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Recommendations for Writing CPUs for VIMS RMM

Paul Nicholson, P.Eng (ON)
TVIC – 5 May 2026




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Recommendations for clear language in your RMP to support the development of a clear, but flexible CPU for VIMS implementation

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Why Keep CPUs Flexible?

- VIMS Design Flexibility
- Development delays
- Development changes
- Existing building use and duration of occupancy prior to redevelopment

Vapour Barriers

Recommendations

- Specify performance metrics rather than brands or type of barrier
- Allows flexibility in design/vendor/approach

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Vapour Barriers

SOIL VAPOUR BARRIER MEMBRANE

- Throughout the Building Area, a continuous leak free soil vapour barrier membrane, such as a sheet geomembrane or spray applied membrane, below the foundation floor slab and above the soil vapour venting layer, and below and along the walls of any subsurface structures such as a sump, and which:
  - i. is of appropriate thickness and meets the appropriate gas permeability and chemical resistance specifications to be considered substantially impermeable to the soil vapour, in accordance with the appropriate ASTM standards such as D412 and D543, as applicable; and

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$$J = D\left(\frac{C_{SS} - C_{IASL}}{L}\right)$$

Fick's Law

J = mass flux $[M/L^2/T]$
D = diffusion coefficient $[L^2/T]$
C_{IASL} - indoor air health based screening level concentration $[M/L^3]$
C_{SS} = the COC concentration in soil gas $[M/L^3]$
L = thickness of the vapour barrier [L]

Key Points

- Concentration gradient basis
- Diffusivity is based on contaminant of concern
- Thickness can be calculated
- Installation considerations (defects will dominate)

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Performance of VIMS – Excerpt from MGRA



MGRA, Appendix 8b

Generally, to indicate that a passive SVIMS is operating as intended within the scope of MGRA, collecting pressure data to demonstrate the presence of a negative pressure field across the foundation slab (e.g., the air pressure below the slab is lower than the indoor air pressure within the building) is considered adequate. For an active SVIMS, the objective is to achieve a pressure differential of at least - 6 Pascal across at least 90% of the building footprint during all seasons. Not achieving this objective at all times or locations; however, does not mean the active SVIMS is not operating effectively, but the Licenced Professional Engineer should assess the SVIMS further and make improvements or repairs of any deficiencies as appropriate or consider collecting additional lines of evidence (see Section 2 of this Appendix). It is recommended that sub-slab differential pressure monitoring be implemented under normal building operating conditions (e.g. ventilation). Also, while measurement of sub-slab differential pressure is generally considered an adequate performance measure of satisfactory system operation, the QP should, based on professional judgement and the best knowledge of site conditions at the time of assessment, consider whether additional performance measures (e.g., vapour sampling) are warranted.

Performance of VIMS – Excerpt from MGRA

- 6 Pa vacuum over 90% of the building footprint
- Not achieving this objective, does not mean active VIMS is not working
- P.Eng to make changes or consider additional lines of evidence
- While differential pressure is considered adequate, QP assess whether additional performance measures are warranted.

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Active VIMS – New Build

Easier to distribute vacuum across floor slab

- Engineered venting layer
- Perforated piping network
- Vapour barrier

Retrofit – harder to adapt

Flow? Or Vacuum? What matters most?

30 ft from the suction pit with no measurable vacuum (<0.25 Pa)

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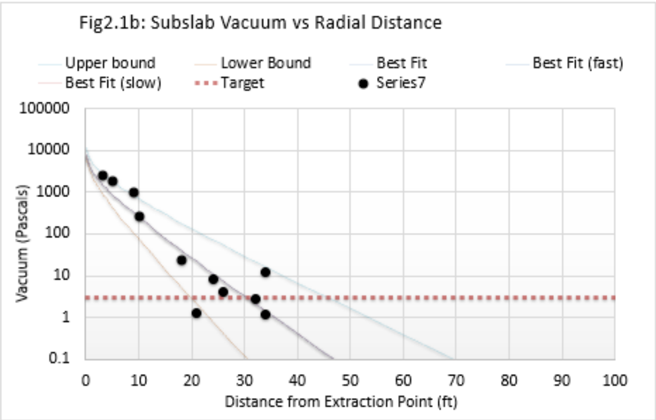
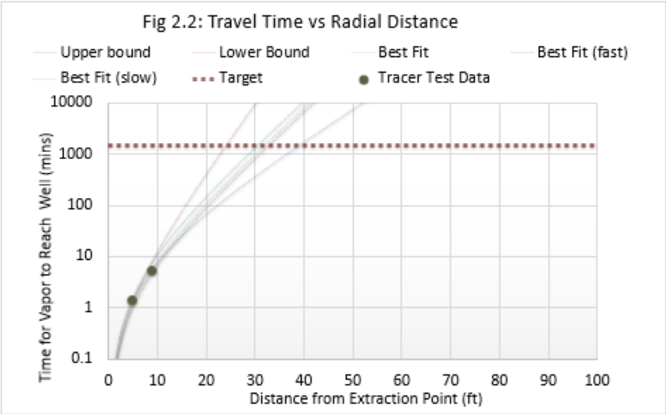
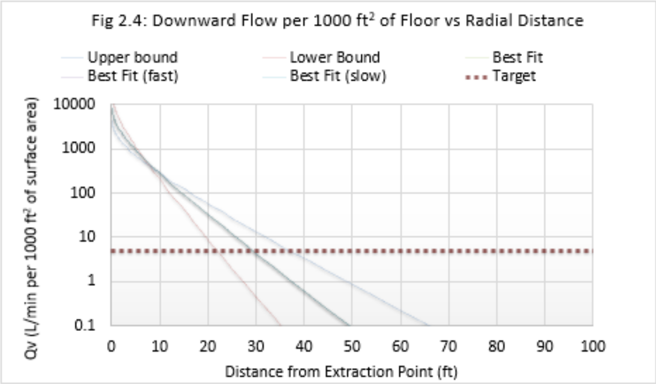
Mitigation ROI Design

- VIM Model (Geosyntec, 2020)
- Data Inputs
  - Vacuum vs distance
  - Vacuum vs time
  - Helium travel time
- Key variables are building specific (transmissivity and leakage)
- Determine ROI

Free Download at
www.Geosyntec.com/VI







SENSITIVITY ANALYSIS

Legend Label	Flow rate, Q (ft^3/min)	Transmissivity, T (ft^2/d)	Leakance, B (ft)	Thickness, b (ft)	Effective Porosity, n (v/v)	ROI based on Flux (ft)
Upper bound	12.2	– 4 +	– 7.50 +	0.8	0.25	41
Lower Bound	12.2	– 5.2 +	– 3.40 +	0.5	0.25	20
Best Fit	12.2	– 5.2 +	– 5.20 +	0.6	0.25	30
Best Fit (fast)	12.2	– 5.2 +	– 5.20 +	0.5	0.25	30
Best Fit (slow)	12.2	– 5.2 +	– 5.20 +	0.8	0.25	29

Radius (ft)	Target Level	Monitoring Poin ID Number	Field Measurments radius (ft)	Vacuum (Pa)	Travel Time (min)	Reasonable Maximum Ambient Cross-Slab Pressure
Vacuum (Pascals)						
0	3		3	2700		
500	3		10	279		
Velocity (ft/day)			5	1900	1.42	
0	3		9	992	5.3	
500	3		18	24.3		3
Travel Time (minutes)			21	1.3		
0	1440		24	8.1		
500	1440		26	4.1		
Qsoil/Area (L/min/1000ft2)			32	2.8		
0	5		34	1.2		
500	5		34	12		

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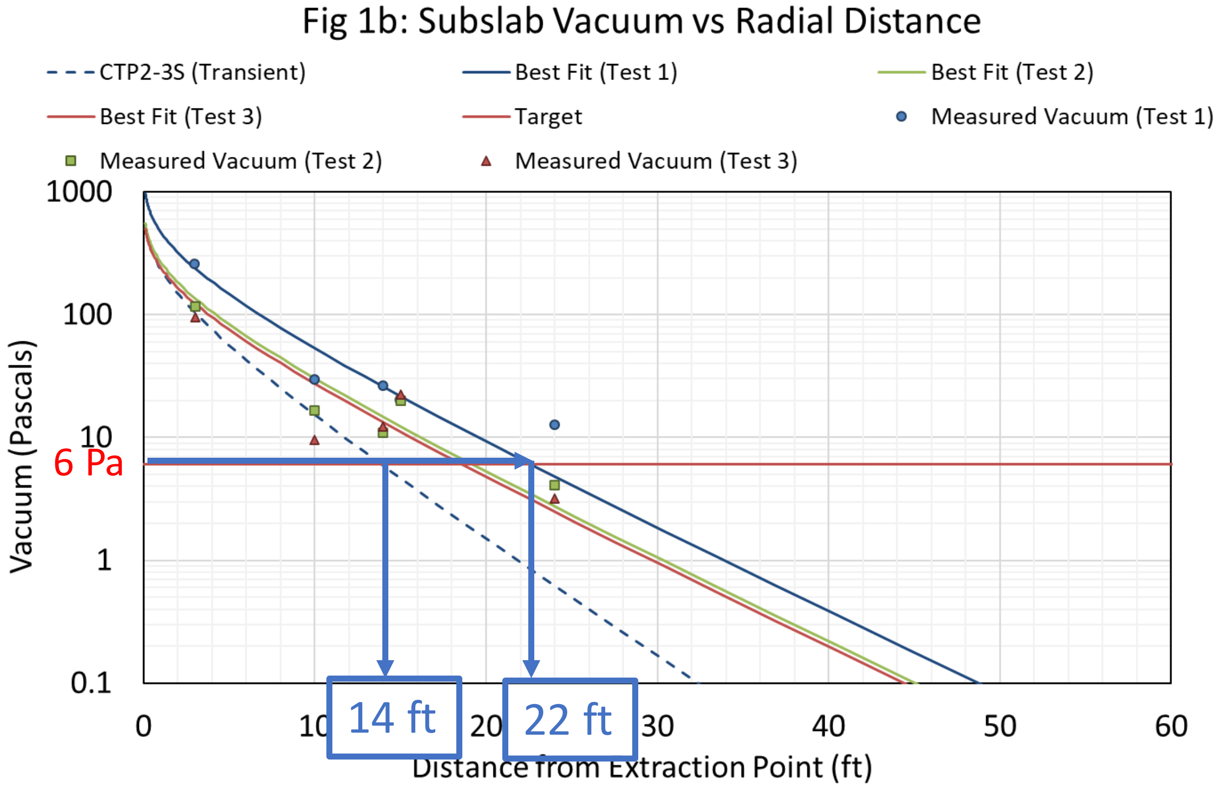
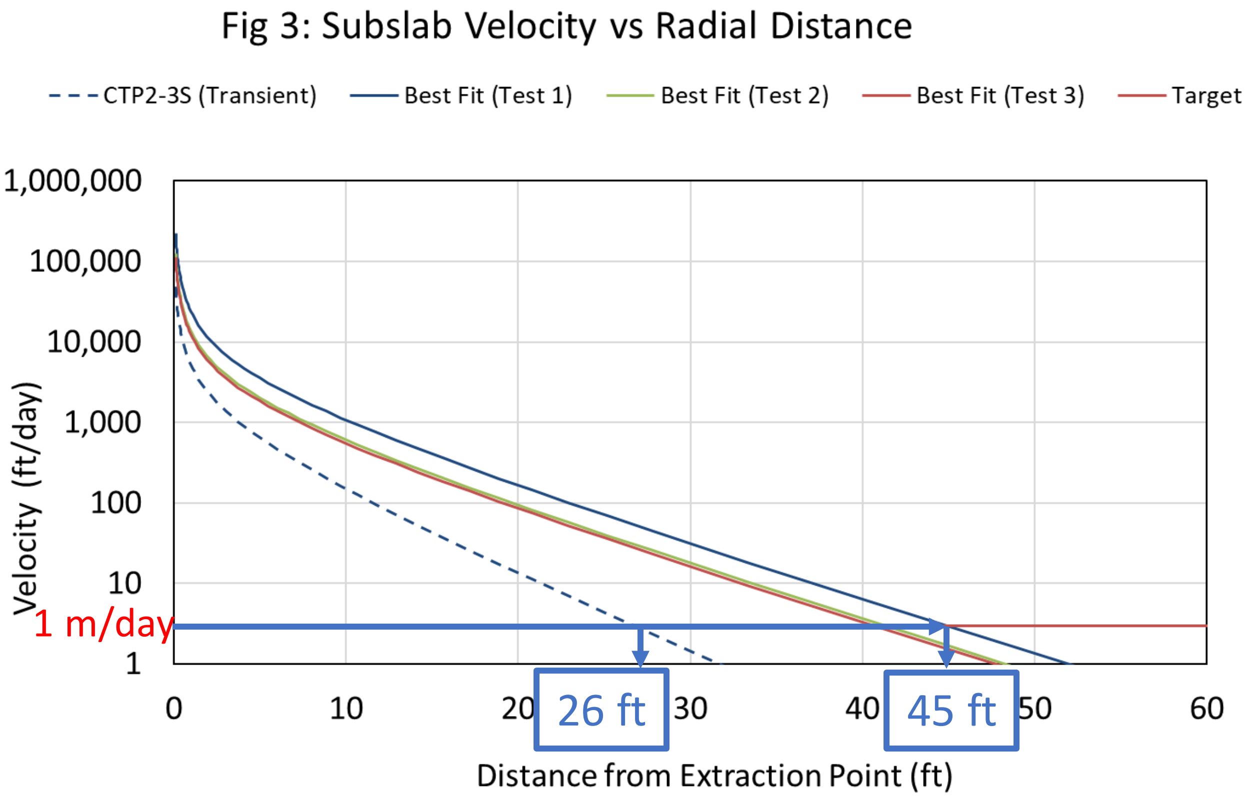
Mitigation ROI Design





- ROI at 6 Pa = 14 to 22 ft
- ROI at 1 m/day = 26 to 45 ft

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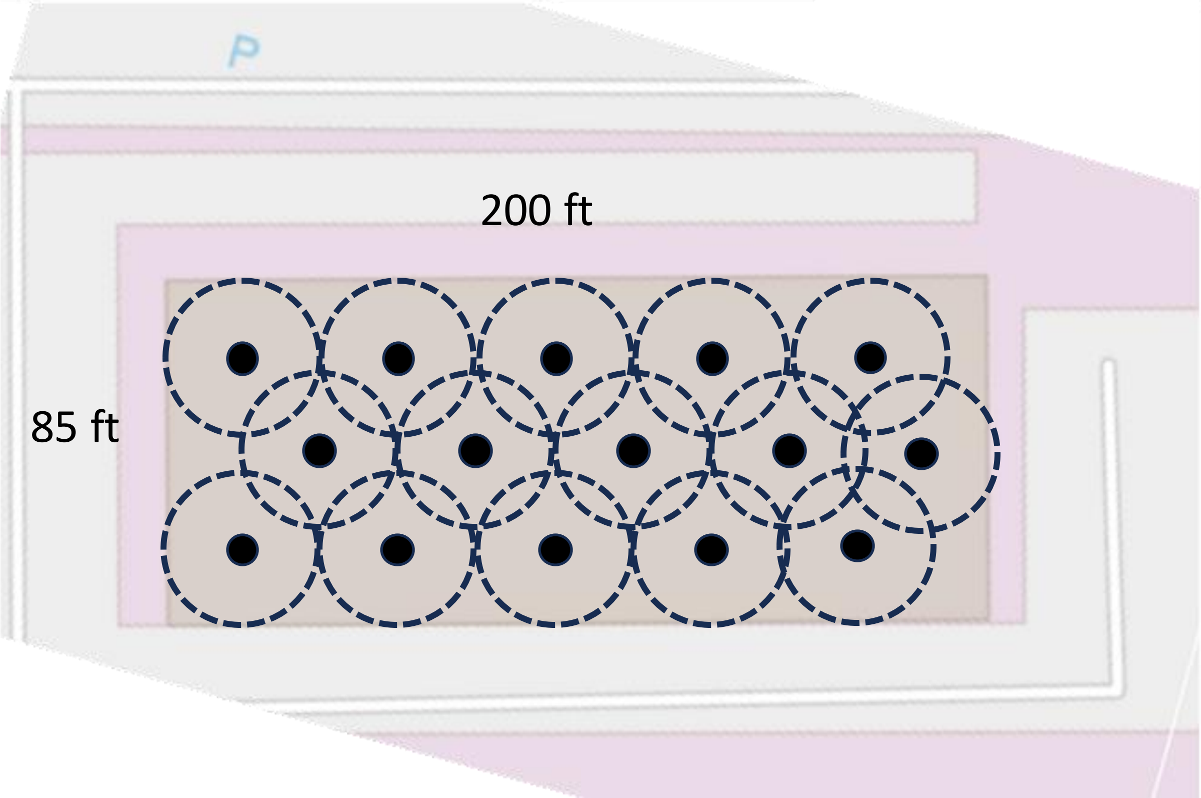
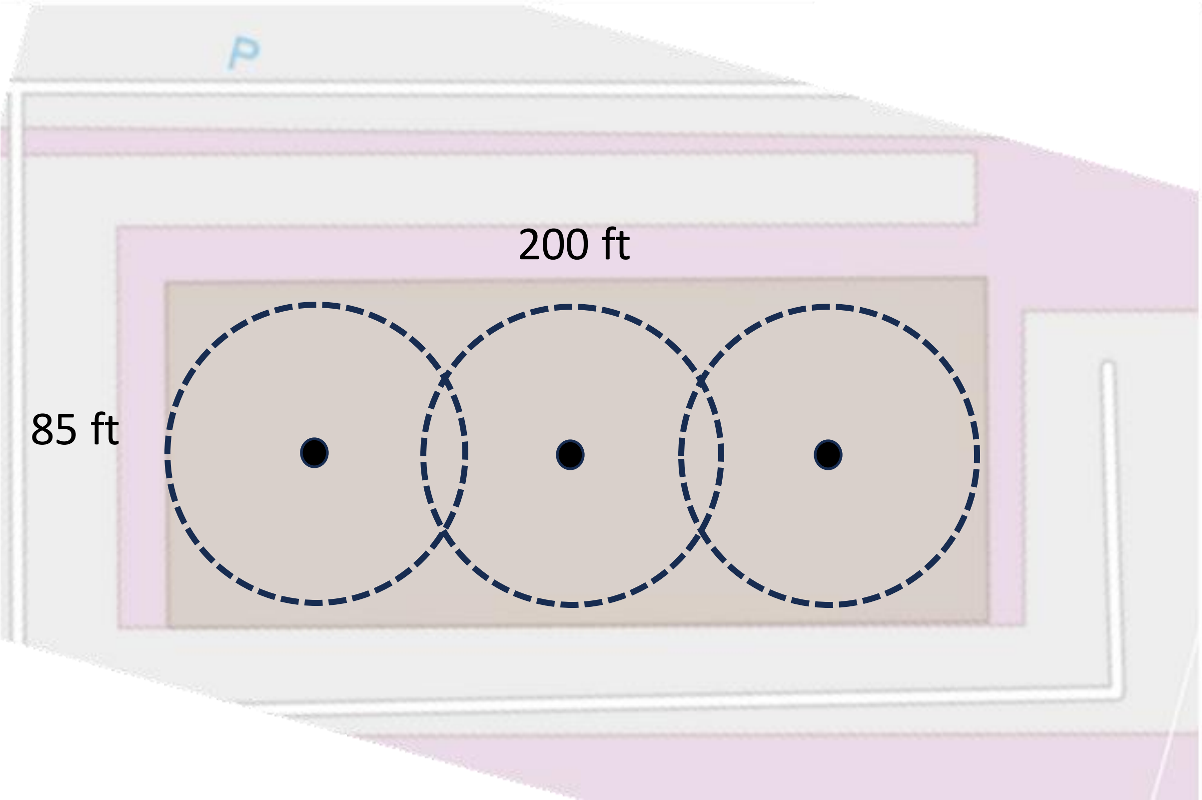
Retrofit VIMS - ROIs

- ROI at 6 Pa = 20 ft
- 15 extraction points



- ROI at 3 ft/day = 40 ft
- 3 extraction points



17,000 sq.ft building

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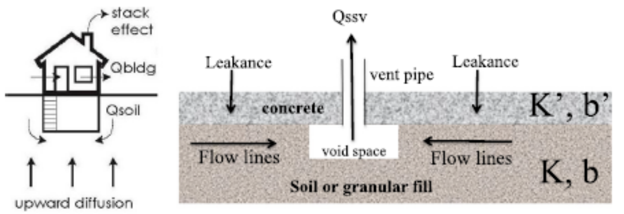
CPU VIMS Performance Metrics

VIMS ROI could be designed based on:

- Barely measurable vacuum
- Velocity > 1m/day
- Travel time < 1 day
- Mass removal rate
- Horizontal Flux > Vertical Flux:



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ELSEVIER

Mathematical analysis and flux-based radius of influence for radon/VOC vapor intrusion mitigation systems

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HIGHLIGHTS

- A new model is derived for the ROI of subslab venting systems based on mass flux.
- A 2-layer flow model was used to analyze 121 pneumatic data sets.
- Multiple lines of evidence (vacuum, velocity, and travel time) are generated.
- New performance metrics are proposed for each line of evidence.
- The incremental cost is small compared to the life-cycle savings.

GRAPHICAL ABSTRACT

$$\text{Vacuum} = \frac{Q_w}{2\pi T} K_0(r/B) \quad Velocity = \frac{Q_w}{2\pi b n B} \frac{1}{} K_1(r/B)$$

$$\text{Flux-Based ROI: } K_1\left(\frac{r}{B}\right) = \frac{2\pi B b}{Q_{ssv}}\left(\frac{T\Delta P}{B^2} + \frac{D_{eff}}{b}\right)$$



CPU VIMS Performance Metrics

ii. be designed, installed and operated with the objective of achieving during all seasons at least 1 Pascal lower air pressure differential below the foundation floor slab, relative to the indoor air pressure within the Existing Building, across the target area identified in Figure 1, Building Details and Target Area for the Vapour Mitigation System;

iii. designed, installed and operated with the objective of extracting soil vapour beneath the foundation floor slab at a flow rate of at [redacted] soil vapour per day from below [redacted] sufficient to maintain a minimum velocity of 1 metre per day beneath the foundation floor slab across the target area; and

Indoor Air Sampling Challenges?

40% TCE

TCE HBIAC = 0.27 µg/m³

PCE in IA = >100 µg/m³

USEPA, 2020

70% PCE

PCE HBIAC = 4.28 µg/m³

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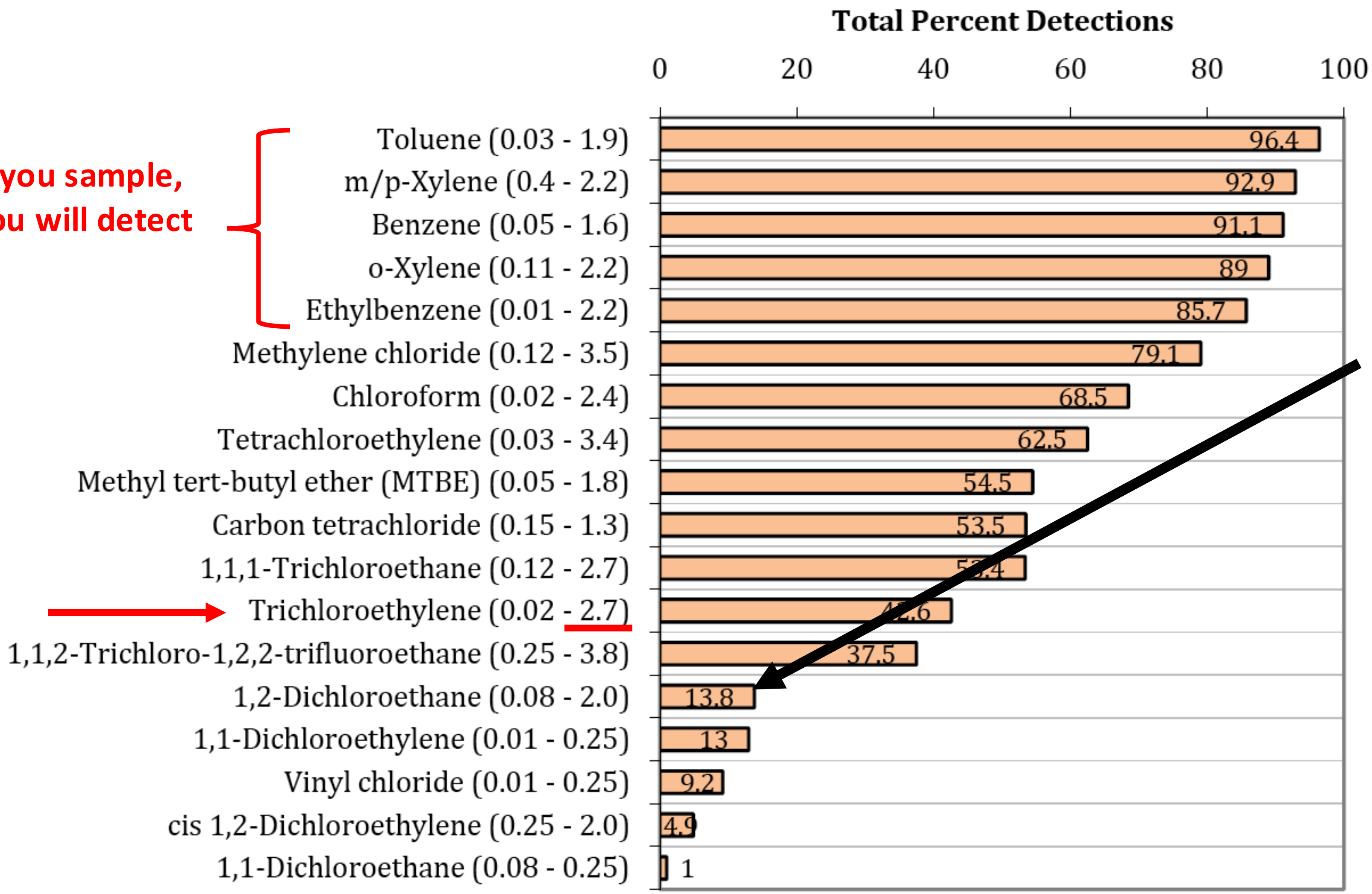
Indoor Air Quality



If you sample, you will detect

1,2-DCA

- Increasing in IA over time

see Doucette et al., GWMR, 2010

Dawson and McAlary, 2009

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Performance Monitoring - Retrofit



Common Approach

- IA Sampling - Quarterly year 1
- IA Sampling - Semi-annual year 2

OR

i. For any Building(s) that meets the requirements of 4.2 h. of the CPU; the indoor air or sub slab soil vapour monitoring shall be carried out as a one-time monitoring event prior to occupancy.

ii. For all other Building(s) (except for temporary Building in 4.2 i), the indoor air or sub slab soil vapour monitoring shall commence prior to occupancy and carried out on a quarterly basis (every three months) for the first year, and semi-annually (every six months) for the second year and thereafter until such time as Director, upon application by the Owner, has reviewed the data available and either alters or revokes the CPU.

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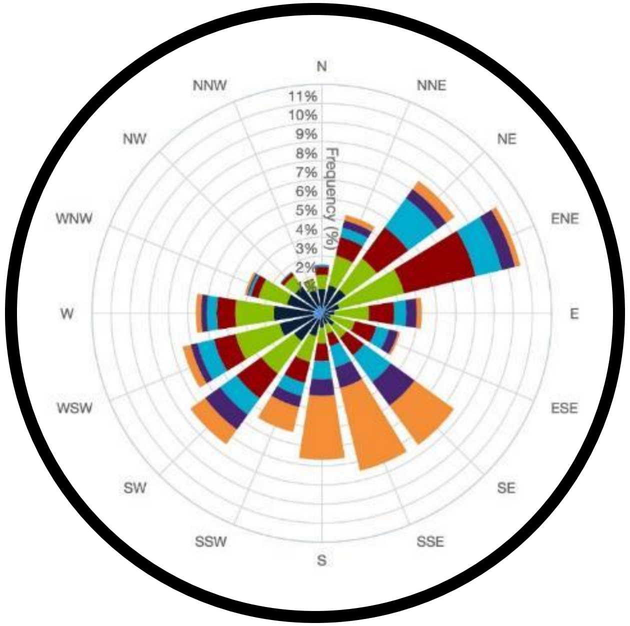
Passive VIMS - MGRA Section 5.1 RMM

SYSTEM REQUIREMENTS

i. the Passive SVIMS is to:

(a) be designed, installed and operated with the objective of achieving during all seasons a lower air pressure differential below the foundation floor slab, relative to the indoor air pressure within the Building, across at least 90% of the Building Area;



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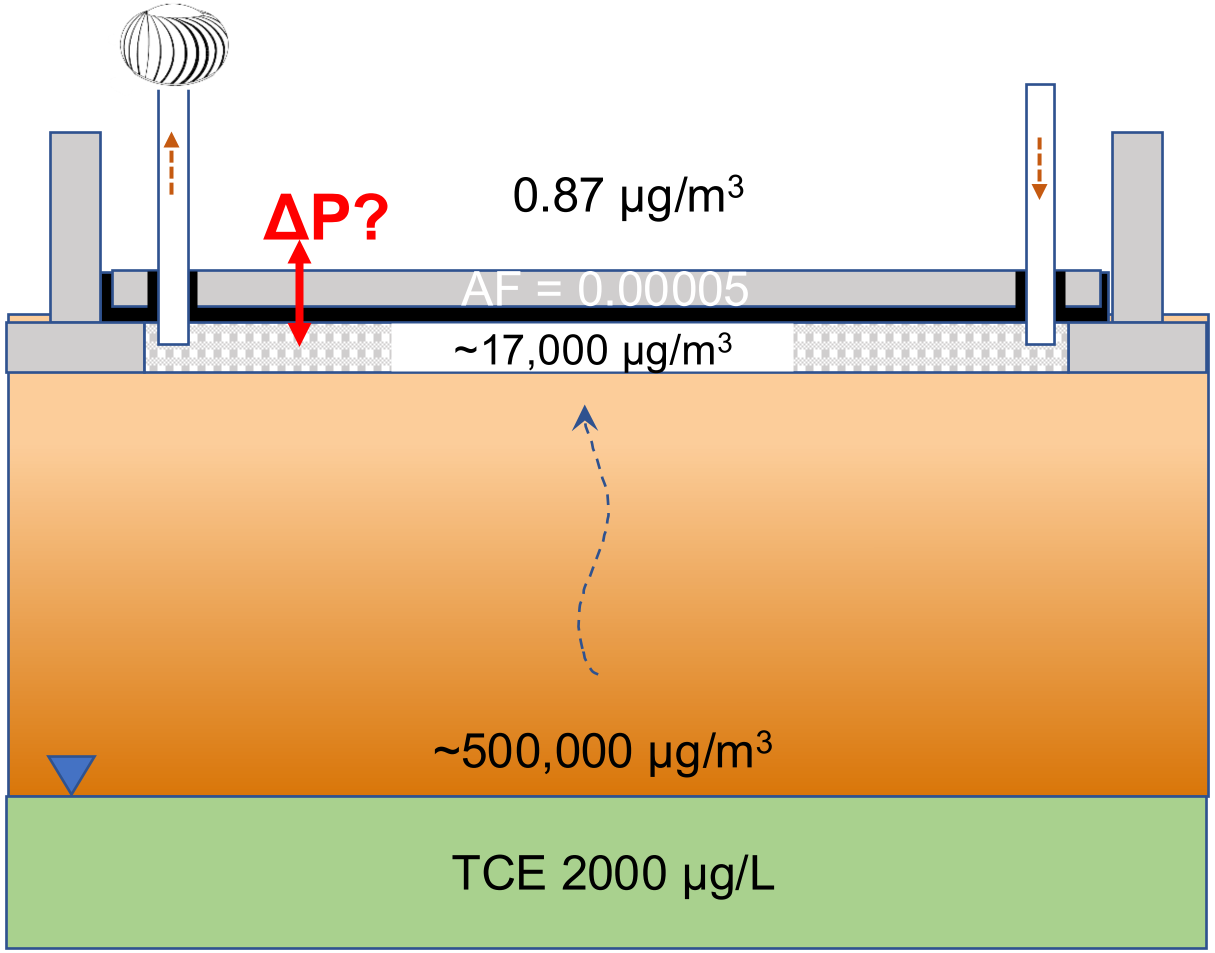
How will the system control the VI pathway at the site?

- Passive barrier plus passive venting



Q_{VENT} ~1 CFM/1000 SF

Key Points

- Passive venting layer removes VOC mass
- Less barrier attenuation required

Performance

- Thermal gradients
- Wind speed/duration
- Natural venting
- Duration of these events?

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Questions

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