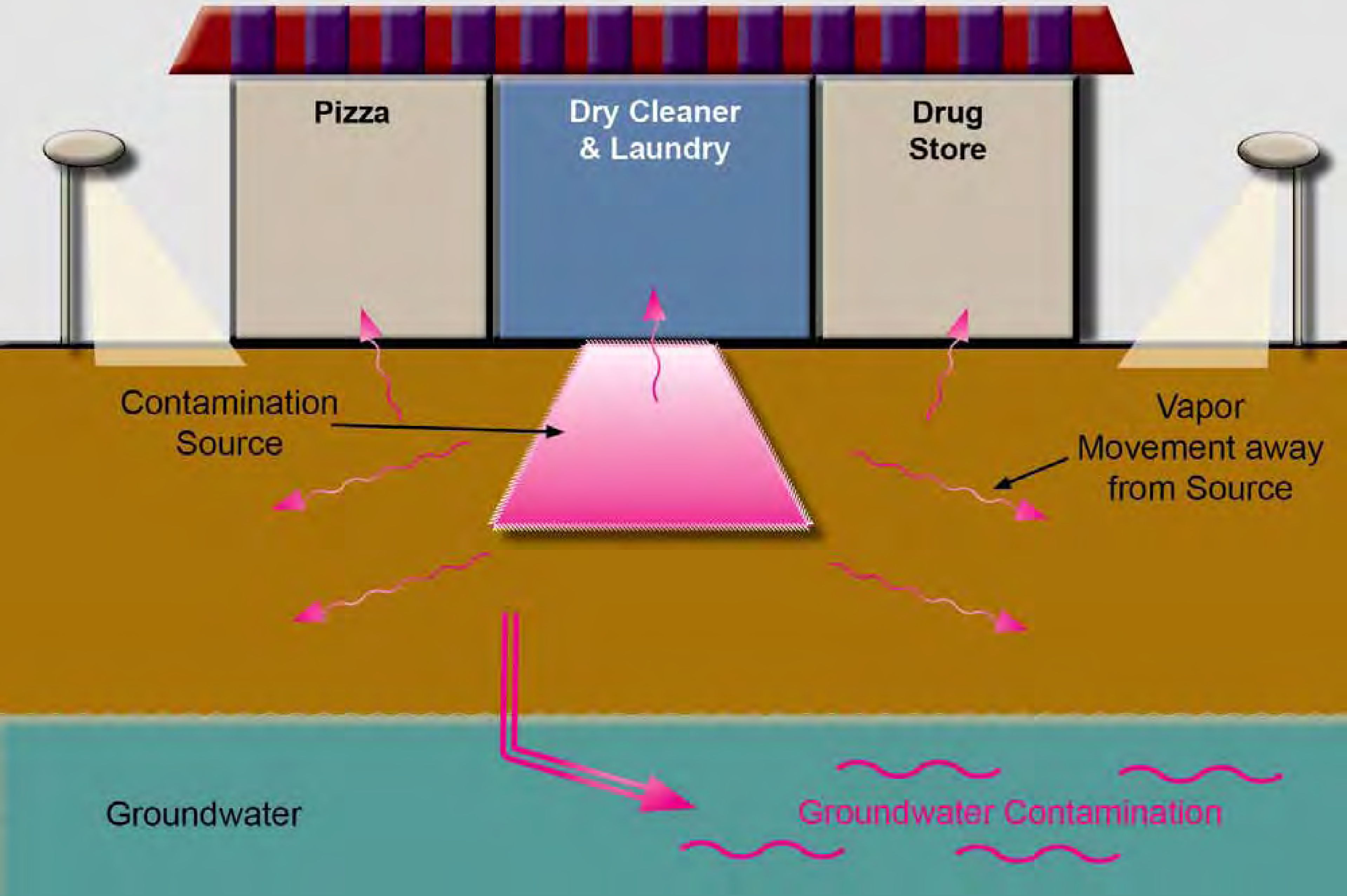
Terry Evanson
Theresa.Evanson@wisconsin.gov
March 2 and 16, 2011

Conceptual Movement of Vapors in the Subsurface

Vapor movement from a VOC source

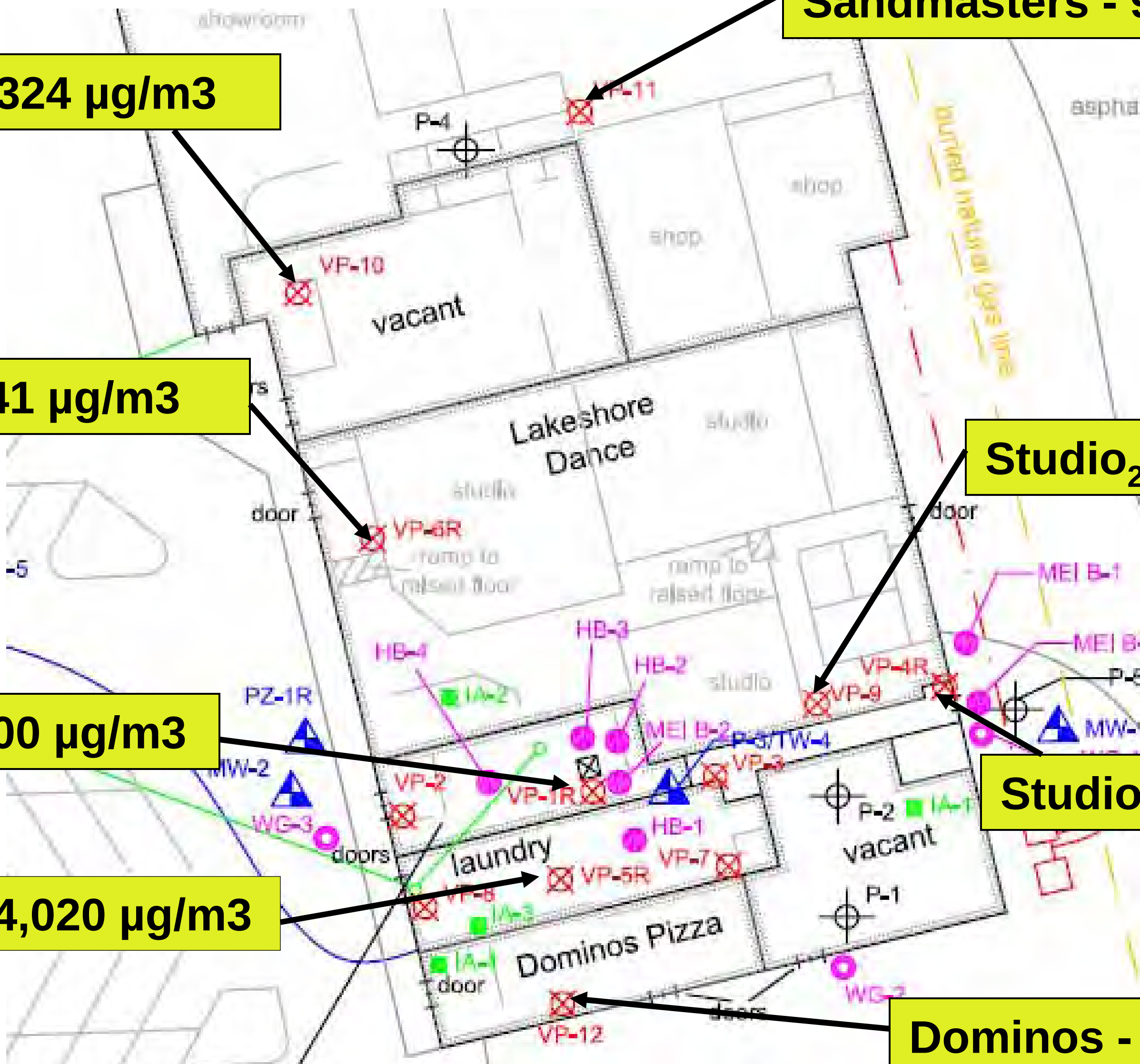


Vapors from a Release Directly Beneath Building & Vapor Movement Through Soils



Source Beneath Building & Lateral Vapor Migration: Saukville Cleaners

Saukville DC – Sub-slab PCE Vapor Concentrations



Sandmasters - 95 µg/m3

Vacant - 3,324 µg/m3

Studio$_1$ - 1,841 µg/m3

Studio$_2$ - 100,960 µg/m3

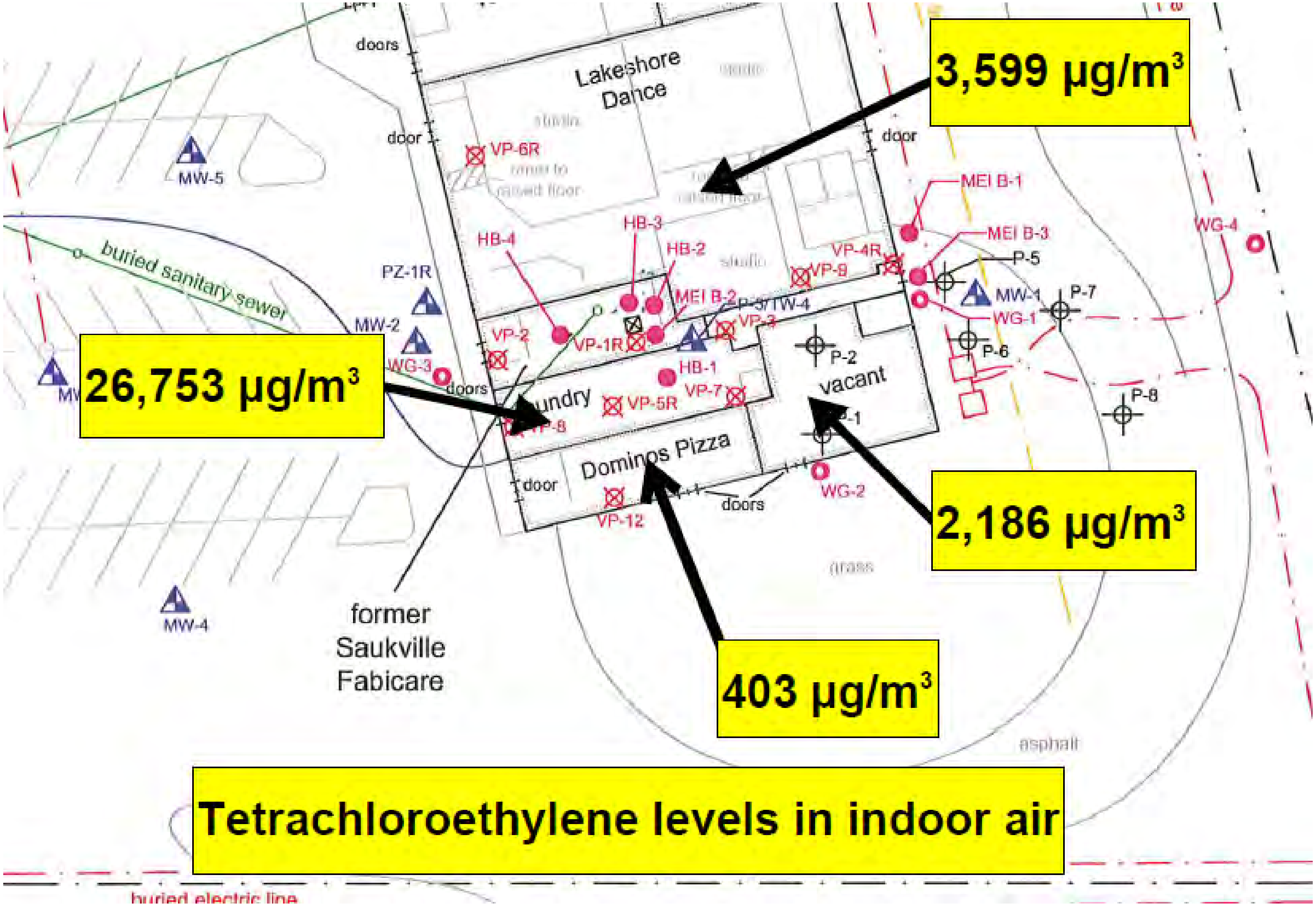
DC – 2,513,600 µg/m3

Studio$_3$ - 14,079 µg/m3

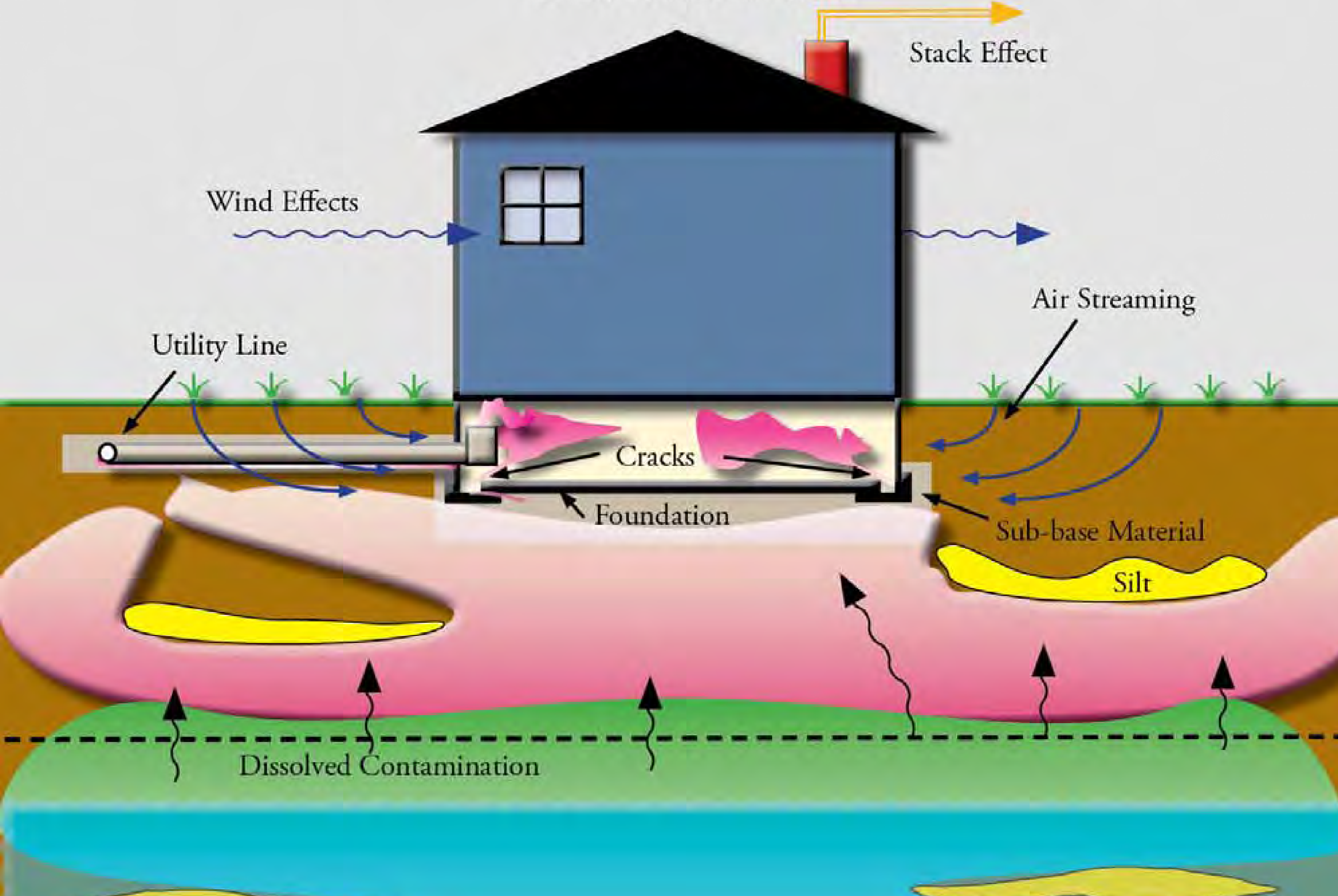
Laundry - 934,020 µg/m3

Dominos - 102,330 µg/m3

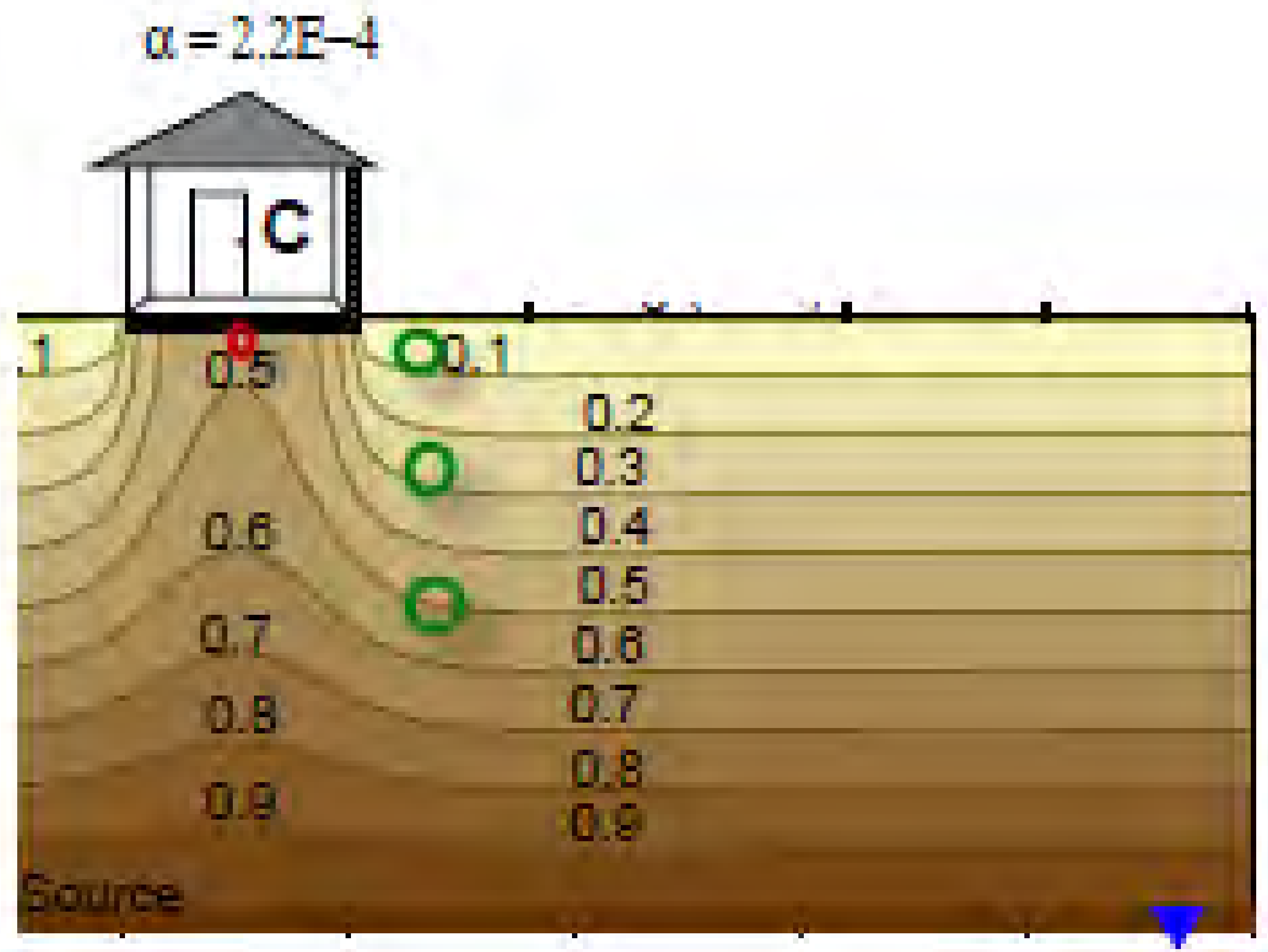
Saukville DC – Indoor Air



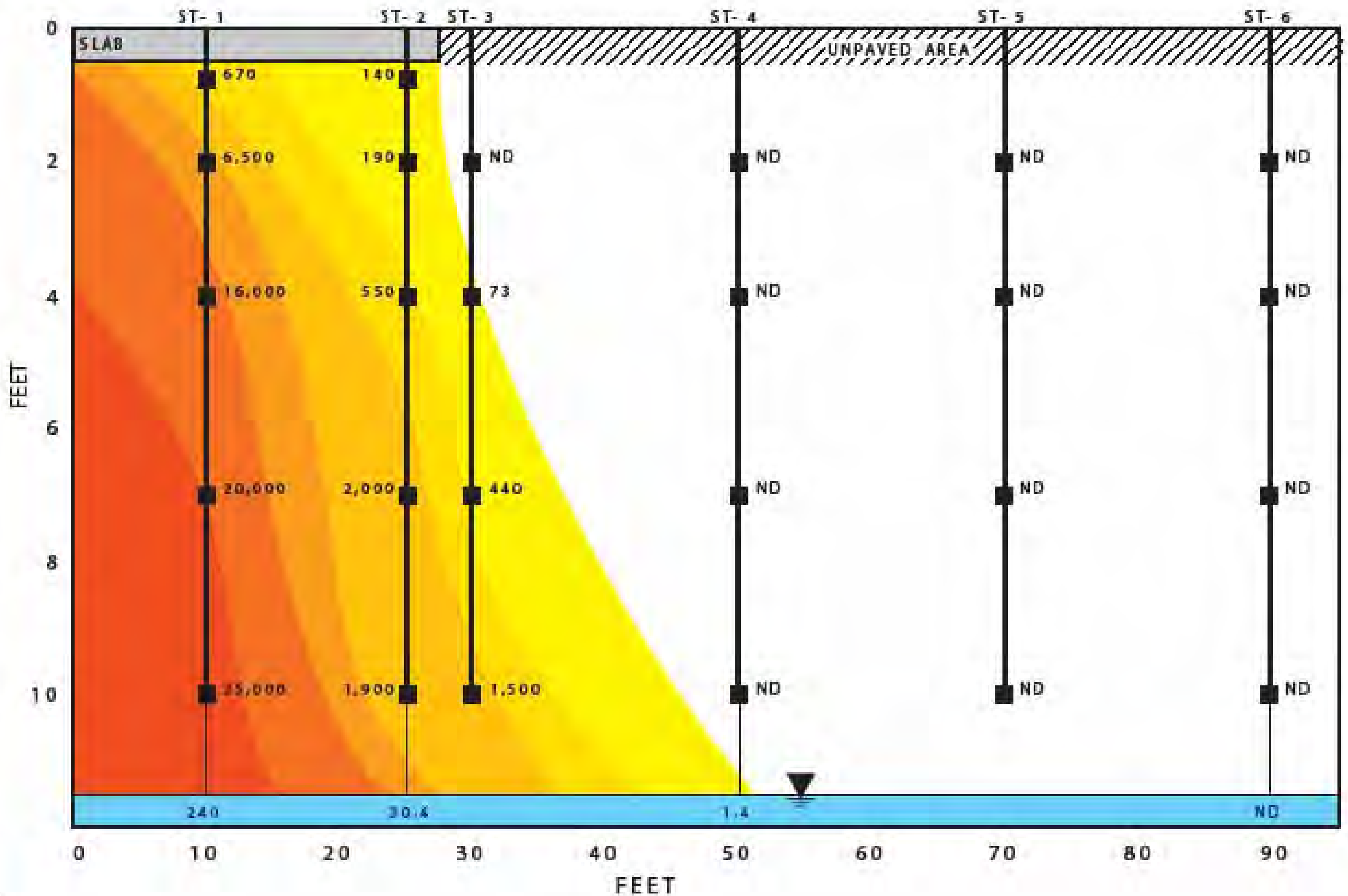
Vapors Migrating from Contaminants Located at the Groundwater Table



Vertical Movement of Vapors from groundwater to surface

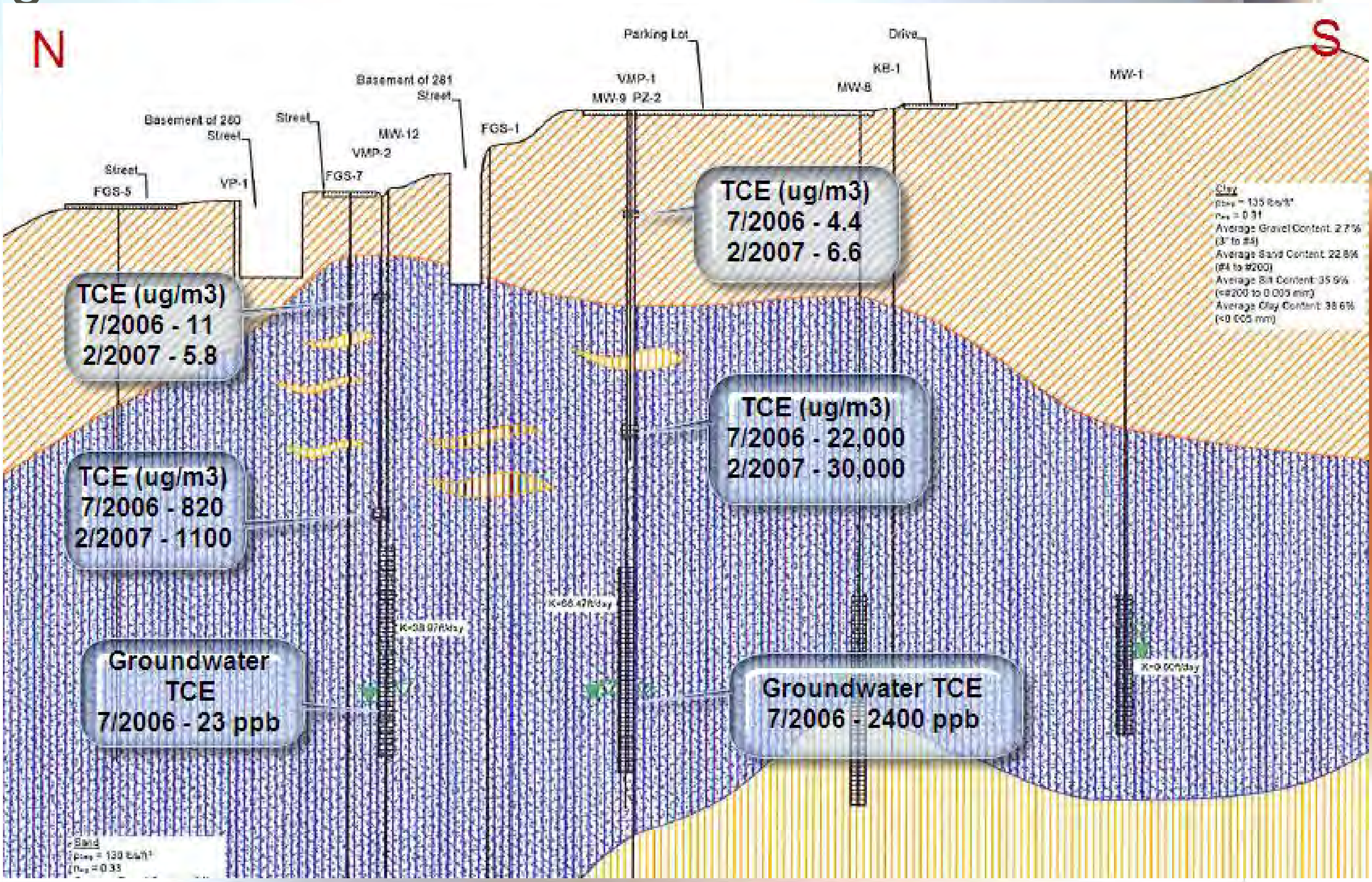


Soil Vapor Profile: TCE in Groundwater Beneath Building



Site in SE WI – TCE in Groundwater

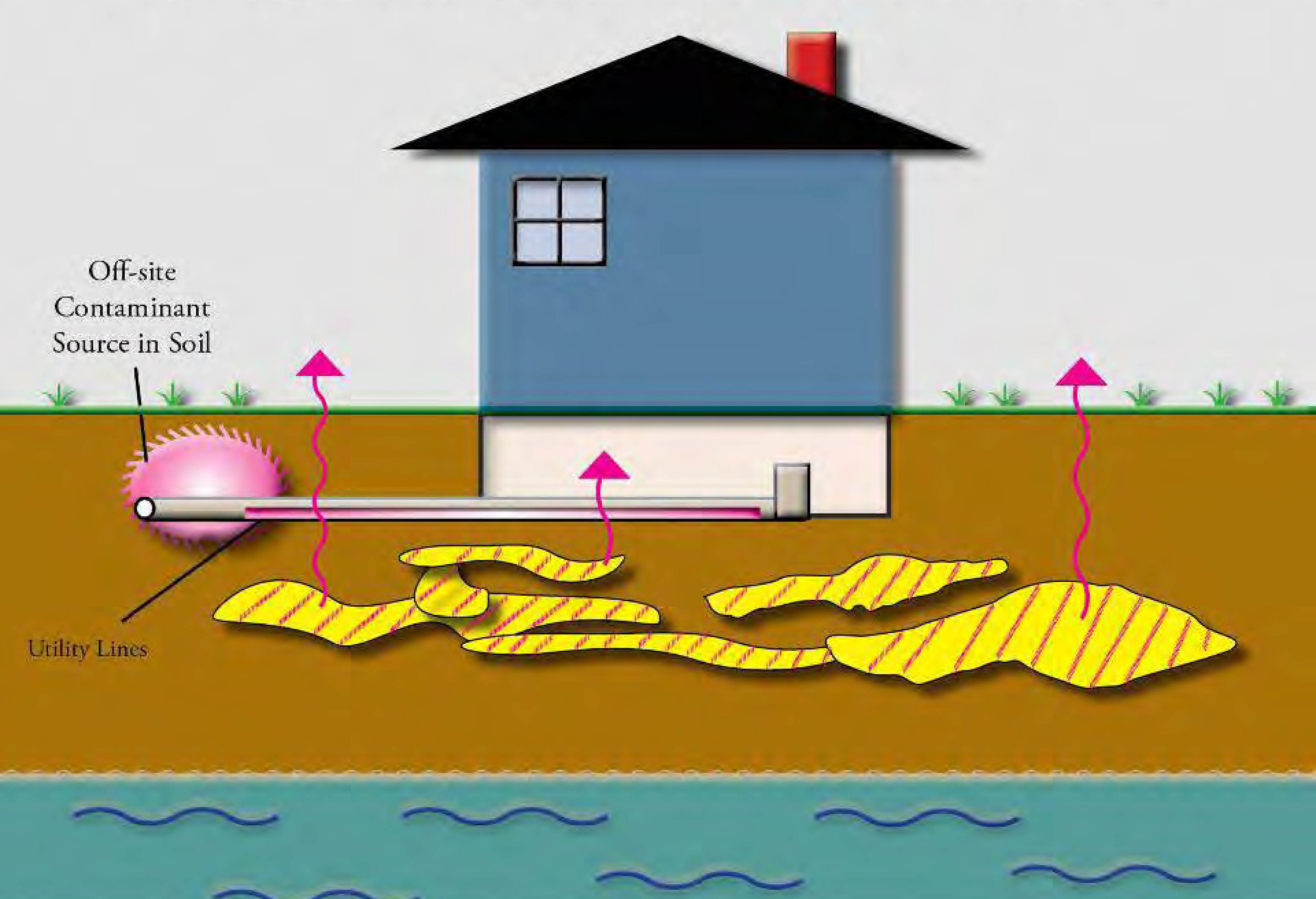
SE WI Site – vapor migration off groundwater table



Stable/Receding Groundwater Plumes & VI Pathway

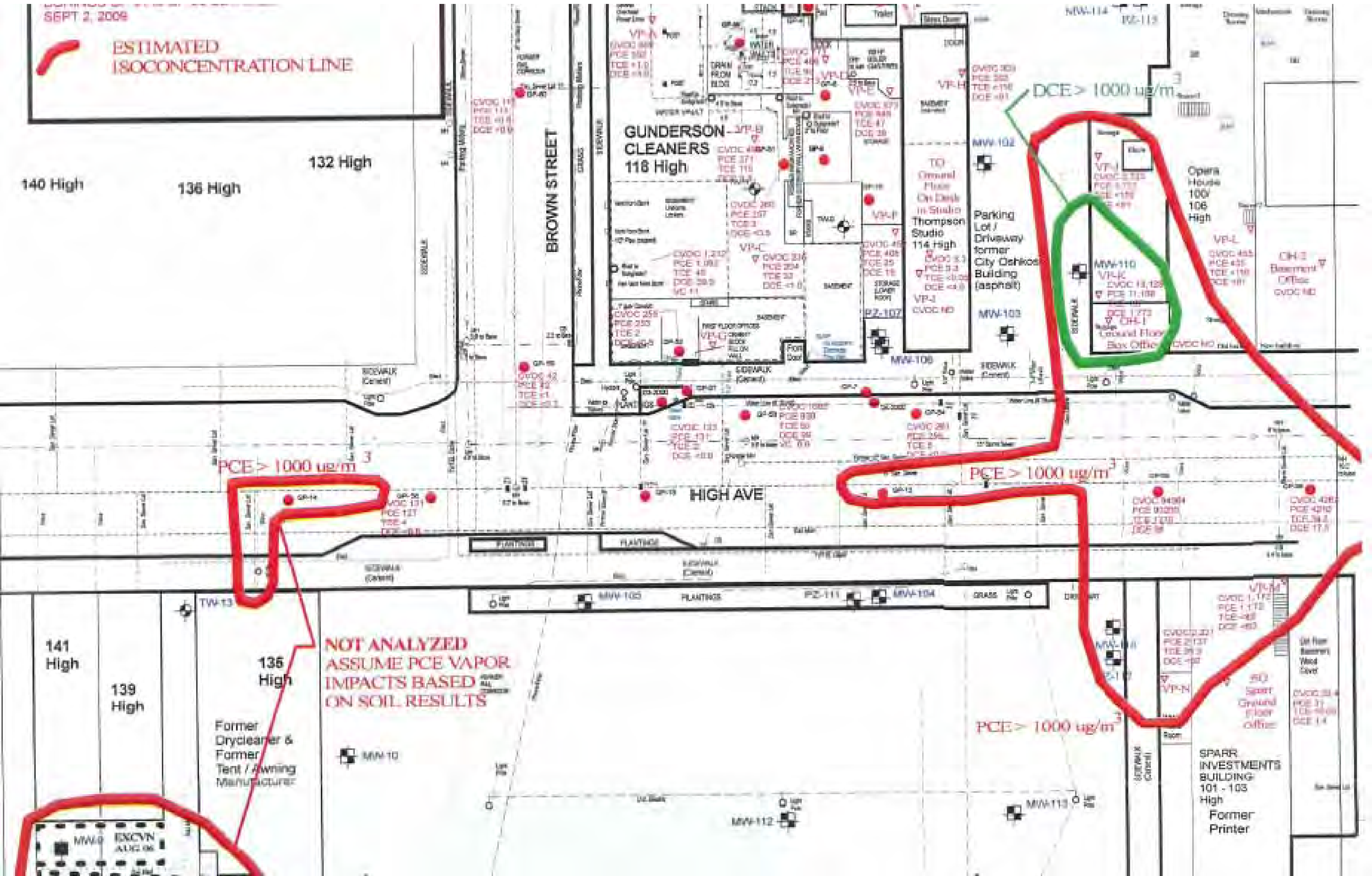
- **“Stable or receding” may describe the groundwater plume behavior, but this is NOT sufficient evidence for closure unless vapor intrusion has been ruled out or adequately investigated and addressed.**

Vapors Migrating Through Preferential Pathways in Soil/Utility Lines

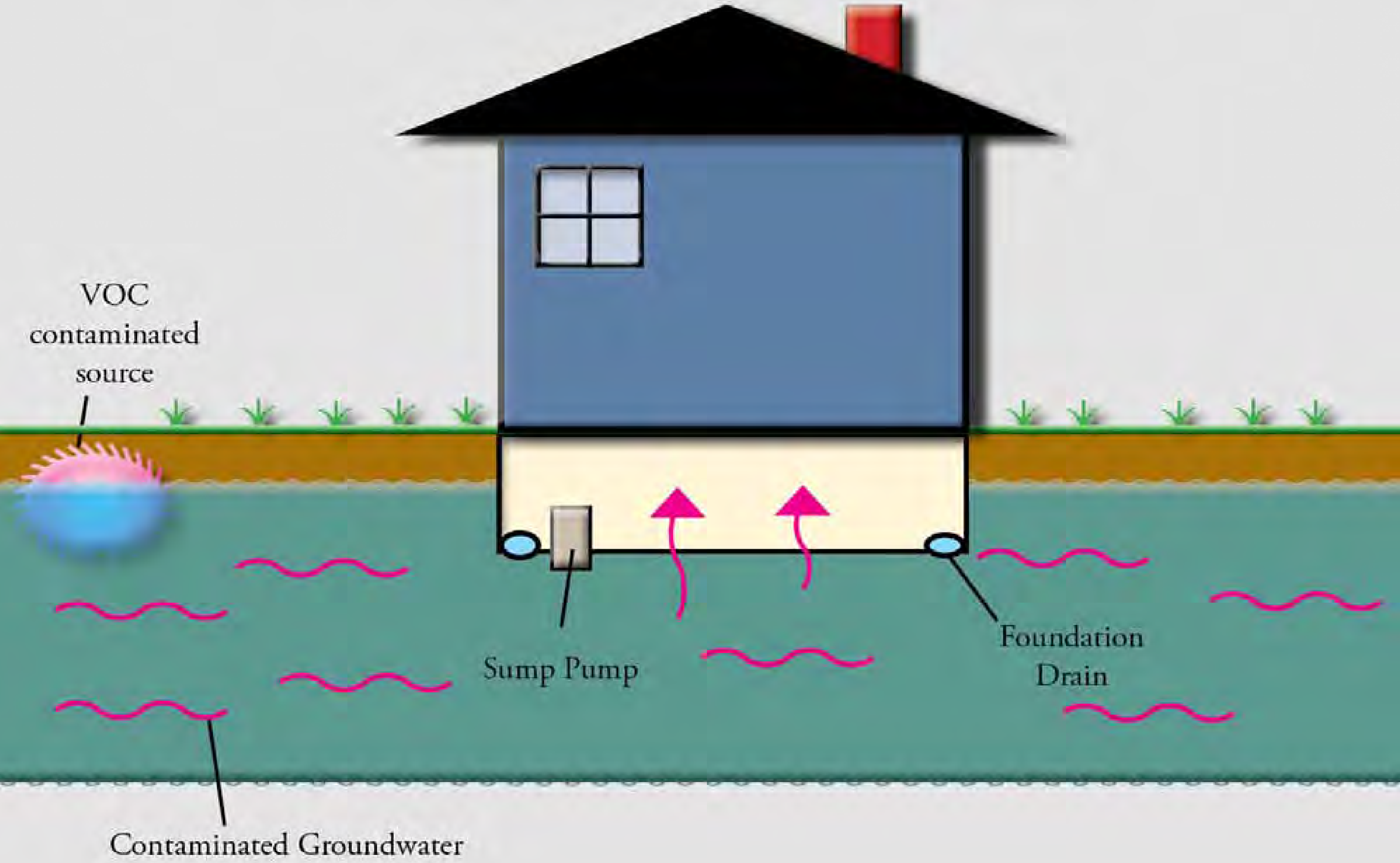


PCE in Sewer - Gunderson DC

Sewer as PCE source



Contaminated Groundwater Entering a Building



Contaminated groundwater entering building - Reedsburg

Table 1: Volatile Organic Compounds in Sump Water
Reedsburg Fire Station
131 S. Park Street, Reedsburg, Sauk County, Wisconsin
March 2007

All concentrations in micrograms per liter (µg/L)

Chemical	Sump Water Crock Locations			Wisconsin Groundwater Enforcement Standards
	Floor Hole NE	Sump East	Sump South	
Petroleum VOCs				
Benzene	890*	450*	3.9	5
Ethylbenzene	230	110	1.1	700
Naphthalene	32	20	ND	100
Toluene	570	300	ND	1,000
1,2,4-Trimethylbenzene	59	40	ND	480
Total Xylenes	250	177	ND	10,000
Dry Cleaning VOCs				
Chloromethane	ND	2	ND	3
cis-1,2,-Dichloroethylene (DCA)	180*	54	20	70
Tetrachloroethylene (PCE)	ND	1	16*	5
Trichloroethylene (TCE)	17*	7	40*	5

Table 2: Volatile Organic Compounds in Indoor Air
Reedsburg Fire Department
131 S. Park Street, Reedsburg, Sauk County, Wisconsin
January 2009

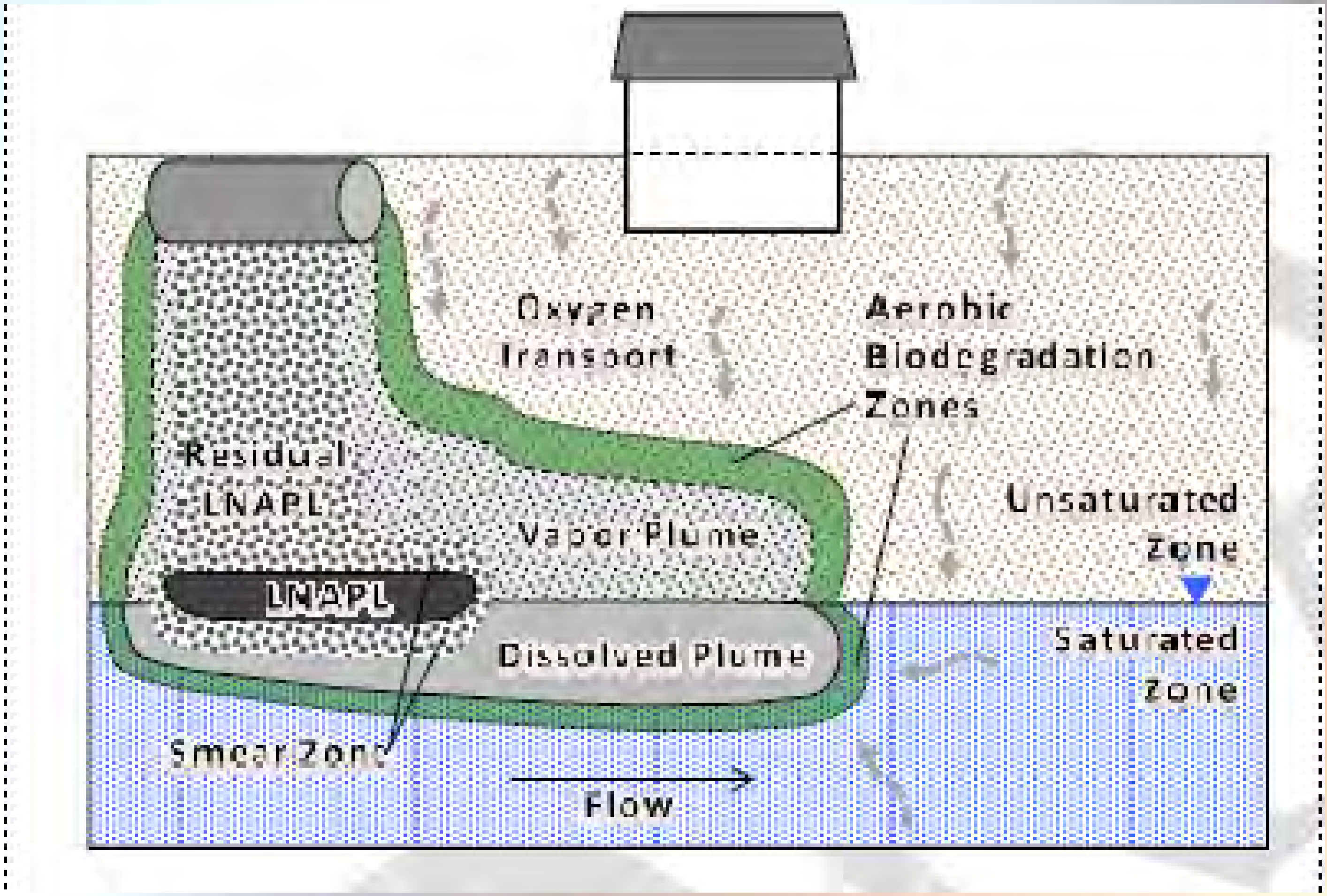
All concentrations in micrograms per cubic meter (μg/m³)

Chemical	Indoor Air Sample Locations				Non-Residential Indoor Air Action Level
	Basement	Office First Floor	Vehicle Bay First Floor	Meeting Room Second Floor	
Petroleum VOCs					
Benzene	52.0*	8.4	5.1	4.0	16.0 [a]
Ethylbenzene	14.0*	2.7	3.1	ND	9.7 [b]
Toluene	73.0	17.0	18.0	12.0	5,000.0 [c]
1,2,4-Trimethylbenzene	6.0	3.0	3.9	2.6	31.0 [d]
Total Xylenes	36.9	10.6	13.9	8.7	3,000.0 [e]
Dry Cleaning VOCs					
Chloromethane	1.0	1.1	ND	ND	68.0 [f]
cis-1,2-Dichlroethylene (DCA)	9.2	ND	ND	ND	n/a
Tetrachloroethylene (PCE)	13.0	ND	ND	ND	21.0 [b]
Trichloroethylene (TCE)	17.0	ND	ND	ND	61.0 [b]

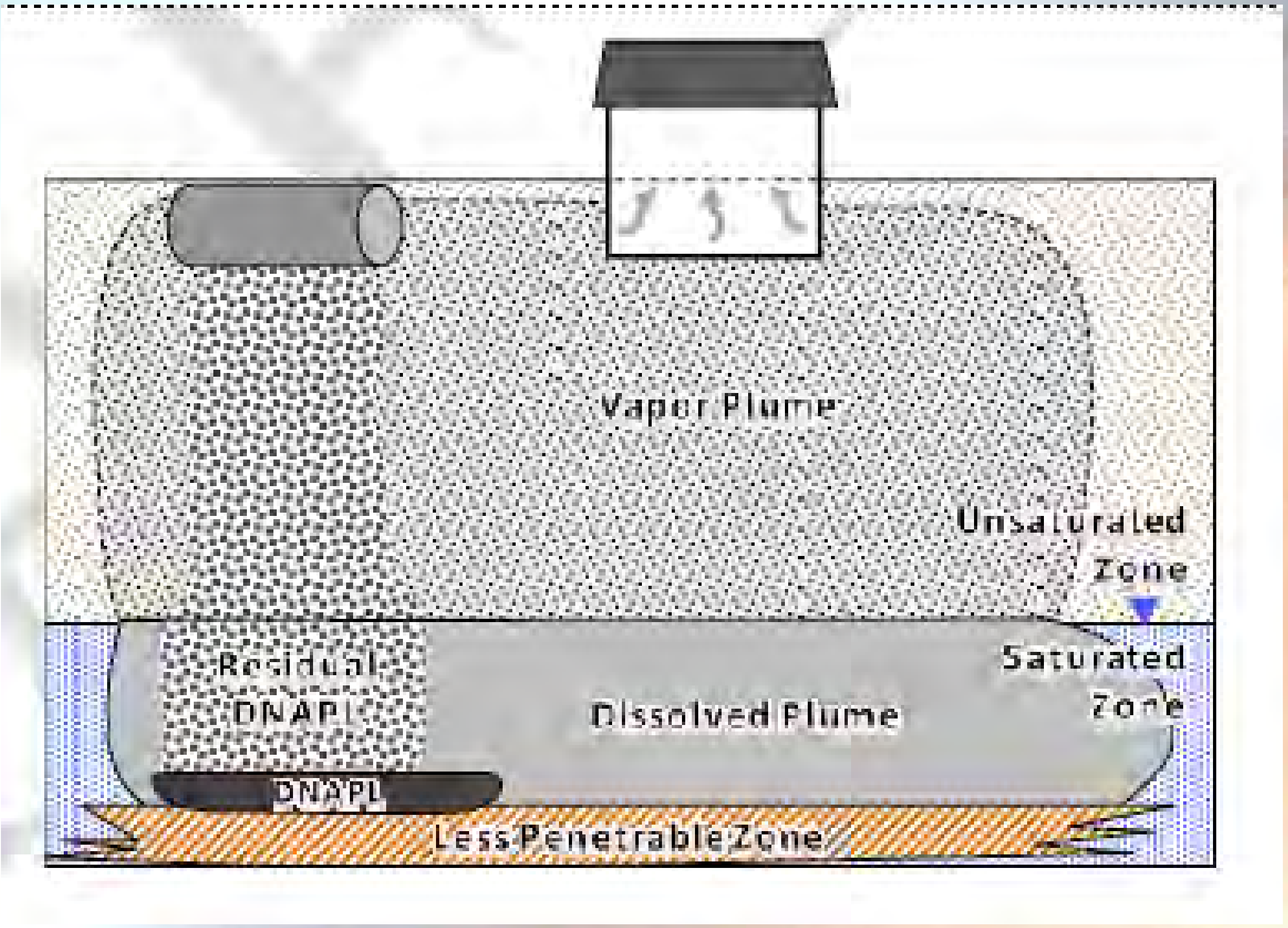
Questions?

Aerobic Degradation of Petroleum VOCs vs. Chlorinated VOCs in Soils

Petroleum VOCs



Chlorinated VOCs



Background VOCs – Indoor Air

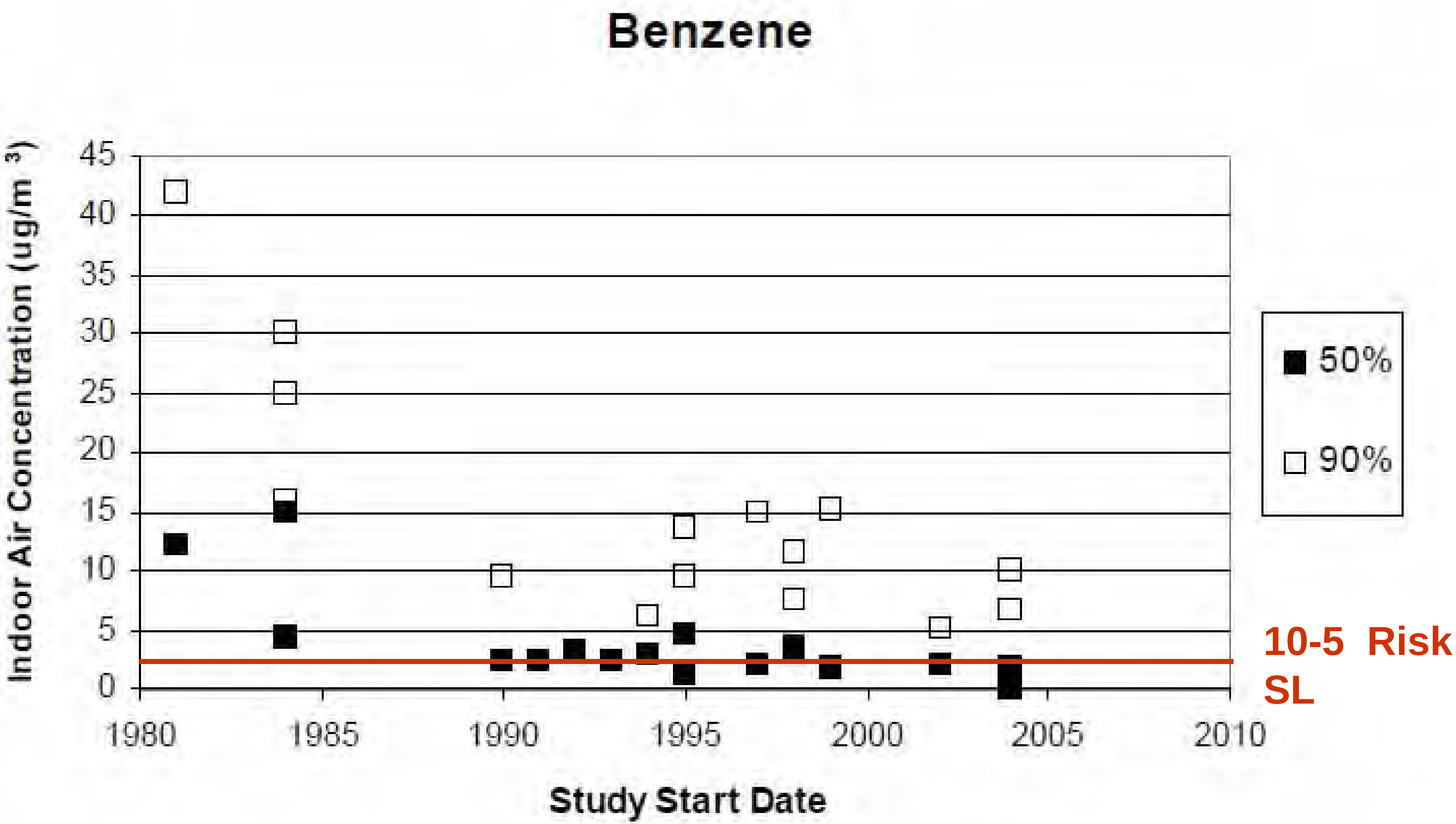
Frequency of Detection in Residential Background Indoor Air

- **Nearly always detected due to background sources: BTEX, PCE, methylene chloride, chloroform, carbon tetrachloride**
- **Very rarely in background IA: 1,1-DCE and cis-1,2-DCE**
- **Almost never in background IA: trans-1,2-DCE and 1,1-DCA**
- **Recent GWMR article: 1,2-DCA & VC may have indoor air sources**

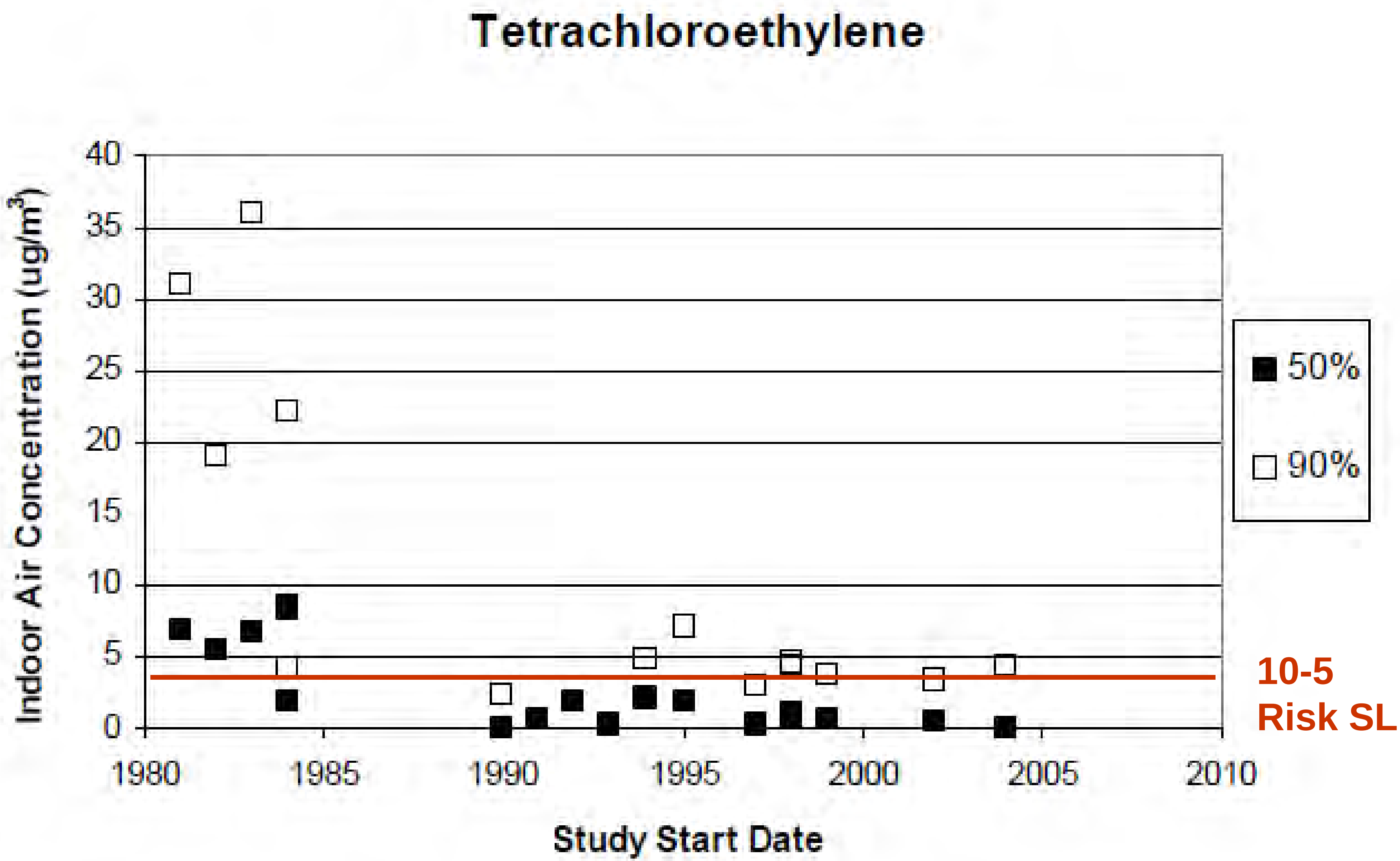
Background vs. Risk Screening Levels

- **Typical background contaminant concentrations will be less than the applicable 10^{-5} Risk Screening Level for most compounds. The main exception is Benzene.**
- **Background PCE will exceed RSL approximately 10% of the time.**
- **Recognize that contaminants can exceed RSL without vapor intrusion.**

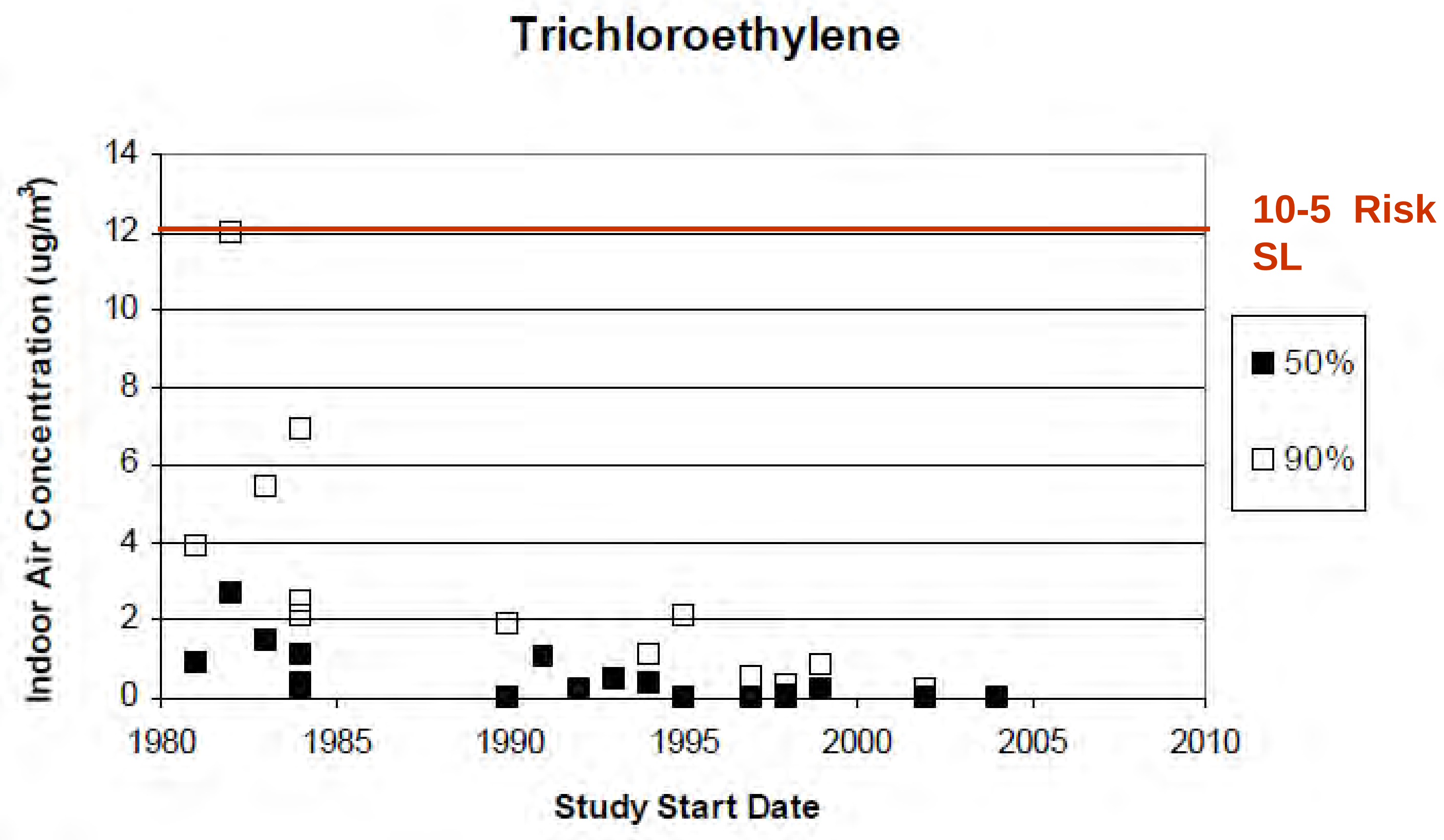
Background Indoor Air (Residential)



Background Indoor Air (Residential)



Background Indoor Air (Residential)



Attenuation Factors and Vapor Intrusion

Definition of Attenuation Factor

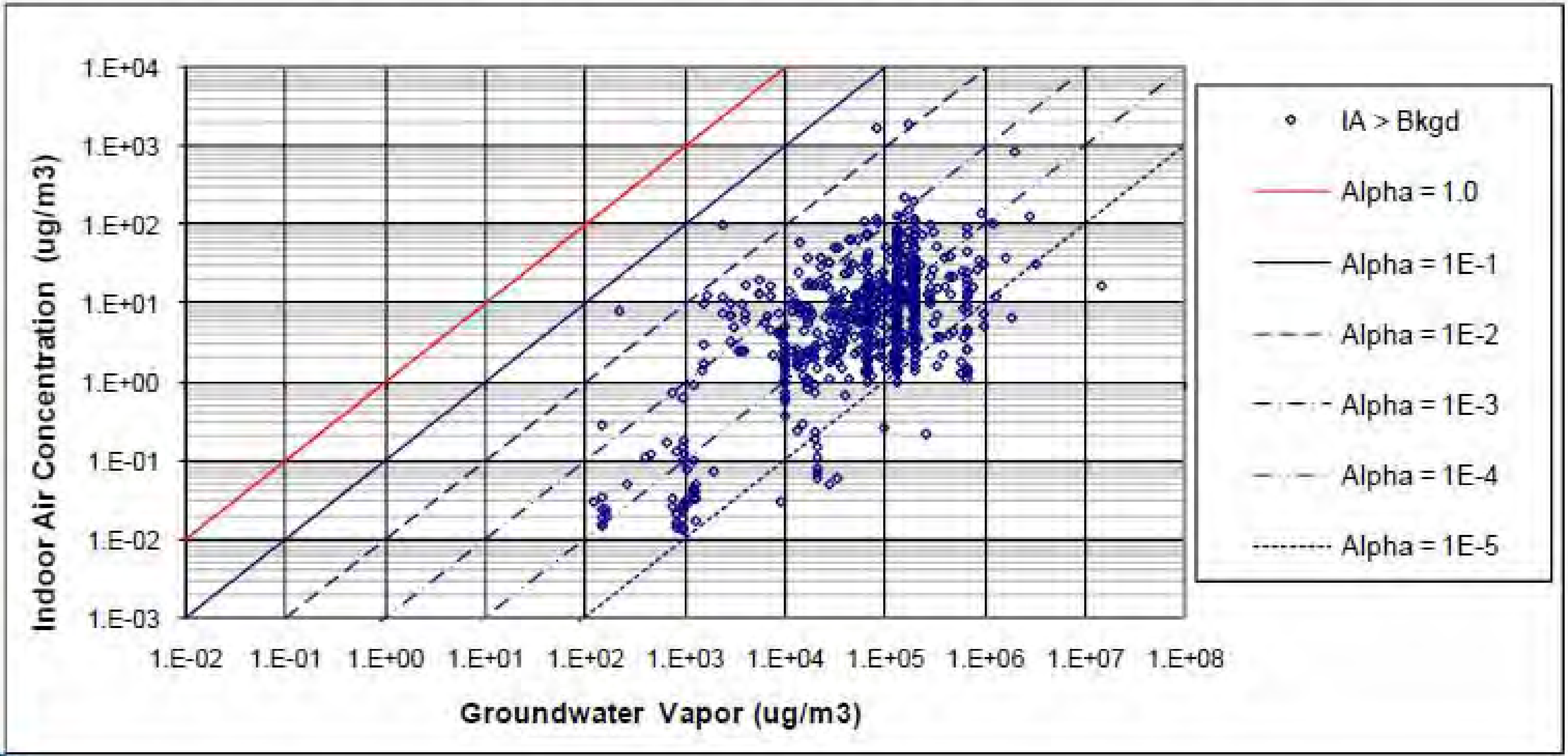
- **Vapor intrusion attenuation factor (AF_{VI}) is defined as:**

$$AF_{VI} = \frac{C_{IA-VI}}{C_{SV}}$$

The ratio of the indoor air concentration due to vapor intrusion (C_{IA-VI}) to the subsurface vapor concentration (C_{SV}) at a point or depth of interest in the VI pathway.

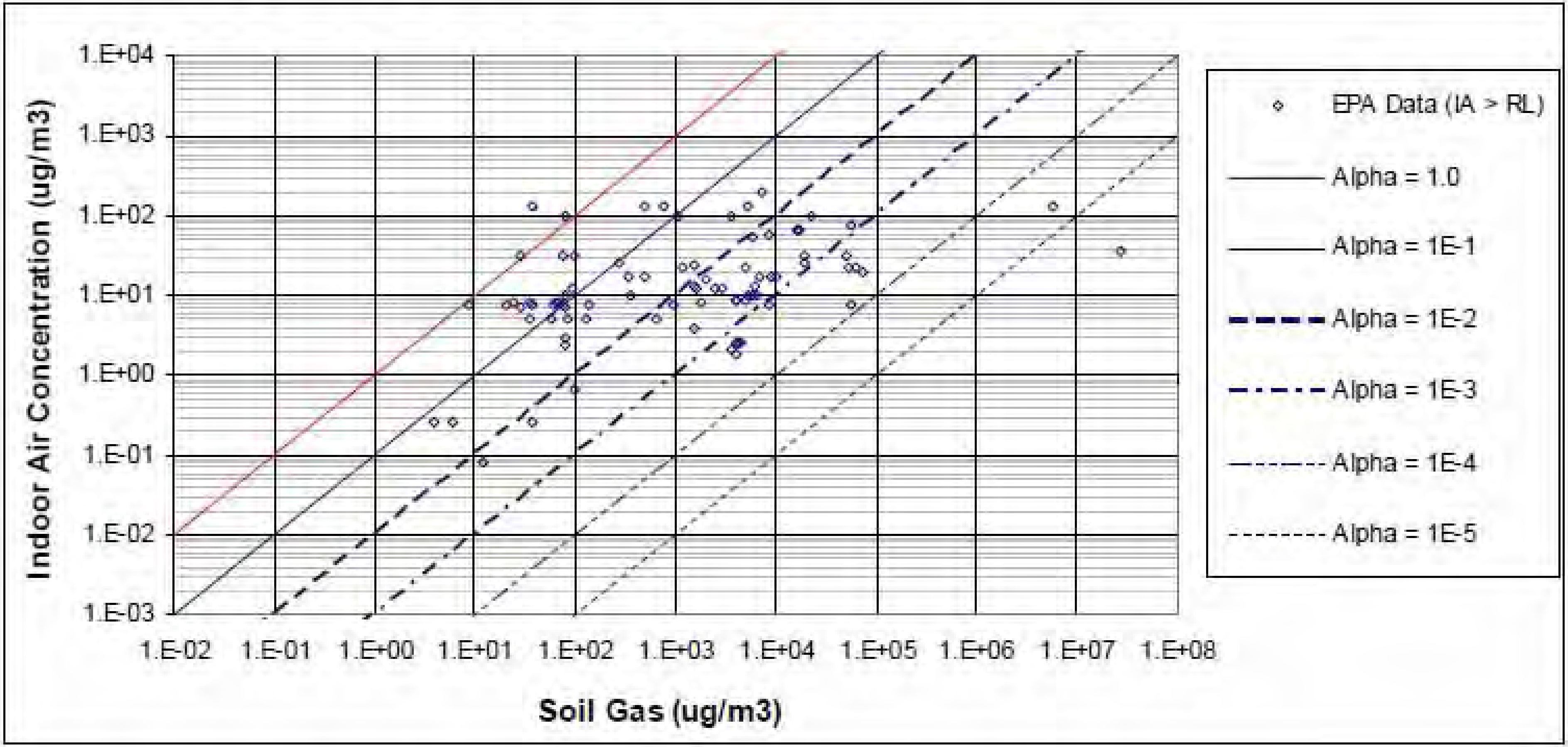
- **Greater attenuation = lower AF value**
- **Less attenuation = higher AF value**

Background Screen
Groundwater Attenuation Factors



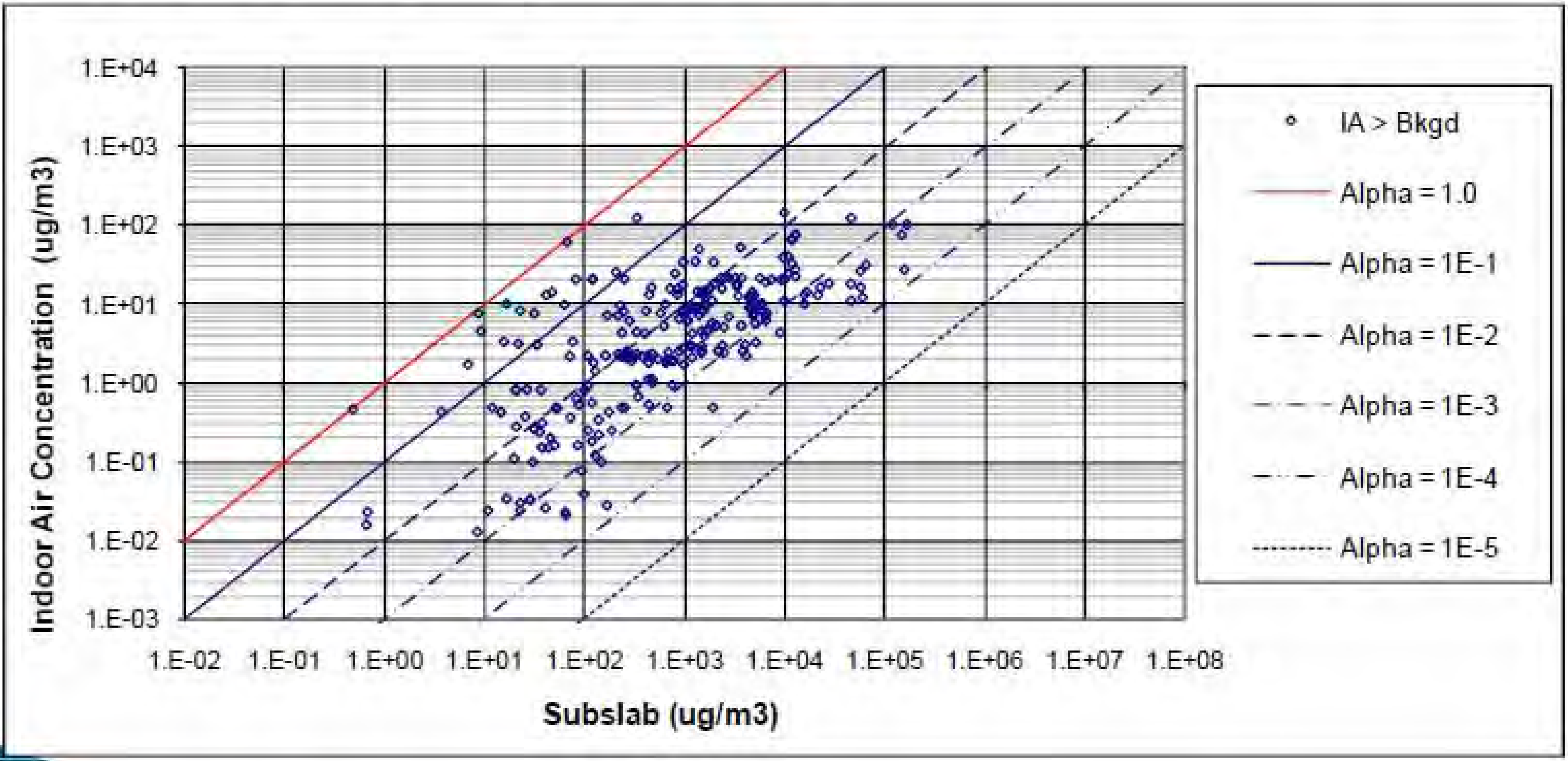
AF = 0.001 at 95th percentile

Background Screened Soil Gas Attenuation Factors



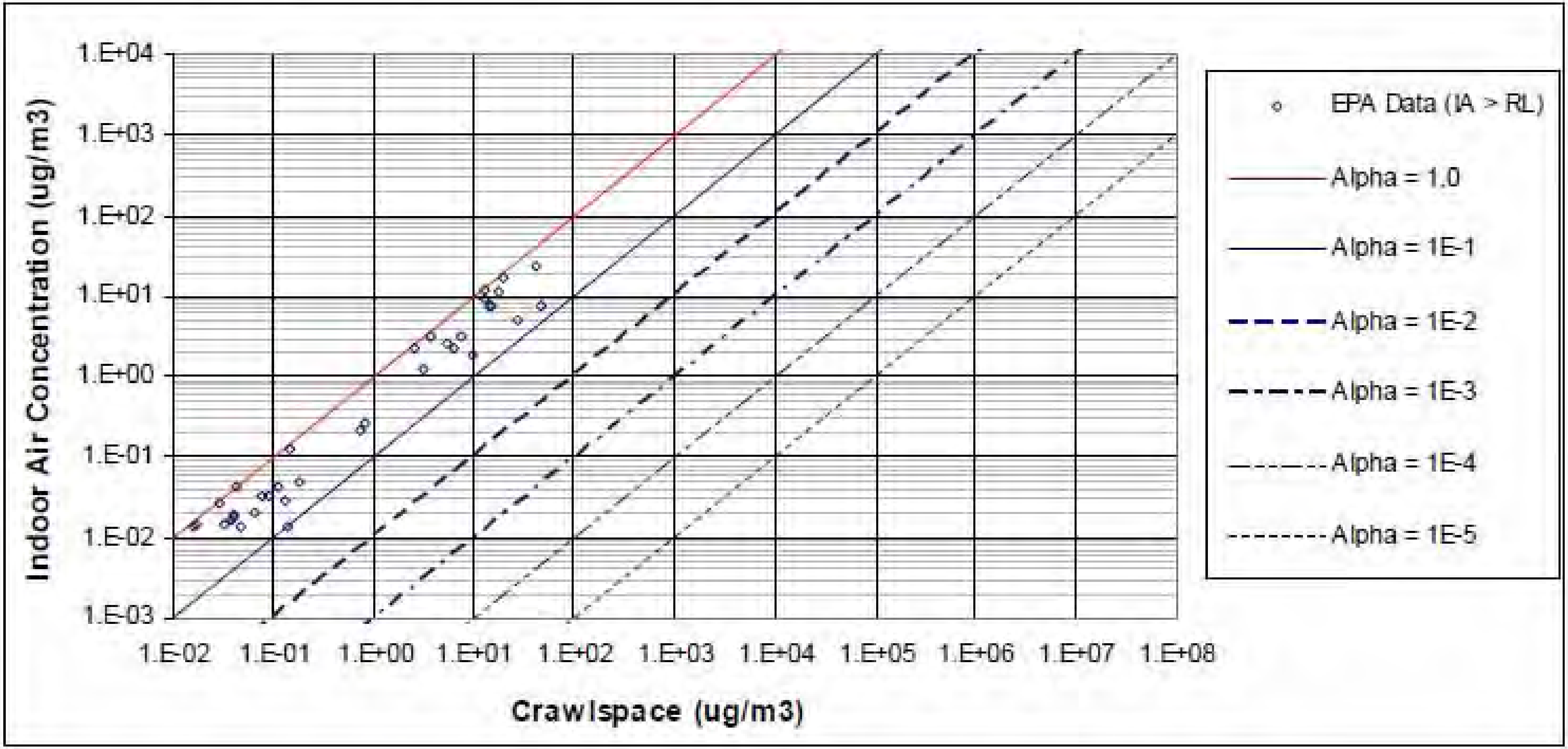
Much greater variability, AF = 1 at 95th Percentile

Background Screened Subslab Attenuation Factors



AF = 0.1 at 95th Percentile

Background Screened Crawlspace Attenuation Factors



AF = 1 at 95th Percentile

Soil Gas vs. Sub-slab Data (EPA's Conclusion from Database)

- **Very poor overall correlation of sub-slab and soil gas concentrations from 6 sites with paired data**
- **May be a function of varying soil gas sampling depths and methods**
- **Recommend using 95th percentile sub-slab attenuation factor for exterior soil gas samples (i.e., 0.1) – at least for shallow samples**

Affect of Buildings on Vapor Intrusion

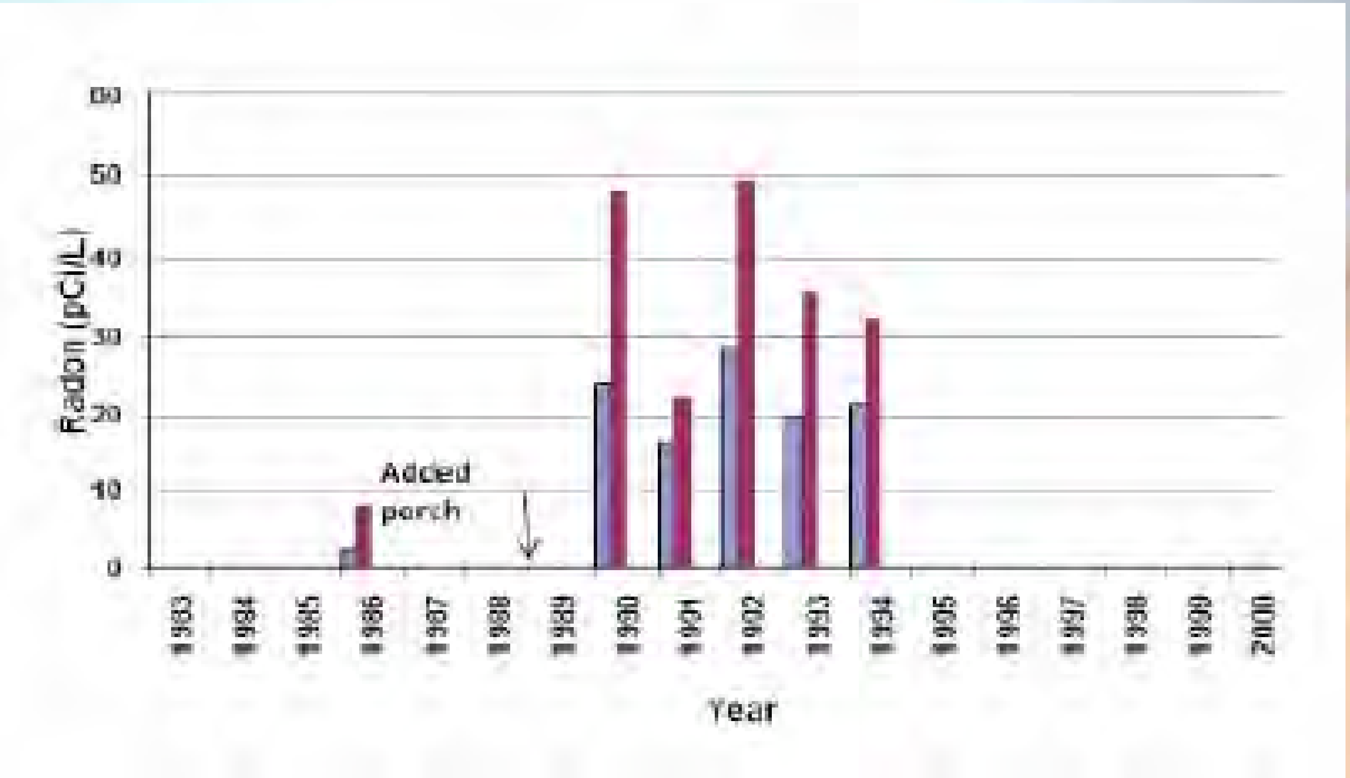
3 Major Factors Affect VI

- **Sub-surface factors**
  - **Collect sub-surface samples (groundwater, soil matrix, soil gas, sub-slab) to define**
- **Building factors**
  - **Collect indoor air samples to define**
- **Above ground factors (weather)**

Building Factors

- **Great deal of spatial and temporal variability in all 3 factors**
- **Effect of an individual building on vapor migration is <u>not</u> predictable (one reason why modeling this pathway is inappropriate)**
- **Therefore, when sub-slab vapor concentrations indicate vapor intrusion is likely, mitigation should be installed or long-term indoor air monitoring should be conducted.**

Effect of changes to a building on Radon concentration



Porch was added to a home and radon concentrations increased by 5x. Similar studies not available for chemical VI, but the processes are the same.

Questions?

Sample Collection to Identify the Vapor Migration Pathway

Sub-slab vapor samples

- **Density of sample**
  - **3 samples for ~5,000 ft^2 and 1 additional sample for each additional 2,000 ft^2**
  - **Target areas where release has occurred**
- **Flow reduction to ~200 ml/min (30 min fill time).**
- **Method TO-14a or TO-15 for VOCs**

Sub-slab vapor samples

- **Quality Control**
  - **Vacuum testing of lines**
    - **Requires a vacuum gage & connection to pull a pressure of ~50 – 100 inches of water column on the sampling line & maintain vacuum for 1 min.**
  - **Leak Detection – ensure effective seal of probe**
    - **Several tracers available, most are detectable only AFTER sample collection**
    - **Recommend He so that leak can be detected BEFORE sample collection**

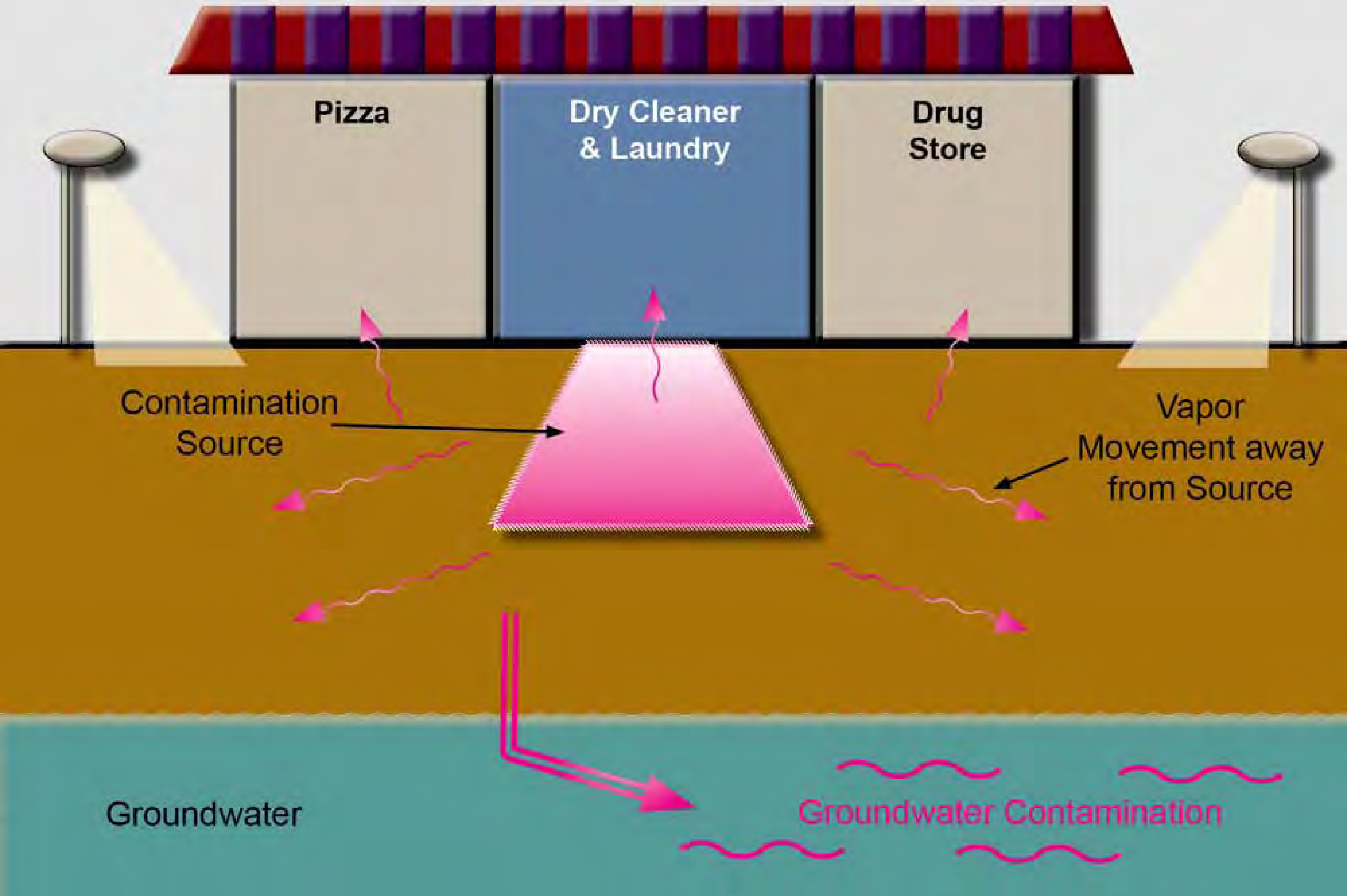
Soil Gas Samples

- **Many approaches (implants, post-run tubing, vapor wells, etc.)**
- **Collect 1-2 ft above water table, if groundwater is vapor source**
- **If groundwater >30 ft bgs, collect ½ way to water table**
- **Collect at least 5 ft bgs, where possible.**
- **Collection method - Tedlar bags or Summa canisters**

Indoor/Outdoor Air Sampling

- **Residential – 24 hr Summa canister sample**
- **Industrial – 8 hr Summa canister sample**
- **One (1) outdoor sample when collecting indoor air samples**
- **Method TO-14a or TO-15**
- **Focus on contaminant of concern**

Vapors from a Release Directly Beneath Building & Vapor Movement Through Soils



Sampling at a vapor source beneath building

- **Sub-slab samples are the primary sampling methodology, both for soil matrix and soil vapor migration.**
- **Groundwater monitoring wells placed outside the building (but occasionally inside large buildings).**

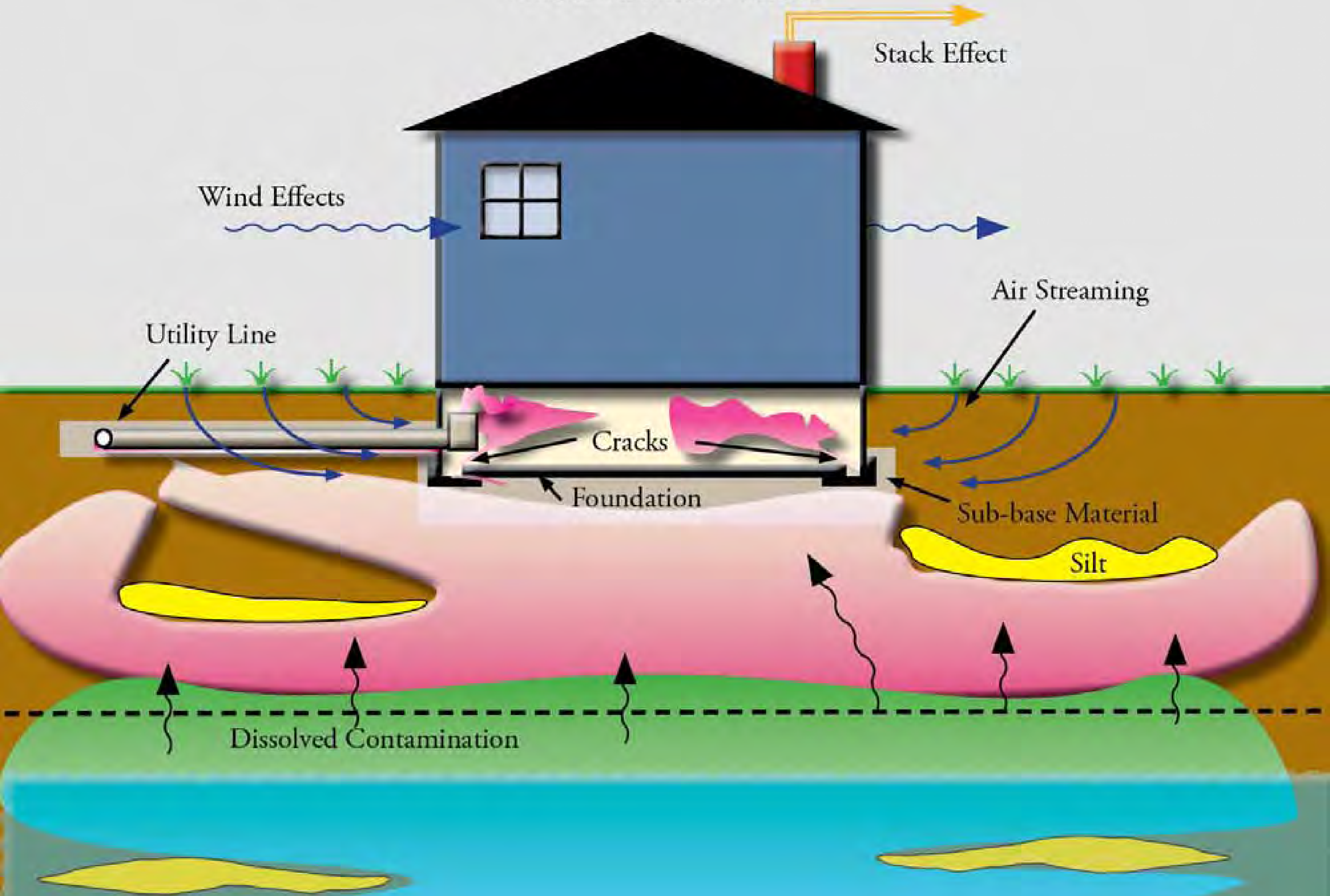
Example: Soil concentration vs. Sub-slab vapor concentration (PCE)

Soil Matrix (ug/kg)	Sub-slab vapor (ug/m^3)	Vapor Risk Screening Level (ug/m^3)
1,500	**2,500,000**	**210**
450	**900,000**	**210**

Sampling for vapors migrating laterally through soils

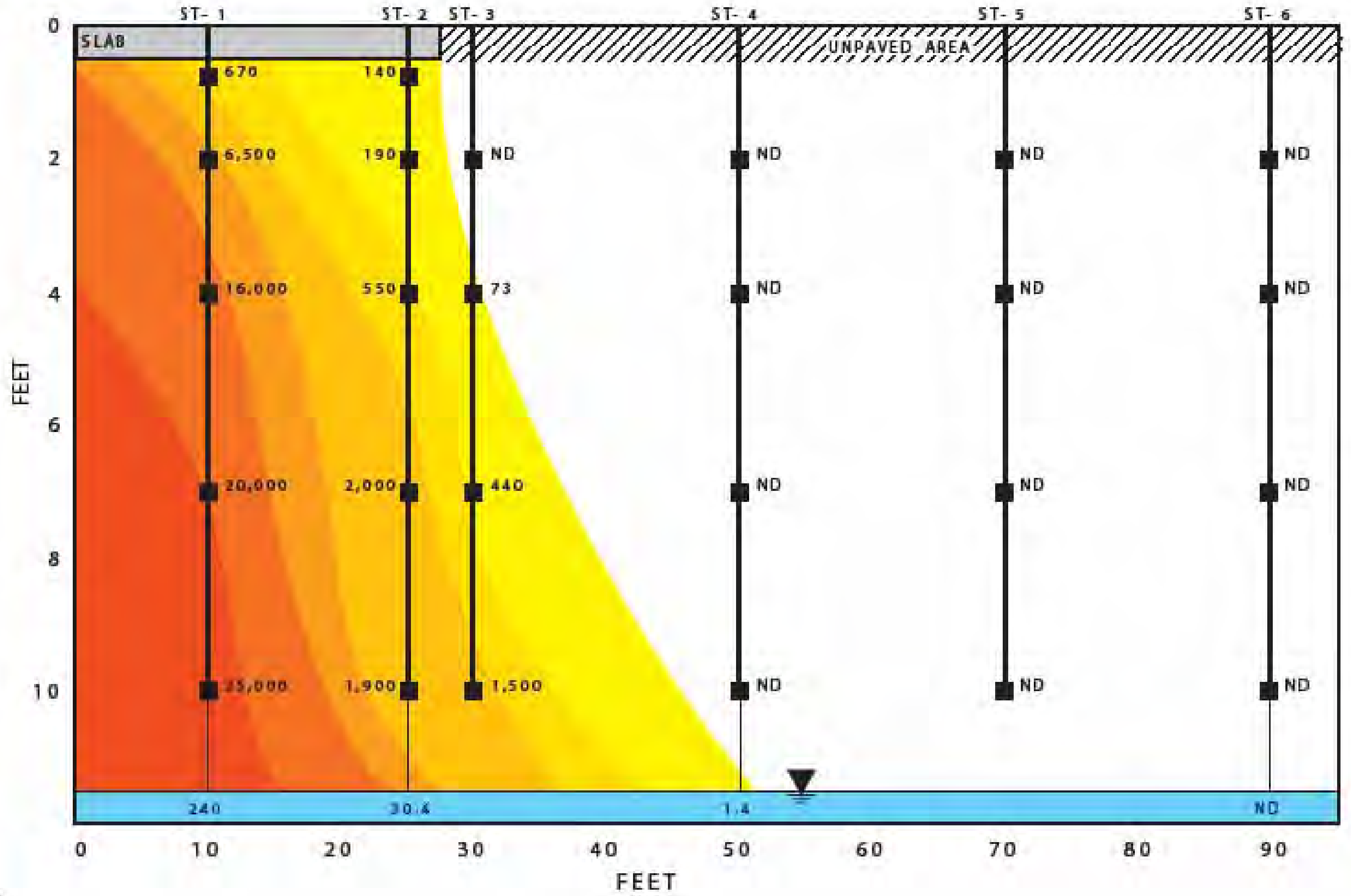
- **Depending on the proximity of the building to the source:**
  - **Sub-slab samples are the preferred method if source and building of interest are fairly close**
  - **Soil vapor samples useful for buildings that may be at a distance from the source. Follow-up with sub-slab & indoor air samples where necessary.**
- **Nested vapor wells recommended to identify lateral vapor movement**

Vapors Migrating from Contaminants Located at the Groundwater Table



Sampling for vapors migrating off the water table

- **Soil vapor samples can be collected above the water table. If near a building, sample above water table may be indicative of sub-slab concentrations.**
- **Follow-up with sub-slab and indoor air samples where necessary.**



If soil gas samples collected, should be taken just above the water table & as close to building as possible.

Screening groundwater for vapor migration

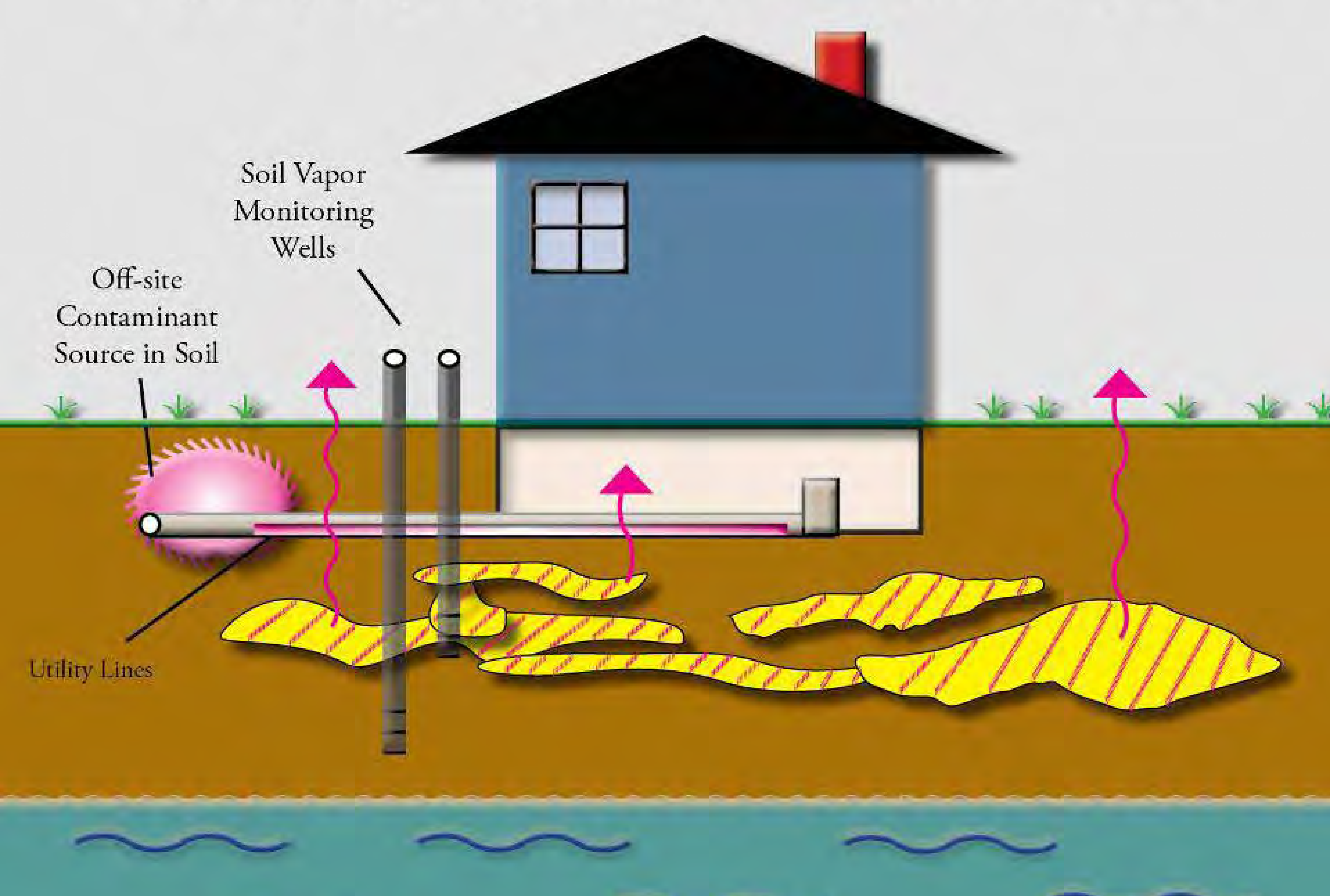
$$C_{gw} = \frac{C_{IA}}{(H \times AF_{gw} \times 1000 \, L/m^3)}$$

H (dimensionless), OSWER Method at 7º C

http://www.epa.gov/athens/learn2model/part-two/onsite/esthenry.html

Contaminant	C_{IA} (Residential)	H (at ~7º C) dimensionless	C_{gw} (µg/L)
PCE	4.1	0.276	15
TCE	12	0.174	69

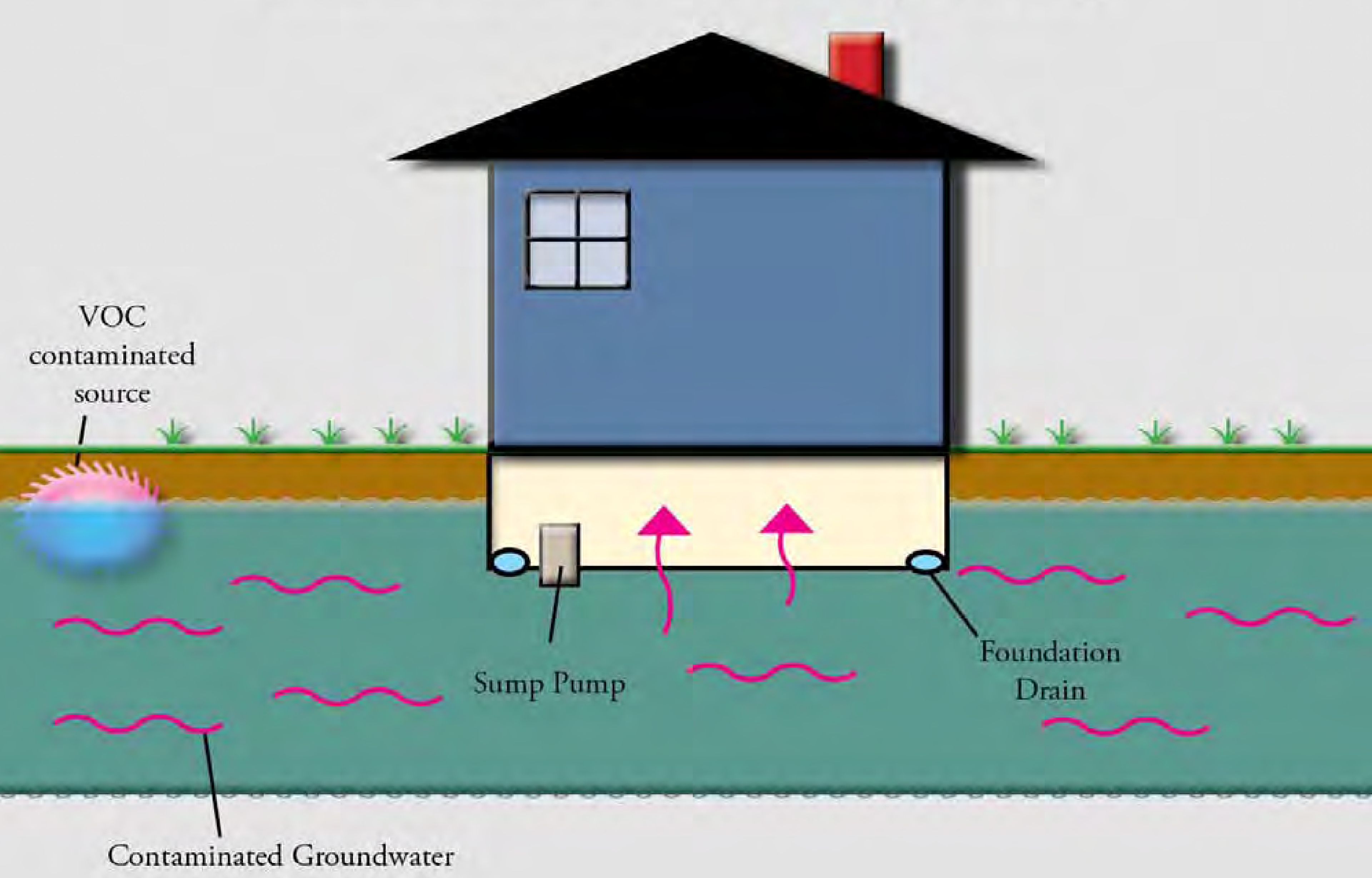
Vapors Migrating Through Preferential Pathways in Soil/Utility Lines



Sampling for Migration through Sewer Laterals (inside building)

- **Are there floor drains in the buildings? Cover them with something sealed to the floor, draw a gentle vacuum on it, and see if you get a sustainable flow of soil gas, if so, the floor drain is not air-tight (very common).**
- **Screen the incoming soil gas with a PID (PCE responds very favorably). If you get high readings (>10 ppmv), there is a good chance you have a candidate for sub-slab venting. If less, collect a sample for lab analysis.**

Contaminated Groundwater Entering a Building



Sampling for contaminated groundwater entering building

- **If possible, sample the groundwater**
- **Seal and sample air above sump**
- **Sample indoor air**

END Part 1

Questions?