DERP Forum

Strengthening Relationships with our Regulatory Partners

St. Louis, Missouri

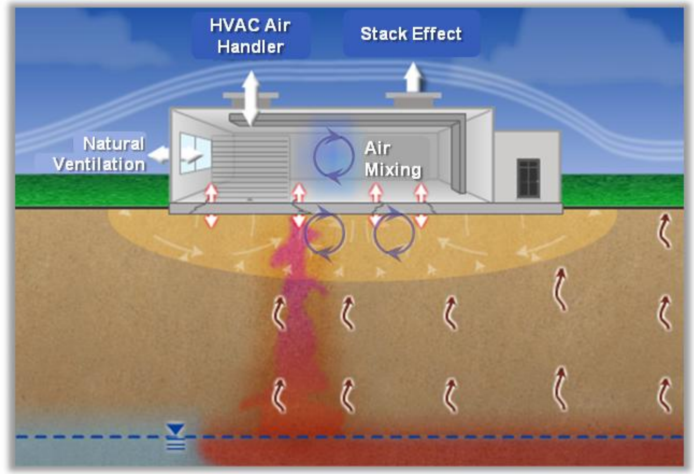
May 8-9, 2019

2019 Defense Environmental Restoration Program (DERP) Forum: Vapor Intrusion Tools and Challenges

Applying New Tools in Vapor Intrusion Assessments
and
DoD's Vapor Intrusion Database of Industrial Buildings

Vapor Intrusion (VI) Challenges

- New tools to address VI challenges:
  - Background indoor sources
  - Temporal and spatial variability
  - Atypical preferential pathways

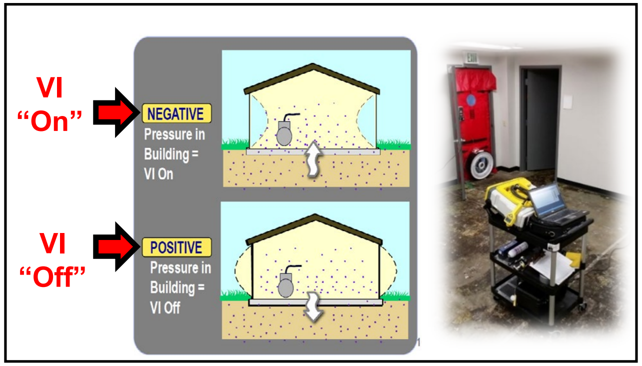


- DoD industrial building VI database / analyses developed to:
  - Provide defensible alternatives to overly conservative assumptions
  - Better understand the causes of variability
  - Identify key factors with greatest influence on VI potential
  - Develop a systematic process to evaluate multiple lines of evidence

Applying New Tools in VI Assessments

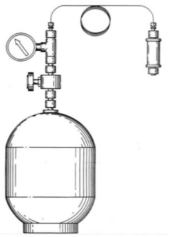
Real-Time Monitoring

Pressure Cycling



Longer Duration Sampling

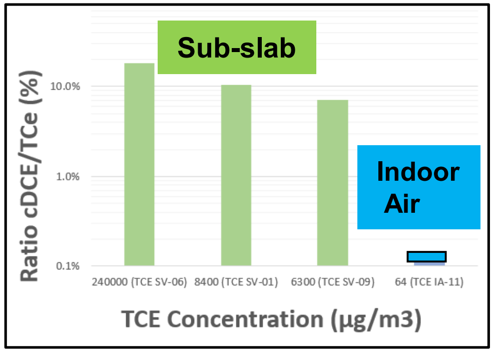
Passive Sampler



Ultra-Low-Flow Canister

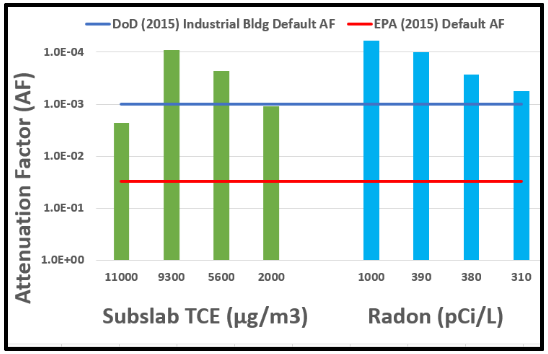
High Volume Sampling

Constituent Ratio Analysis



Indicators / Tracers

(Radon / Pressure / Temperature)



Key Point Applying innovative technologies reduces uncertainties, time, and cost

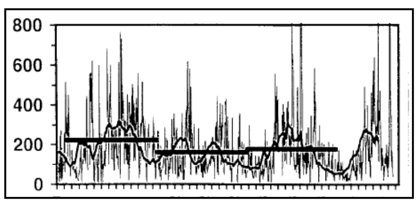
DoD VI Handbook Fact Sheets for New Technologies
http://www.denix.osd.mil/irp/vaporintrusion/

Applying New Tools to Address VI Challenges

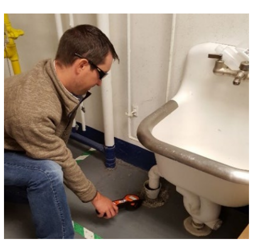
Challenge

Background Sources

Temporal and Spatial Variability



Preferential Pathways



Solution

Background Sources:

- ❖ Constituent ratio analysis
- ❖ Pressure cycling
- ❖ Near real-time monitoring
- ❖ Comparison to outdoor air

Temporal and Spatial Variability:

- ❖ Pressure cycling & near worst-case VI
- ❖ High volume sampling
- ❖ Real-time monitoring
- ❖ Indicators / tracers
- ❖ Longer duration sampling
  - ❖ Passive sampler
  - ❖ Ultra-low-flow controller on canister

Preferential Pathways:

- ❖ Utility surveys
- ❖ Pressure cycling
- ❖ Real-time monitoring
- ❖ Indicators / tracers

VI Industrial Building Database

2011

2012

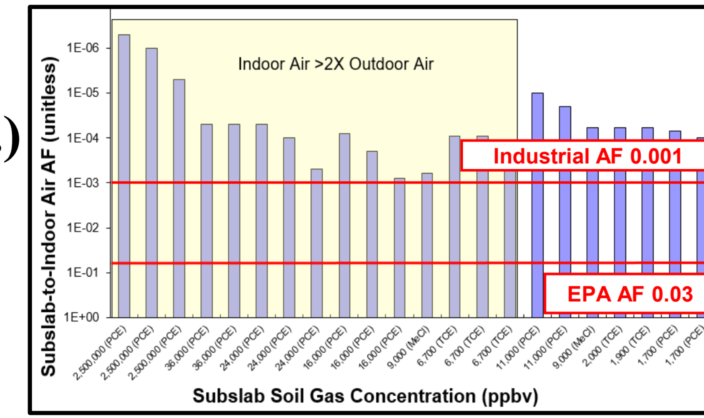
2013

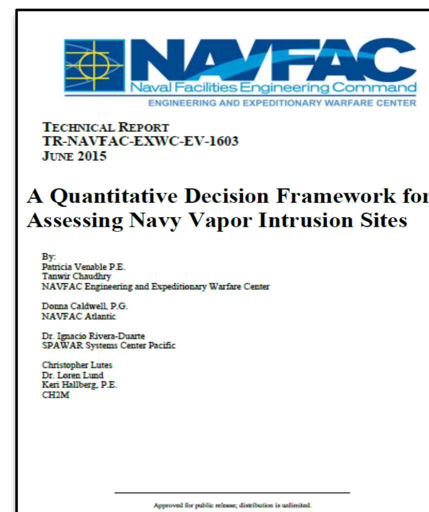
2014

2015

- **Default attenuation factors (AF) are not representative of industrial buildings**
- **Created industrial VI database (49 bldgs.)**
  - Applied same data filters used by EPA for residential database
    - 90th % published background
    - 50x source strength
  - Analysis showed 1-2 orders of magnitude more attenuation than EPA residential default
  - Conducted robust statistical analysis to identify key influencing lines of evidence
  - VI SMEs ranked the strength of these key influencing lines of evidence
  - Developed Quantitative Decision Framework for systematically assessing multiple lines of evidence

Empirical Sub-slab AFs for ~20 Industrial Buildings





NAVFAC
Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

TECHNICAL REPORT
TR-NAVFAC-EXWC-EV-1603
JUNE 2015

A Quantitative Decision Framework for Assessing Navy Vapor Intrusion Sites

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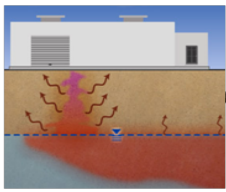
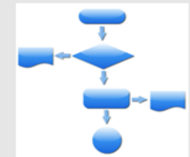
VI Quantitative Decision Framework for Industrial Buildings (2015)



VI Database

Key Influencing Factors	Input Range	Weight of Importance
Dimensions	<100 to >100,000 sq ft	0 to 4
Exterior Wall	Yes/No	0 to 2
Vadose Zone Source /Soil Type	Yes/No; Fine/Coarse	0 to 3
Distance to Source	<10 ft to >200 ft	0 to 8
Source Concentration	>100,000x to <300x SL	0 to 8
Preferential Pathways	Yes/Unknown/No	0 to 3



Flowcharts

Scorecard

Decision Matrix

Key Points

- Tool to systematically and defensibly review multiple lines of evidence
- Provides defensible alternative to using overly conservative assumptions
- Useful tool during planning, investigation, and long-term stewardship

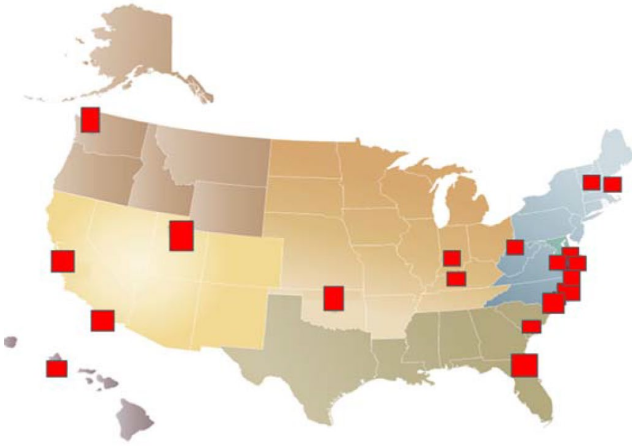
NESDI Project #476: *Quantitative Decision Framework for Assessing Navy Vapor Intrusion Sites* www.nesdi.navy.mil/Files/FinalReports/FR_476.pdf

Expanded VI Industrial Building Database

2016

- **Added 30 industrial buildings to VI database**
- **22 installations, 27 sites, and 79 bldgs.**
  - Majority sites with depth to water <15 ft
  - Large (50%), medium (35%), and small (15%) buildings

2017



- **More robust database**
  - TCE indoor air results increased from 270 to 1082 (pre-filter)
  - PCE indoor air results increased from 202 to 923 (pre-filter)

2018

- > 100,000 sq ft: 9 buildings
- 20,000 – 100,000 sq ft: 30 buildings
- 6,000 – 20,000 sq ft: 26 buildings
- <6,000 sq ft: 14 buildings

2019

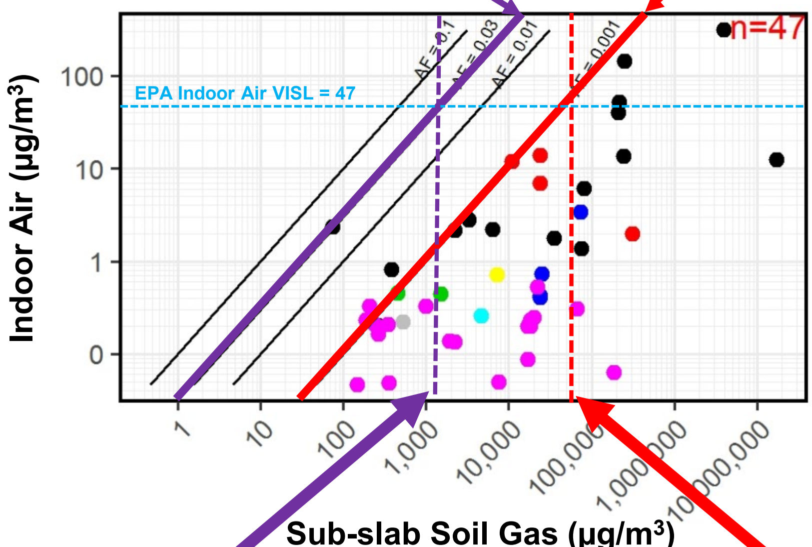
- **On-going re-analysis of expanded database**

Expanded Database Preliminary Re-Analysis: Attenuation Factors

PCE Sub-slab vs. Indoor Air

EPA SS AF = 0.03

Empirical SS AF = 0.001



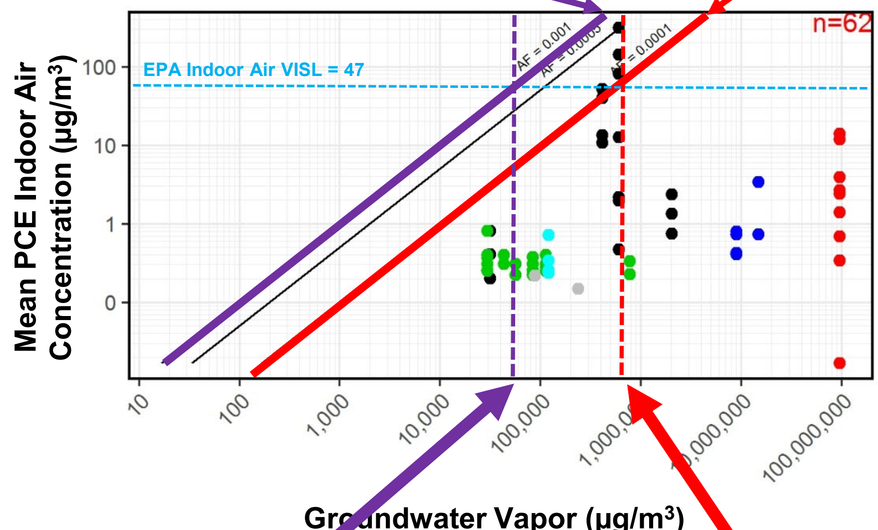
EPA Default SS VISL (1,600 µg/m³)

Empirical Industrial SS VISL (47,000 µg/m³)

PCE Groundwater Vapor vs. Indoor Air

Empirical GW AF = .0001

EPA GW AF = .001



EPA Default GW VISL = 65 µg/L (47,000 µg/m³)

Empirical Industrial GW VISL = 650 µg/L (470,000 µg/m³)

Key Point Preliminary re-analysis for PCE is consistent with attenuation in industrial bldgs. conservatively 1-2 orders of magnitude greater than EPA residential defaults

VISL = VI Screening Level; SS = Subslab; GW = Groundwater

Ongoing Re-Analysis of Expanded VI Database

- **VI SME Team:**
  - Jacobs: Dr. L. Lund and C. Lutes
  - Geosyntec: Dr. H. Dawson and Dr. T. McAlary
  - EPA: Dr. R. Kapuscinski
- **Expanding robust statistical analyses to include:**
  - Applying various source strength screens (e.g. 50x, 100x, and 1000x)
  - Applying various paired data combinations in a sampling zone (e.g. individual pairs, averages, averages over time)
  - Statistical analysis to re-assess key influencing factors in VI potential
- **VI Industrial Database Re-Analysis Summary**
  - Evidence of **>1** order of magnitude more attenuation in industrial vs residential buildings
  - Re-assessing/confirming key VI influencing parameters with expanded database analysis
  - Updating Quantitative Decision Framework for systematically evaluating multiple lines of evidence

Key Point VI assessments are more than comparing VOCs to VISLs

Thank You

Backup Slides

On-going Research of Temporal Variability in Industrial Buildings

- **Objectives**
  - Compare temporal variability of VI in Navy industrial buildings to residences
  - Evaluate if near worst case VI conditions can be induced by controlled building pressure
  - Strategies for selecting sampling zones to optimize VI evaluations

Project Components

Building Survey/ Diagnostic Testing → **Pressure Cycling of Four Zones** → **Year-long Indoor /Sub-slab /Outdoor Air Monitoring**

Building Survey/ Diagnostic Testing:
- ❖ HVAC Analysis
- ❖ Tracer Gas Testing
- ❖ Pressure Differential Monitoring
- ❖ Temperature Differences

Pressure Cycling of Four Zones:
- ❖ Building pressure cycling method
- ❖ GC/ECD
- ❖ HAPSITE

Year-long Indoor /Sub-slab /Outdoor Air Monitoring:
- ❖ GC/ECD – grab sample
- ❖ Summa Canisters
- ❖ Pressure Differential
- ❖ Temperature Differential

Expanded VI Industrial Building Database

New Sites Have Added A Lot of Data

49 Buildings in Database (2015)

Quantitative Decision Framework for Assessing Navy VI Sites (NESDI#476)
30 June 2015

Table 6-1. Number of Detected Concentrations in Indoor Air after Each Screening Step

Detected Indoor Air	TCE	PCE	cis-1,2-DCE	trans-1,2-DCE	1,2-DCA	1,1-DCA	1,1,1-TCA	VC
No screen	134	99	58	65	29	27	11	15
Baseline screen	133	99	58	65	29	27	11	15
Baseline screen + Source strength screen	98	64	58	65	8	27	9	9
Baseline screen + Background screen	48	8	58	65	22	27	0	10
No screen + Preferential pathway=false	107	78	37	56	28	11	11	8
Baseline screen + Source strength screen + Preferential pathway=false	78	43	37	56	7	11	9	2
Baseline screen + Background screen + Preferential pathway=false	39	7	37	56	22	11	0	6

Expanded to 79 Buildings in Database (2019)

Table 6-1

Number of Detected Concentrations in Infoor Air after Each Screening Step

	TCE	PCE	cis-12-DCE	trans-12-DCE	12-DCA	11-DCA	111-TCA	11-DCE	VC
No screen	1031	918	928	631	720	698	767	621	972
Baseline screen	964	692	585	440	194	296	441	276	254
Baseline screen + Source strength screen	734	428	585	440	67	296	239	238	235
Baseline screen + Preferential Pathway	844	581	475	413	173	277	429	160	215
Baseline screen + Source strength screen + Preferential Pathway	615	332	475	413	59	277	239	132	196

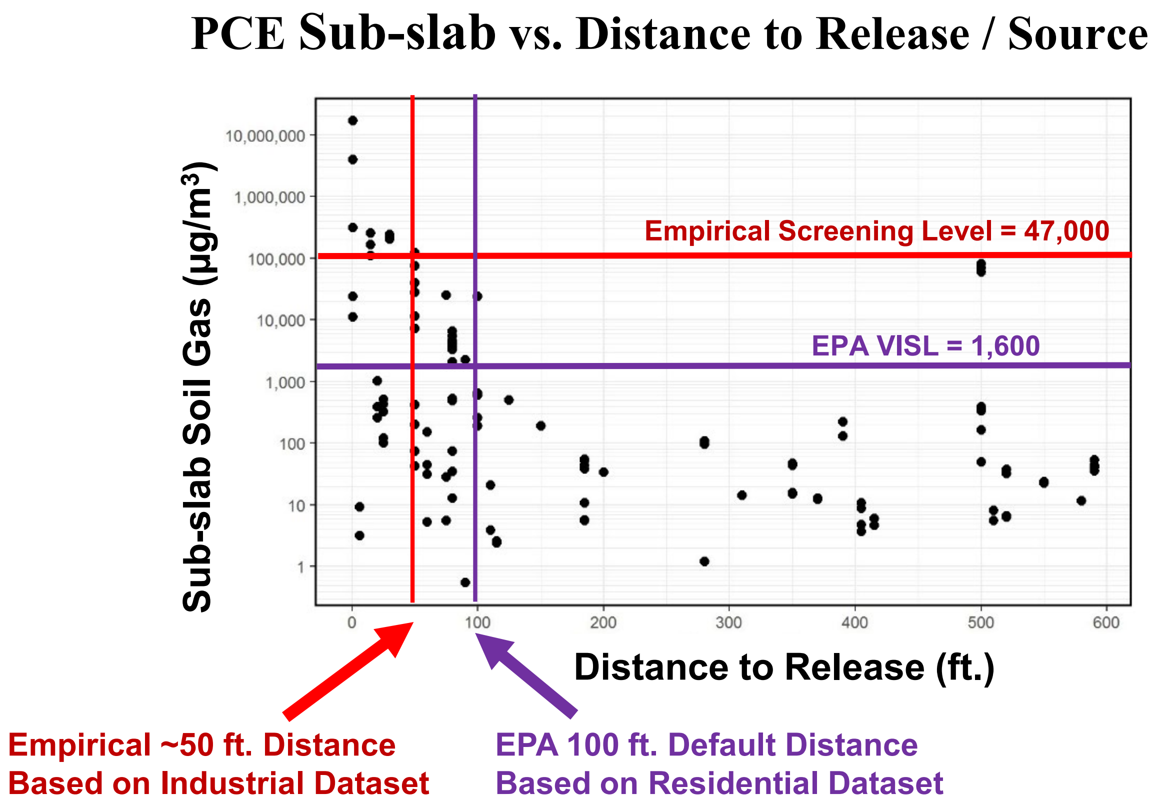
Background Study Results

Background Studies used in Filtering Data

Table 5-3. Literature Indoor Air Background Concentration Information Used in This Study

Analyte	90th percentile of the BASE study indoor air distribution (NYSDOH, 2006 Appendix C-2)	Median of 90th Percentile Concentration from multiple studies as used in USEPA, 2012a	95th Percentile Rago, 2014, Commercial Buildings	Selected background value for the purpose of this study and for indoor air screening	Source Strength Screening Level for Sub-slab = 50X selected value	Source Strength Screening Level for Groundwater Vapor = 1000x selected value
	100 public and commercial office buildings, Sampled 1994-1996, Three samples per building	Fifteen studies of residences sampled 1990-2005, total 2898 samples	10 Offices and 10 schools, sampled 2013 in Mass; some multiple floors, total 37 samples			
1,1,1-Trichloroethane	20.6	3.1	0.3	20.6	1030	20600
1,1-Dichloroethane	<0.7	<RL		<RL	<RL	<RL
cis-1,2-Dichloroethene	<1.9	<RL		<RL	<RL	<RL
Tetrachloroethene	15.9	3.8	8.2	15.9	795	15900
Trichloroethene	4.2	0.5	24.6	4.2	210	4200

Expanded Database Preliminary Re-Analysis: Distance to Release



Key Point

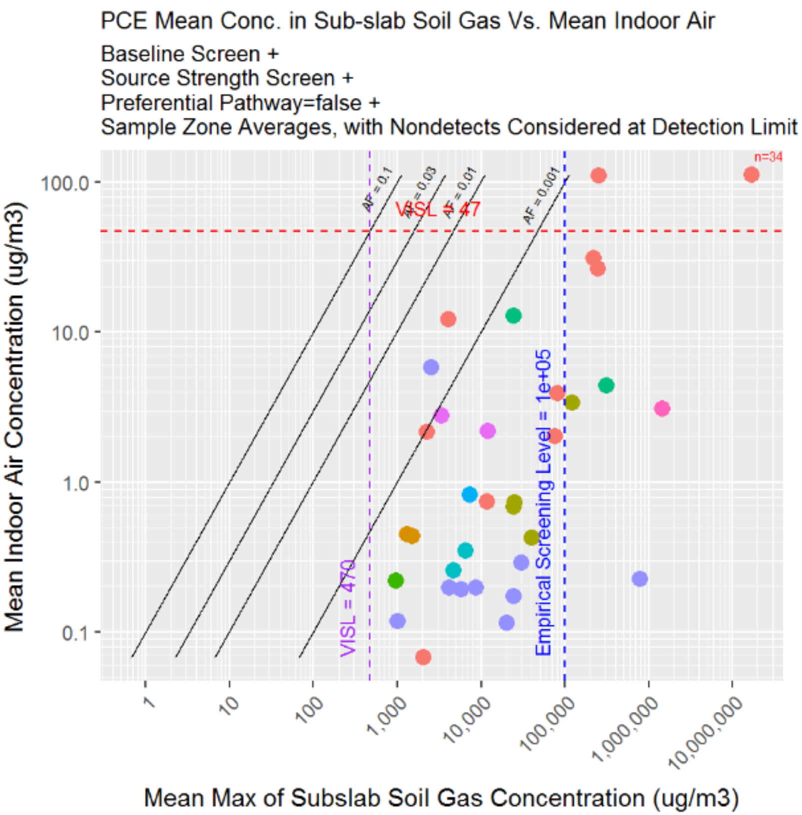
Preliminary re-analysis of distance to source for PCE sub-slab concentrations is consistent with 50 ft. default for industrial bldgs.

Sub-slab Soil Gas vs. Indoor Air– PCE

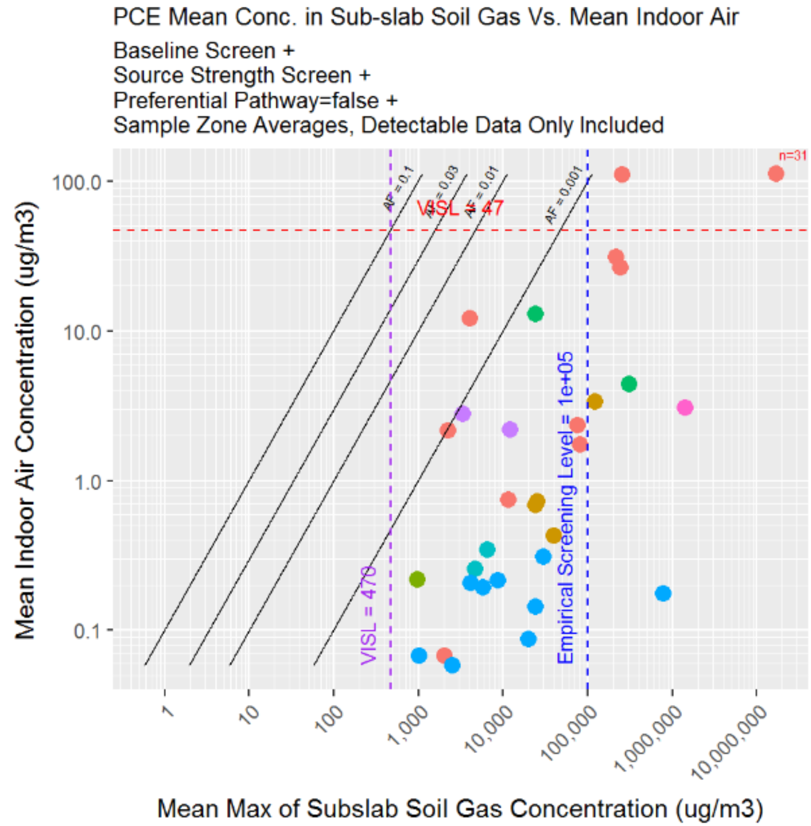
Non-Detects at Reporting Limits vs. Non-Detects Excluded

Little difference if Non-Detects excluded or Reporting Limits used

Non-detects at detection limits

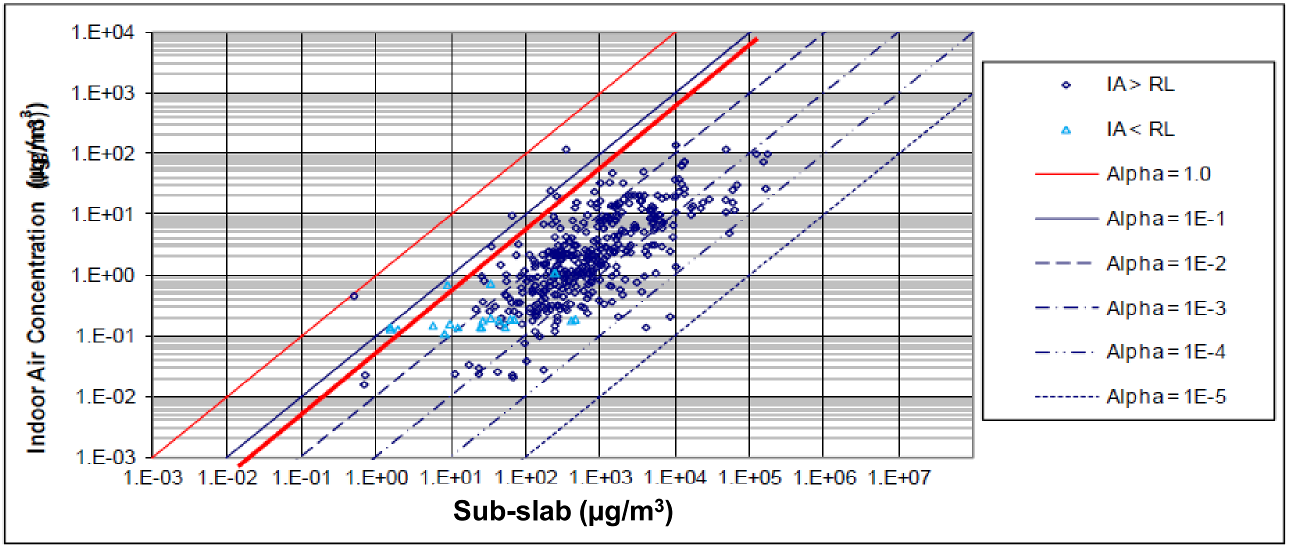


Non-detects excluded

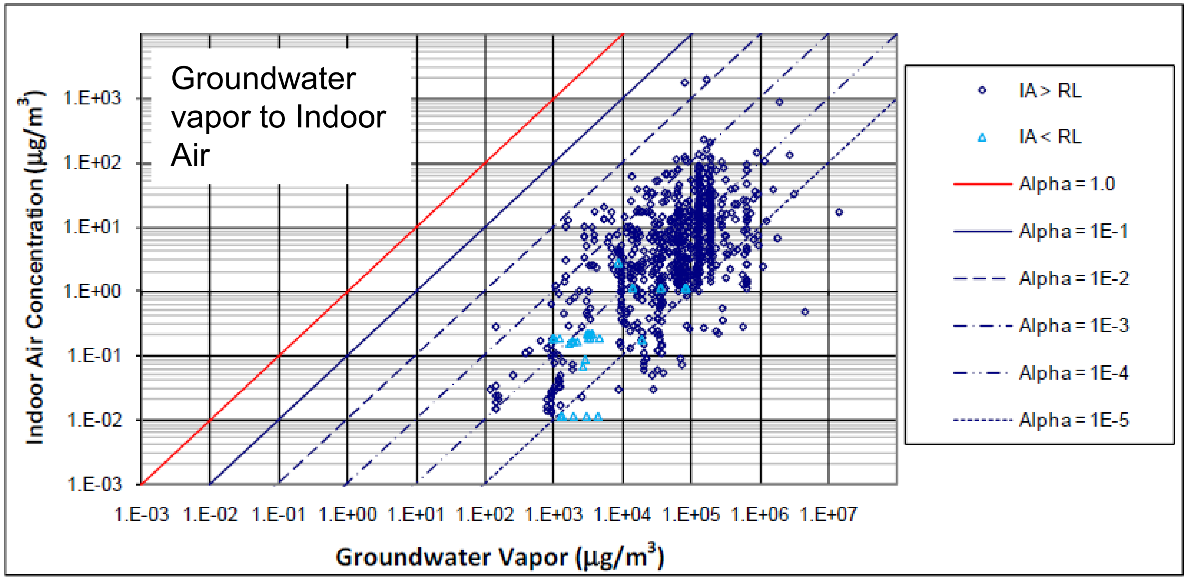


EPA 2012 Residential Database: Attenuation Factors

Residential Sub-slab to Indoor Air AF = 0.03



Residential Groundwater to Indoor Air AF = 0.001



Example Industrial QDF MLE Weights of Importance for VI

Parameter	Range Observed	Weight of Importance	Interpretation
Sample Zone Area	<100 sq ft	4	Smaller sample zones provide less potential for VOC dilution if contaminant flux (from either indoor or Subslab sources) is equal.
	100-1,000 sq ft	3	
	1,000-10,000 sq ft (or no information available)	2	
	10,000-100,000 sq ft	1	
	>100,000 sq ft	0	
Average Subslab Concentration	<300x risk-based on IA screening level	0	Data analysis shows that concentrations above a minimum value in subslab are needed to observe any corresponding increase in indoor air concentrations.
	300-2,000x risk-based IA screening level	2	
	2,000-10,000x risk-based IA screening level	4	
	10,000-100,000x risk-based IA screening level	6	
	>100,000x risk-based IA screening level	8	
Average Groundwater Vapor Concentration (deep soil gas calculated using Henry's Law)	<1,000x risk-based IA screening level	0	Data analysis shows that concentrations above a minimum value are needed to observe increase in indoor air concentrations.
	<10,000x risk-based IA screening level	2	
	10,000-100,000x risk-based IA screening level	4	
	>100,000x risk based on indoor air screening level	6	

Interpreting MLE with Indoor Air Data