Three Technology Advancements in Vapor Intrusion Mitigation

FL AL Brownfields Conferece | April 26, 2022

Jordan Knight

National Sales Manager

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The Vapor Intrusion industry is becoming more sophisticated.

VI Guidance: Federal, State, County level

- many documents in development and revision;

EGLE Vapor Intrusion Guidance Document 2021 Addendum

Professional Organization guidance: ITRC, ANSI/AARST, AVIP

- goal of standardizing the industry

End-user guidance and minimum performance specifications

The Vapor Intrusion industry is becoming more sophisticated.

Inherent need for technology advancement, calibration and improvement

Property owners demand tailored, proven solutions to mitigate their exposure to environmental risks

- *green spaces are dwindling*

There are powerful incentives and resources available at the federal, state, and local level for contaminated site redevelopment

Alabama Brownfields Association

MDEQ

Georgia Brownfield Association

Florida Brownfields Association

Spray-Applied Vapor Intrusion Barriers

- Meet or exceed VI Guidance
- Offer high chemical resistance
- Easily applied in the field
- Robust & durable for construction
- Several layers of QA/QC

ASK THE AUDIENCE

RAISE YOUR HAND IF YOU HAVE RECENTLY…

- ENJOYED A BAG OF CHIPS?
- ATTENDED A CHILD'S BIRTHDAY PARTY?
- VISITED A DOCTOR'S OFFICE?

If you answered YES…

METALLIZED FILMS

NITRILE

METALLIZED FILMS

- Mylar Balloons
  - Introduced in the 1970s
  - Designed to improve balloon longevity
  - Limited He gas diffusion across film
    - Porous latex facilitates seepage
- Food Packaging
  - Incorporated for use in 1970s
  - Flexible
  - Barrier to moisture and O_2
    - Prolongs freshness

Hanlon, J. (1998) 3rd ed. Handbook of Package Engineering, Boca Raton, FL, CRC Press LLC: ISBN 1-56679-306-1. Chapter 3 Films and Foils.

NITRILE

Sansone, E.B.; Tewari, Y.B. "Differences in the extent of solvent penetration through natural rubber and nitrile gloves from various manufacturers. Am. Ind. Hyg. Assoc. J. 1980, 41(7), 527-8.

- Adopted in 1980's and commercialized in the 1990's by medical and PPE community for:
  - No allergic reaction compared to latex
    - Synthetic
  - Low permeance of contaminants, oils, acids
    - Minimized dermal exposure
  - Enhanced puncture resistance

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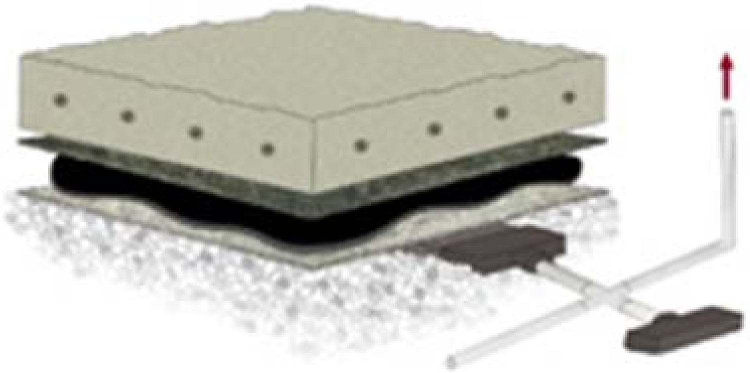
COMPOSITE VI BARRIER EVOLUTION

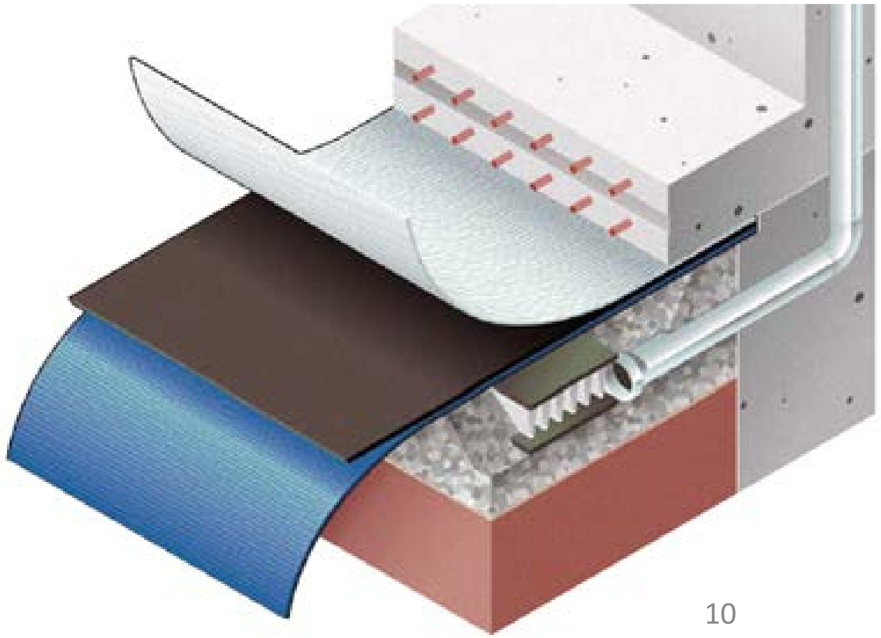
Spray-applied barriers placed on geotextiles introduced in 1980s-2000s

- Methane mitigation
- VOC mitigation
  - PCE: $1.32 \times 10^{-13}\ m^2/sec$

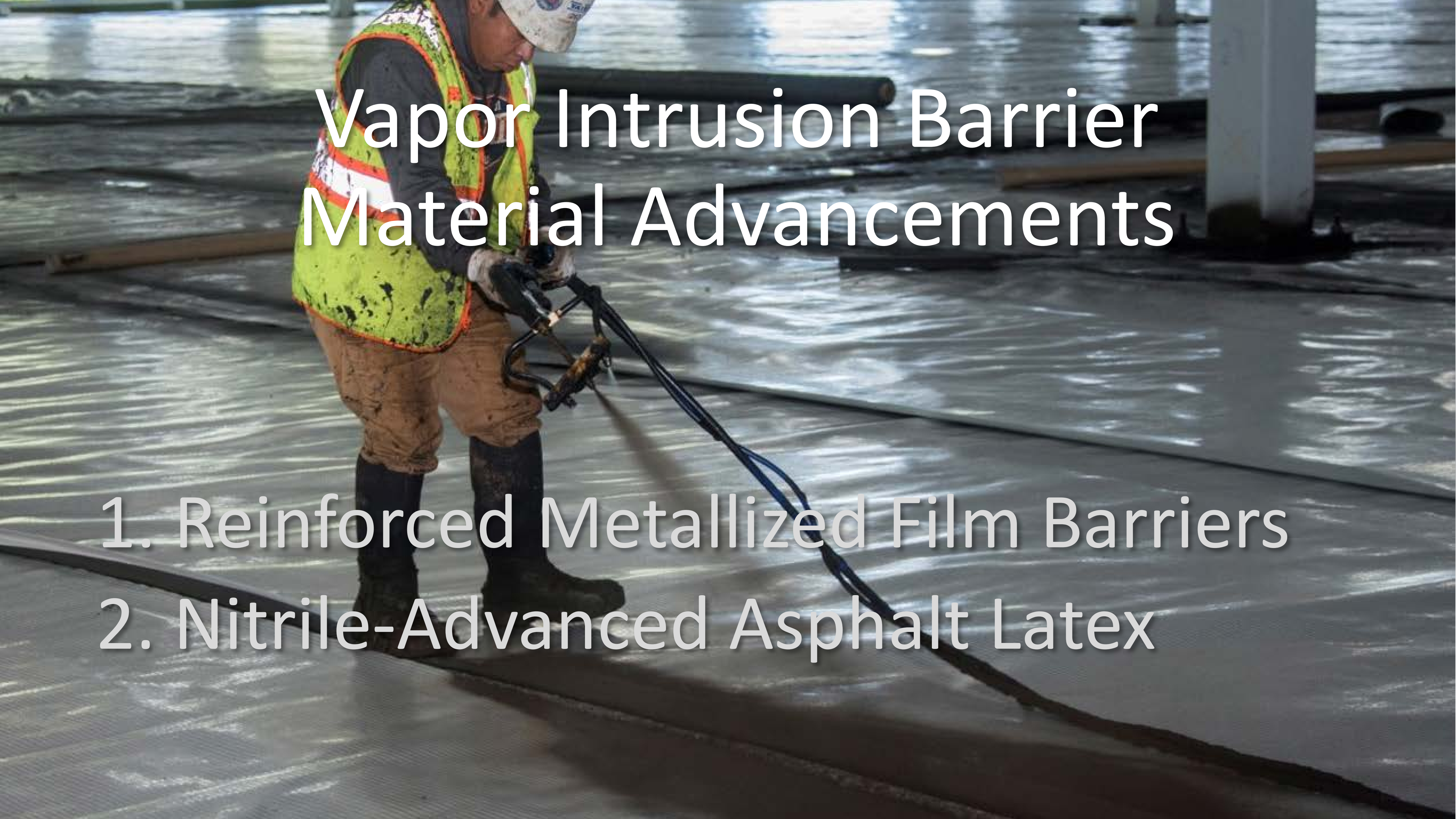


Land Science commercialized composite barriers with dual chemical resistant PE layers in 2007 for VOC mitigation

- Base Layer: HDPE/geotextile
- 60-mil asphaltic spray-applied core
- Top Layer: HDPE/geotextile
- 685X lower diffusion coefficient



R&D Hypothesis: Chemical resistance performance will be further enhanced by the addition of METALLIZED FILM & NITRILE

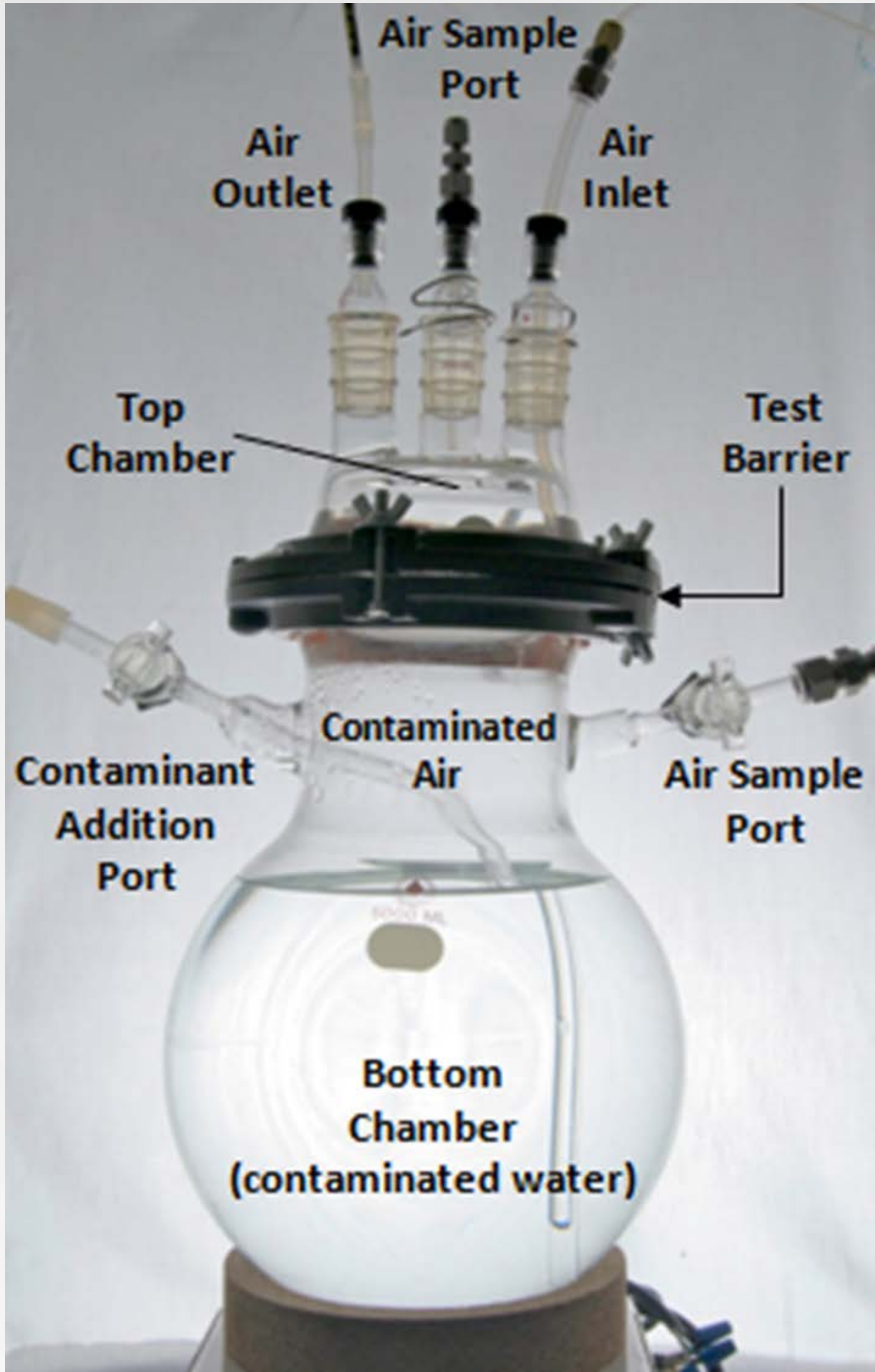


Vapor Intrusion Barrier Material Advancements

1. Reinforced Metallized Film Barriers
2. Nitrile-Advanced Asphalt Latex

Chemical Resistance Testing: Comparing Base Layers

- Two-Chamber active diffusion testing
  - Relative performance
- Represent sub-slab cVOC challenge contaminant vapors
- TerraBase reinforced metalized polyethylene sheet vs HDPE sheet (10 mil)
  - 100 mg/L TCE
  - 7000 ppmV in vapor phase
- Only place for vapors to go is through the membrane material



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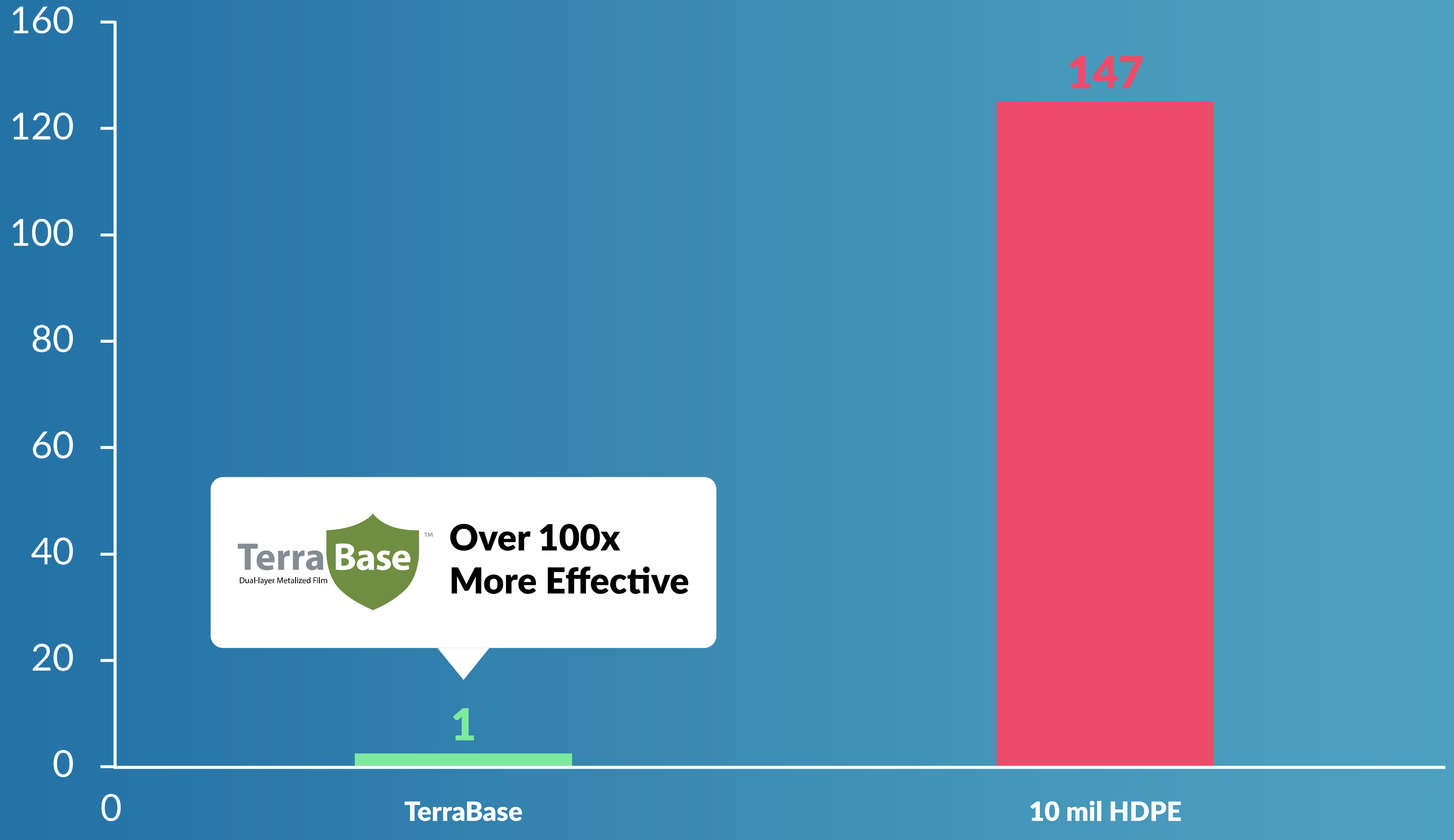
Base Layer TCE Diffusion Flux Comparison



Implications of Results

- Base Layers of Spray-Applied membranes are the first line of defense in eliminating the VI pathway through the building
  - Only line of defense if using a single layer system
- Introducing a highly resistive material into the VIMS design specifications improves the longevity and performance of that system

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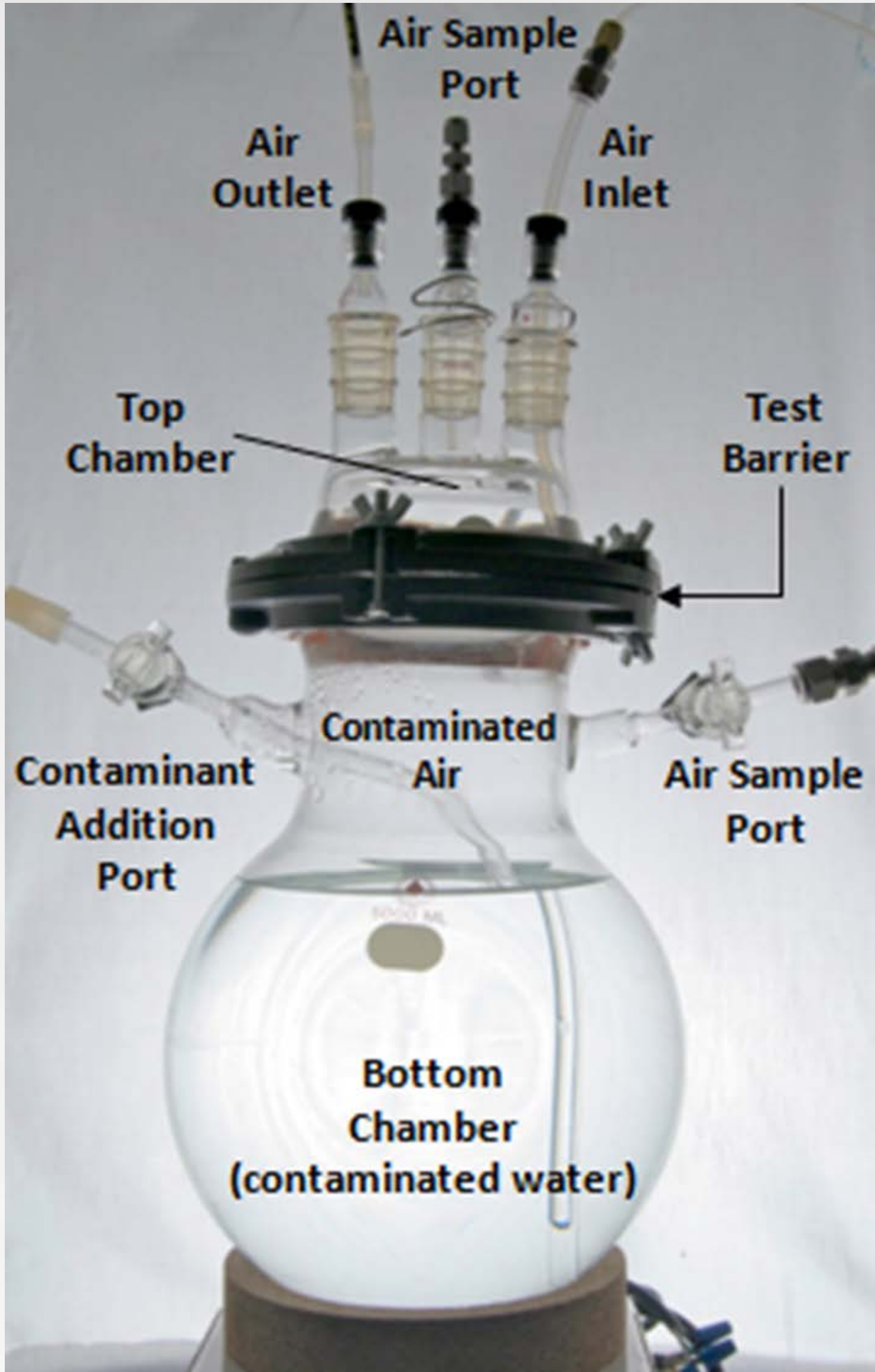
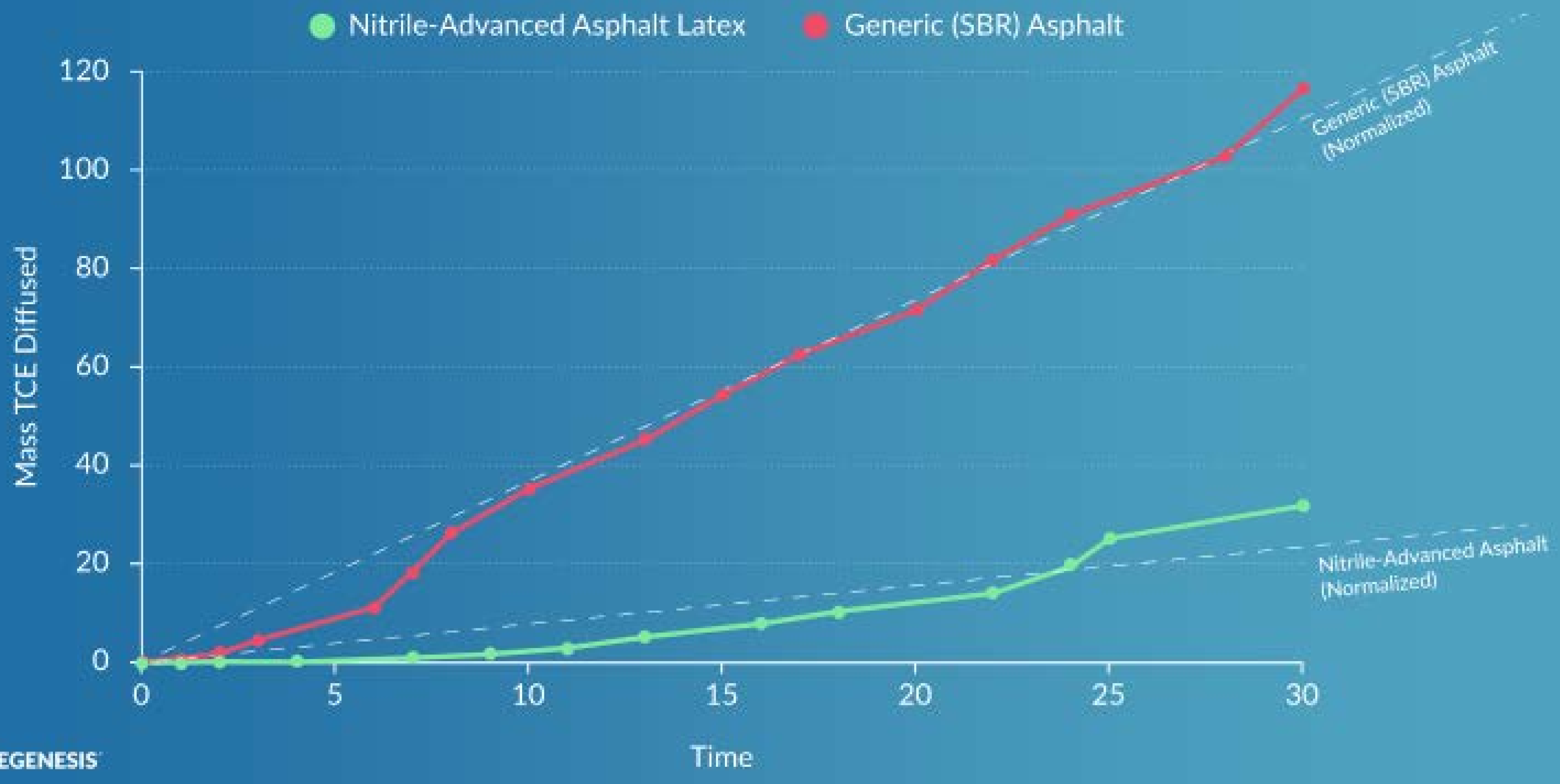
Chemical Resistance Testing: Comparing Spray-Applied Layers

- Two-Chamber active diffusion testing
  - Relative performance
- Represent sub-slab cVOC challenge contaminant vapors
- Nitrile-Advanced Asphalt Latex 20-mil sample vs. historic Asphalt Latex (SBR) 20-mil sample
  - 10 mg/L TCE
  - 700 ppmV in vapor phase
- Only place for vapors to go is through the membrane material



Nitrile-Advanced Asphalt Latex vs. Generic Asphalt Latex Performance Comparison



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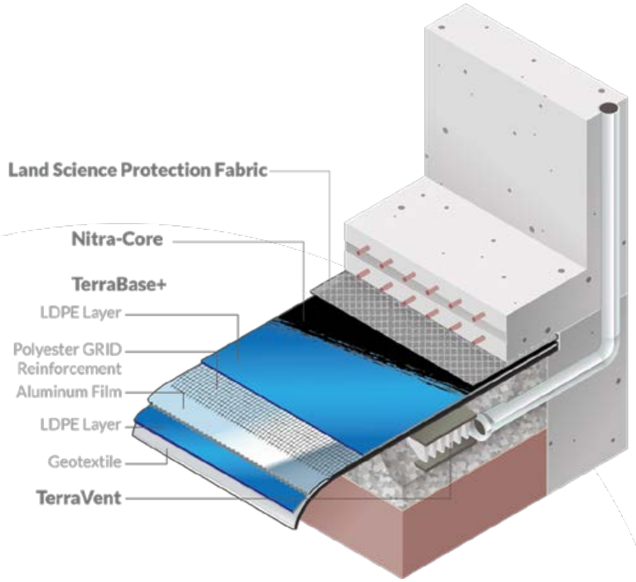
Implications of Results

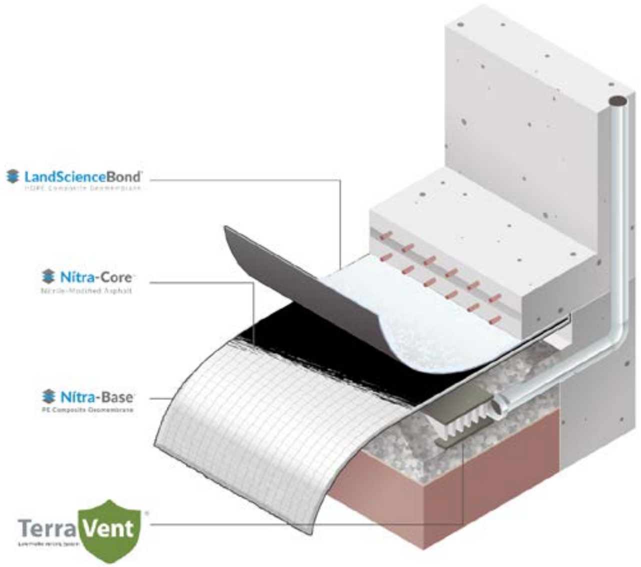
- The most critical pathways and entry points of a membrane system:
  - Utility conduits
  - Plumbing penetrations
  - Seams
  - Foundation Perimeters
- Applying a material with exceptional resistivity to contaminant diffusion strengthens the susceptible parts of your system
  - Reliant on the spray-applied material

Three VIM Technology Advancements

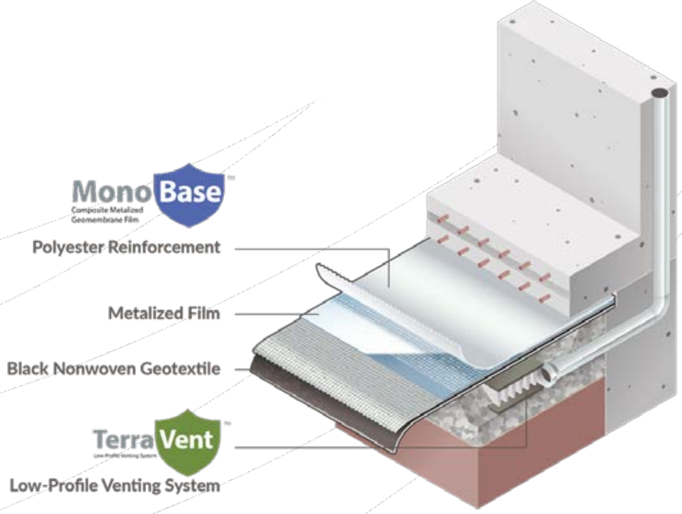
TerraShield®
Aluminum Nitrile Vapor Barrier



Nítra-Seal®
Nitrile-Advanced Vapor Barrier



MonoShield®
Reinforced Aluminum Contaminant Vapor Barrier



Up to 4 orders of magnitude (10^4) greater protection v. simple spray applieds on geotextiles

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Spray-Applied Vapor Intrusion Barriers

- Meet or exceed VI Guidance
- Offer high chemical resistance
- Easily Applied in the field
- Robust & durable for construction
- Several layers of QA/QC

Nitrile-Advanced Asphalt Latex & Reinforced Metallized Film vapor intrusion barriers represent major advancements to the VI industry to ensure future occupants are protected for the life of the building.

Latest Technologies Solve VI Challenges for Redevelopment of a Former Gas Station

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Patrick W. Lowery, PG
Senior Environmental Manager

Begin with the end in mind

- Common Redevelopment Scenario
  - Repeatable Pre-emptive Vapor Intrusion Mitigation Strategy
- Identify Best Practices for VIM
  - Design, Implementation & Performance Verification
- Recipe for Success
    - Assurance the project can move forward
    - Meeting Budgetary & Performance objectives
    - Peace of mind that future occupants are safe for lifetime of the building

Proposed Town Hall and Library

Site History and Due Diligence

- Phase I
  - Identified former gas station
  - Operated 3 USTs from 1973-1991
  - Closed without any reporting

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Due Diligence

Limited Phase II ESA

SOIL

- Benzene – above NC Maximum Soil Contaminant Concentration (MSCCs) for Soil to Groundwater. Indicates Benzene exists at a concentration that could leach to the groundwater table at the property

- VPH – a NC required analytical method. It is an analysis for specific aromatic carbon chains. Exceeded MSCCs Soil to Groundwater – same as above.

GROUNDWATER

- Widespread petroleum compounds at concentrations above the North Carolina Groundwater Standards (NC2L).

NCDEQ UST Department closed the release using Risk-Based Closure and implemented a Groundwater Use Restriction attached to the Deed.

Table 1: Soil Sample Detection Summary Table

		Sample ID		SS-1		SS-2		SS-3		SS-4		SS-5		SS-6	
		Sample Date		6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020	
		Sample Depth ('bgs)		9-10'		10-11'		9-10'		9-10'		9-10'		9-10'	
		Field Screening Result (ppm)		0.0		126.8		0.0		555.0		342.0		0.0	
	All Values in mg/kg	DEQ Reference Values													
CAS	VOC Analyte	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
67-64-1	Acetone	3.60E+05	2.40E+01	ND	0.02	0.022	0.02	0.012 J	0.02	0.012 J	0.02	0.029	0.02	ND	0.02
71-43-2	Benzene	1.64E+02	5.60E-03	ND	0.005	ND	0.005	ND	0.005	ND	0.005	0.012	0.005	ND	0.005
78-93-3	2-Butanone (MEK)	2.45E+05	1.60E+01	ND	0.02	0.004 J	0.02	ND	0.02	ND	0.02	0.007 J	0.02	ND	0.02
75-15-0	Carbon disulfide	4.09E+04	4.30E+00	ND	0.005	0.004 J	0.005	ND	0.005	ND	0.005	0.002 J	0.005	ND	0.005
100-41-4	Ethylbenzene	4.00E+04	4.90E+00	ND	0.005	0.077	0.005	ND	0.005	0.008	0.005	1.1	0.36	ND	0.005
98-82-8	Isopropylbenzene	4.09E+04	1.70E+00	ND	0.005	0.026	0.005	ND	0.005	0.002 J	0.005	0.17	0.005	ND	0.005
108-87-2	Methylcyclohexane	NA	NA	ND	0.005	0.11	0.005	ND	0.005	0.006	0.005	0.2	0.005	ND	0.005
108-88-3	Toluene	3.20E+04	4.30E+00	ND	0.005	ND	0.005	ND	0.005	ND	0.005	0.025	0.005	ND	0.005
1330-20-7	Xylenes (total)	8.18E+04	4.60E+00	ND	0.01	0.12	0.01	ND	0.01	0.026	0.01	2.2	0.7	ND	0.01
CAS	SVOC Analyte	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
83-32-9	Acenaphthene	2.40E+04	8.20E+00	ND	0.002	ND	0.002	ND	0.003	ND	0.002	0.002 J	0.003	ND	0.003
208-96-8	Acenaphthylene	1.23E+04	1.10E+01	ND	0.002	ND	0.002	ND	0.003	ND	0.002	ND	0.003	ND	0.003
120-12-7	Anthracene	1.22E+05	9.40E+02	ND	0.002	0.002 J	0.002	ND	0.003	0.002 J	0.002	0.002 J	0.003	ND	0.003
100-52-7	Benzaldehyde	NA	NA	ND	0.014	ND	0.014	ND	0.016	ND	0.014	ND	0.015	ND	0.016
56-55-3	Benzo(a)anthracene	8.00E+00	3.50E-01	ND	0.002	ND	0.002	0.005	0.003	ND	0.002	ND	0.003	ND	0.003
50-32-8	Benzo(a)pyrene	7.80E-01	9.60E-02	ND	0.002	ND	0.002	0.006	0.003	ND	0.002	ND	0.003	ND	0.003
205-99-2	Benzo(b)fluoranthene	8.00E+00	1.20E+00	ND	0.002	ND	0.002	0.009	0.003	ND	0.002	ND	0.003	ND	0.003
191-24-2	Benzo(g,h,i)perylene	1.23E+04	6.40E+03	ND	0.002	ND	0.002	0.005	0.003	ND	0.002	ND	0.003	ND	0.003
207-08-9	Benzo(k)fluoranthene	7.80E+01	1.20E+01	ND	0.002	ND	0.002	0.003 J	0.003	ND	0.002	ND	0.003	ND	0.003
92-52-4	1,1'-Biphenyl	NA	NA	ND	0.014	ND	0.014	ND	0.016	ND	0.014	0.006 J	0.015	ND	0.016
218-01-9	Chrysene	7.80E+02	3.90E+01	ND	0.002	ND	0.002	0.006	0.003	ND	0.002	ND	0.003	ND	0.003
84-74-2	Di-n-butyl phthalate	NA	NA	0.006 J	0.014	0.006 J	0.014	ND	0.016	ND	0.014	ND	0.015	ND	0.016
206-44-0	Fluoranthene	1.64E+04	2.90E+02	ND	0.002	ND	0.002	0.008	0.003	ND	0.002	0.001 J	0.003	0.001 J	0.003
86-73-7	Fluorene	1.64E+04	4.70E+01	ND	0.002	0.001 J	0.002	ND	0.003	0.002 J	0.002	0.003	0.003	ND	0.003
193-39-5	Indeno(1,2,3-c,d)pyrene	8.00E+00	3.40E+00	ND	0.002	ND	0.002	0.003	0.003	ND	0.002	ND	0.003	ND	0.003
91-57-6	2-Methylnaphthalene	1.64E+03	3.60E+00	ND	0.002	0.023	0.002	0.002 J	0.003	0.037	0.002	0.35	0.003	0.003	0.003
91-20-3	Naphthalene	8.18E+03	3.60E+00	ND	0.002	0.006	0.002	0.002 J	0.003	0.004	0.002	0.15	0.003	0.002 J	0.003
85-01-8	Phenanthrene	1.23E+04	5.60E+01	ND	0.002	0.004	0.002	0.003 J	0.003	0.004	0.002	0.006	0.003	ND	0.003
129-00-0	Pyrene	1.23E+04	2.70E+02	ND	0.002	0.002 J	0.002	0.008	0.003	0.002 J	0.002	0.002 J	0.003	0.002 J	0.003
CAS	MA VPH	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
SESI-0029	C5 - C8 Aliphatics	2.45E+04	6.80E+01	ND	4.4	9.2	4.1	ND	5	ND	4.5	24	5.5	ND	4.4
SESI-0030	C9 - C12 Aliphatics	4.00E+04	5.40E+02	ND	4.4	5	4.1	ND	5	2.3 J	4.5	35	5.5	ND	4.4
SESI-0031	C9 - C10 Aromatics	1.23E+04	3.10E+01	ND	1.5	5.9	1.4	ND	1.7	1.7	1.5	35	1.8	ND	1.5

ND = Not detected at or above MDL
BOLD = Concentration Above Reference Values
MDL = Method Detection Limit
J = Estimated Concentration (=<RL>MDL)
NT = Not Tested
MSCCs = Maximum Soil Contaminant Concentration Levels

Table 1: Soil Sample Detection Summary Table (continued)

		Sample ID		SS-7		SS-8		SS-9		SS-10		SS-11		SS-12	
		Sample Date		6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020	
		Sample Depth ('bgs)		9-10'		3-4'		3-4'		3-4'		9-10'		9-10'	
		Field Screening Result (ppm)		343.0		85.0		8.9		5.5		151.0		115.0	
	All Values in mg/kg	DEQ Reference Values													
CAS	VOC Analyte	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
67-64-1	Acetone	3.60E+05	2.40E+01	0.016 J	0.022	ND	0.02	ND	0.02	ND	0.028	ND	0.016	0.017 J	0.025
71-43-2	Benzene	1.64E+02	5.60E-03	0.0054 J	0.005	ND	0.005	ND	0.005	ND	0.007	ND	0.004	ND	0.006
78-93-3	2-Butanone (MEK)	2.45E+05	1.60E+01	ND	0.02	ND	0.02	ND	0.02	ND	0.028	ND	0.016	ND	0.025
75-15-0	Carbon disulfide	4.09E+04	4.30E+00	ND	0.005	ND	0.005	ND	0.005	ND	0.007	ND	0.004	0.044 J	0.006
100-41-4	Ethylbenzene	4.00E+04	4.90E+00	0.49	0.32	0.24 E	0.005	ND	0.005	0.005 J	0.007	0.014	0.004	2.1	0.29
98-82-8	Isopropylbenzene	4.09E+04	1.70E+00	0.35 E	0.005	0.048	0.005	ND	0.005	ND	0.007	0.003 J	0.004	0.18	0.006
108-87-2	Methylcyclohexane	NA	NA	0.24 E	0.005	0.055	0.005	ND	0.005	ND	0.007	ND	0.004	0.15	0.006
108-88-3	Toluene	3.20E+04	4.30E+00	0.056	0.005	0.007	0.005	ND	0.005	ND	0.007	ND	0.004	ND	0.006
1330-20-7	Xylenes (total)	8.18E+04	4.60E+00	1.6	0.64	0.7	0.61	ND	0.01	0.029	0.014	0.069	0.008	2.2	0.59
CAS	SVOC Analyte	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
83-32-9	Acenaphthene	2.40E+04	8.20E+00	ND	0.033	0.006	0.003	ND	0.003	ND	0.016	ND	0.003	ND	0.003
208-96-8	Acenaphthylene	1.23E+04	1.10E+01	ND	0.033	ND	0.003	0.002 J	0.003	ND	0.016	ND	0.003	ND	0.003
120-12-7	Anthracene	1.22E+05	9.40E+02	ND	0.033	0.006	0.003	0.003	0.003	ND	0.016	0.001 J	0.003	0.004	0.003
100-52-7	Benzaldehyde	NA	NA	ND	0.16	ND	0.016	0.012 J	0.017	ND	0.079	ND	0.014	ND	0.015
56-55-3	Benzo(a)anthracene	8.00E+00	3.50E-01	0.04	0.033	0.003	0.003	0.012	0.003	0.02	0.016	ND	0.003	ND	0.003
50-32-8	Benzo(a)pyrene	7.80E-01	9.60E-02	0.034	0.033	ND	0.003	0.013	0.003	0.018	0.016	ND	0.003	ND	0.003
205-99-2	Benzo(b)fluoranthene	8.00E+00	1.20E+00	0.056	0.033	ND	0.003	0.02	0.003	0.027	0.016	ND	0.003	ND	0.003
191-24-2	Benzo(g,h,i)perylene	1.23E+04	6.40E+03	0.021 J	0.033	ND	0.003	0.006	0.003	0.008 J	0.016	ND	0.003	ND	0.003
207-08-9	Benzo(k)fluoranthene	7.80E+01	1.20E+01	ND	0.033	ND	0.003	0.006	0.003	0.009 J	0.016	ND	0.003	ND	0.003
92-52-4	1,1'-Biphenyl	NA	NA	ND	0.16	0.024	0.016	ND	0.017	ND	0.079	ND	0.014	ND	0.015
218-01-9	Chrysene	7.80E+02	3.90E+01	0.035	0.033	0.001 J	0.003	0.013	0.003	0.015 J	0.016	ND	0.003	ND	0.003
132-64-9	Dibenzofuran	1.64E+03	4.70E+00	ND	0.016	ND	0.016	0.01 J	0.017	ND	0.079	ND	0.014	ND	0.015
84-74-2	Di-n-butyl phthalate	NA	NA	ND	0.16	0.007 J	0.016	0.009 J	0.017	0.032 J	0.079	0.007 J	0.014	ND	0.015
206-44-0	Fluoranthene	1.64E+04	2.90E+02	0.054	0.033	0.003	0.003	0.016	0.003	0.019	0.016	ND	0.003	0.001 J	0.003
86-73-7	Fluorene	1.64E+04	4.70E+01	ND	0.033	0.01	0.003	ND	0.003	ND	0.016	ND	0.003	0.003	0.003
193-39-5	Indeno(1,2,3-c,d)pyrene	8.00E+00	3.40E+00	0.018	0.033	ND	0.003	0.004	0.003	0.008 J	0.016	ND	0.003	ND	0.003
91-57-6	2-Methylnaphthalene	1.64E+03	3.60E+00	0.68	0.033	1.4	0.003	0.049	0.003	0.032	0.016	0.058	0.003	0.037	0.003
91-20-3	Naphthalene	8.18E+03	3.60E+00	0.68	0.033	1	0.003	0.042	0.003	0.026	0.016	0.037	0.003	0.039	0.003
85-01-8	Phenanthrene	1.23E+04	5.60E+01	0.064	0.033	0.014	0.003	0.026	0.003	0.013 J	0.016	0.001 J	0.003	0.007	0.003
129-00-0	Pyrene	1.23E+04	2.70E+02	0.05	0.033	0.006	0.003	0.017	0.003	0.021	0.016	0.002 J	0.003	0.004	0.003
CAS	MA VPH	Commercial MSCC	Soil-to-Water MSCC	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
SESI-0029	C5 - C8 Aliphatics	2.45E+04	6.80E+01	20	5	5.7	4.7	ND	5.2	ND	5.1	ND	4.3	9.7	4
SESI-0030	C9 - C12 Aliphatics	4.00E+04	5.40E+02	50	5	6.6	4.7	1.9 J	5.2	ND	5.1	ND	4.3	27	4
SESI-0031	C9 - C10 Aromatics	1.23E+04	3.10E+01	59	1.7	8.2	1.6	1.7	1.7	0.83 J	1.7	1 J	1.4	25	1.3

ND = Not detected at or above MDL
BOLD = Concentration Above Reference Values
MDL = Method Detection Limit
J = Estimated Concentration (=<RL>MDL)
NT = Not Tested
MSCCs = Maximum Soil Contaminant Concentration Levels

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Table 2: Groundwater Sample Detection Summary Table

CAS	Analyte	NC 2L GWQS	GCL	Non-Res Vapor GWSL	TMW-1 Result	TMW-1 RL	TMW-2 Result	TMW-2 RL	TMW-3 Result	TMW-3 RL	TMW-4 Result	TMW-4 RL	TMW-5 Result	TMW-5 RL	TMW-6 Result	TMW-6 RL
	Sample ID				TMW-1		TMW-2		TMW-3		TMW-4		TMW-5		TMW-6	
	Sample Date				6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020		6/8/2020	
	Temp Well Depth ('bgs)				13'		13'		13'		13'		13'		13'	
	Depth to Water ('bgs)				10.1'		12.7'		DRY		8.7'		9.0'		8.65'	
	All Values in ug/L	DEQ Reference Values														
CAS	VOC Analyte	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
67-64-1	Acetone	6.00E+03	6.00E+06	1.90E+07	23	10	ND	200	NT		ND	500	ND	200	5.7 J	10
71-43-2	Benzene	1.00E+00	5.00E+03	6.90E+01	ND	0.5	ND	10	NT		300	25	130	10	ND	0.5
78-93-3	2-Butanone (MEK)	4.00E+03	4.00E+06	1.90E+06	4.5 J	10	ND J	200	NT		ND	500	ND	200	ND	10
104-51-8	n-Butylbenzene	7.00E+01	6.90E+03	NE	1.5	0.5	ND	10	NT		ND	25	130	10	4	0.5
135-98-8	sec-Butylbenzene	7.00E+01	8.50E+03	NE	0.79	0.5	31	10	NT		27	25	37	10	0.84	0.5
74-87-3	Chloromethane	3.00E+00	3.00E+03	2.20E+02	0.47 J	0.5	ND	10	NT		ND	25	ND	10	ND	0.5
108-20-3	Diisopropyl ether (IPE)	7.00E+01	7.00E+04	5.90E+03	ND	0.5	ND	10	NT		ND	25	11	10	17	0.5
100-41-4	Ethylbenzene	6.00E+02	8.45E+04	1.50E+02	12	0.5	2600	10	NT		5600	25	3000	10	6.7	0.5
98-82-8	Isopropylbenzene	7.00E+01	2.50E+04	7.50E+02	1.6	0.5	130	10	NT		190	25	150	10	1.2	0.5
99-87-6	p-Isopropyltoluene	2.50E+01	1.17E+04	NE	0.46 J	0.5	18	10	NT		ND	25	21	10	0.53	0.5
1634-04-4	Methyl tertiary butyl ether (MTBE)	2.00E+01	2.00E+04	2.00E+04	ND	0.5	ND	10	NT		ND	25	ND	10	3.2	0.5
75-09-2	Methylene chloride	5.00E+00	5.00E+03	4.00E+03	ND	0.5	ND	10	NT		ND	25	8 J	10	ND	0.5
91-20-3	Naphthalene	6.00E+00	6.00E+03	1.50E+02	8.3	0.5	900	10	NT		1400	25	760	10	5.1	0.5
103-65-1	n-Propylbenzene	7.00E+01	3.00E+04	2.00E+03	5.4	0.5	420	10	NT		570	25	510	10	4.8	0.5
108-88-3	Toluene	6.00E+02	2.60E+05	1.60E+04	ND	0.5	64	10	NT		1100	25	220	10	ND	0.5
108-67-8	1,3,5-Trimethylbenzene	4.00E+02	2.85E+04	1.50E+02	9.9	0.5	770	10	NT		1000	25	580	10	6.5	0.5
95-63-6	1,2,4-Trimethylbenzene	4.00E+02	2.50E+04	2.10E+02	36	0.5	3000	10	NT		4300	25	1700	10	22	0.5
179601-23-1	m+p-Xylenes	NA	NA		13	0.5	3000	10	NT		6000	25	1700	10	6.1	0.5
95-47-6	o-Xylenes	NA	NA		6.7	0.5	2700	10	NT		7300	25	2500	10	6.4	0.5
1330-20-7	Xylenes (total)	5.00E+02	8.55E+04	3.20E+02	19.7	0.5	5700	10	NT		13300	25	4200	10	12.5	0.5
CAS	SVOC Analyte	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
84-66-2	Diethylphthalate	6.00E+03	NA	NE	8.9 B	3.2	ND	16	NT		ND	16	ND	16	17 B	3.2
131-11-3	Dimethyl phthalate	NA	NA	NE	1.6 J	3.2	ND	16	NT		ND	16	ND	16	2.2 J	3.2
105-67-9	2,4-Dimethylphenol	1.00E+02	1.00E+05	NE	3 BJ	3.2	97	16	NT		40	16	61	16	24 B	3.2
84-74-2	Di-n-butyl phthalate	NA	NA	NE	ND	3.2	0.006 J	16	NT		ND	16	ND	16	ND	3.2
90-12-0	1-Methylnaphthalene	1.00E+00	1.00E+03	NE	2.7 J	3.2	97	16	NT		140	16	120	16	2.3 J	3.2
91-57-6	2-Methylnaphthalene	3.00E+01	1.25E+04	NE	4.6	3.2	170	16	NT		260	16	210	16	4.2	3.2
108-5-2	Phenol	3.00E+01	3.00E+04	NE	ND	3.2	ND	16	NT		ND	16	9.9 J	16	2.3 J	3.2
CAS	EDB	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
106-93-4	1,2-Dibromoethane	2.00E-02	5.00E+01	7.70E+00	ND	0.0097	ND	0.0097	NT		0.013	0.0096	ND	0.0097	ND	0.0099
CAS	MA EPH	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
	C11 - C22 Aromatics	2.00E+02	NE	NE	ND	100	1500	100	NT		1700	100	1200	100	120	100
	C9 - C18 Aliphatics	7.00E+02	NE	NE	ND	100	130	100	NT		ND	100	110	100	ND	100
CAS	MA VPH	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
SESI-0029	C5 - C8 Aliphatics	4.00E+02	NE	NE	ND	75	1600 J	3800	NT		3300	7500	4400	3800	22 J	75
SESI-0030	C9 - C12 Aliphatics	7.00E+02	NE	NE	140	75	16000	3800	NT		25000 J	7500	12000	3800	91	75
SESI-0031	C9 - C10 Aromatics	2.00E+02	NE	NE	190	25	10000	1300	NT		18000	2500	8200	1300	160	25
CAS	Metals	NC 2L GWQS	GCL	Non-Res Vapor GWSL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL
7439-92-1	Lead	1.50E+01	1.50E+04	NA	1.4E-05	0.00001	6.8E-06 J	0.00001	NT		1.4E-05	1.4E-05	1.3E-05	0.00001	1.3E-05	0.00001

ND = Not detected at or above MDL
BOLD = Concentration Above Reference Values
MDL = Method Detection Limit
NE = Not Established
GWSL = February 2018 Non-Residential Vapor Intrusion Groundwater Screening Levels

J = Estimated Concentration (=<RL>MDL)
NT = Not Tested
NC 2L = NC Groundwater Standards
GCL = NC Gross Contamination Levels

Site "Closed"

- 10 years ago, we would have stopped there… Closure!!
- NCDEQ UST does not take the VI pathway into consideration as an exposure route
- SUMMIT further characterized the VI exposure pathway
  - Compared result values to NC Non-Residential VI Screening Levels
  - Exceedances for multiple petroleum compounds
    - Benzene, ethylbenzene, naphthalene

Key Details of the Conceptual Site Model

- Sandy Silts
- GW ~10 ft bgs
- Contaminated soils:
  - May continue to leach into groundwater table
  - Volatilize under a new foundation slab


What’s
next?

What's Next?

1 Additional Assessment

Further characterize the soil gas concentrations with additional assessment

- Money
- Time
- **No Guarantees...**

2 Pre-emptively Mitigate

Implement engineering controls during building construction

- Money
- Time
- **Assurance of Protection**

Door #1. Additional Assessment

IMPLICATIONS

Additional soil gas assessment

- $16k-$20k
- ~40-day timeline

Results could come back "clean" OR

Likely would exceed residential VISLs…

ADDITIONAL CONSIDERATIONS

Proposed structure (Town Hall and Library) qualified to be screened using Commercial VISLs

- Library on first floor
- Children occupying this area
    - Sensitive receptor

Door 1…?

1

$20k

+40 Days

No Guarantees of Avoiding VIMS Requirement

Unquantifiable Risk

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Door 2. Pre-emptively Mitigate

Best Practices:

- Detailed Passive VIMS Design
- Certified VIMS Installation
- System Inspection and Performance Verification

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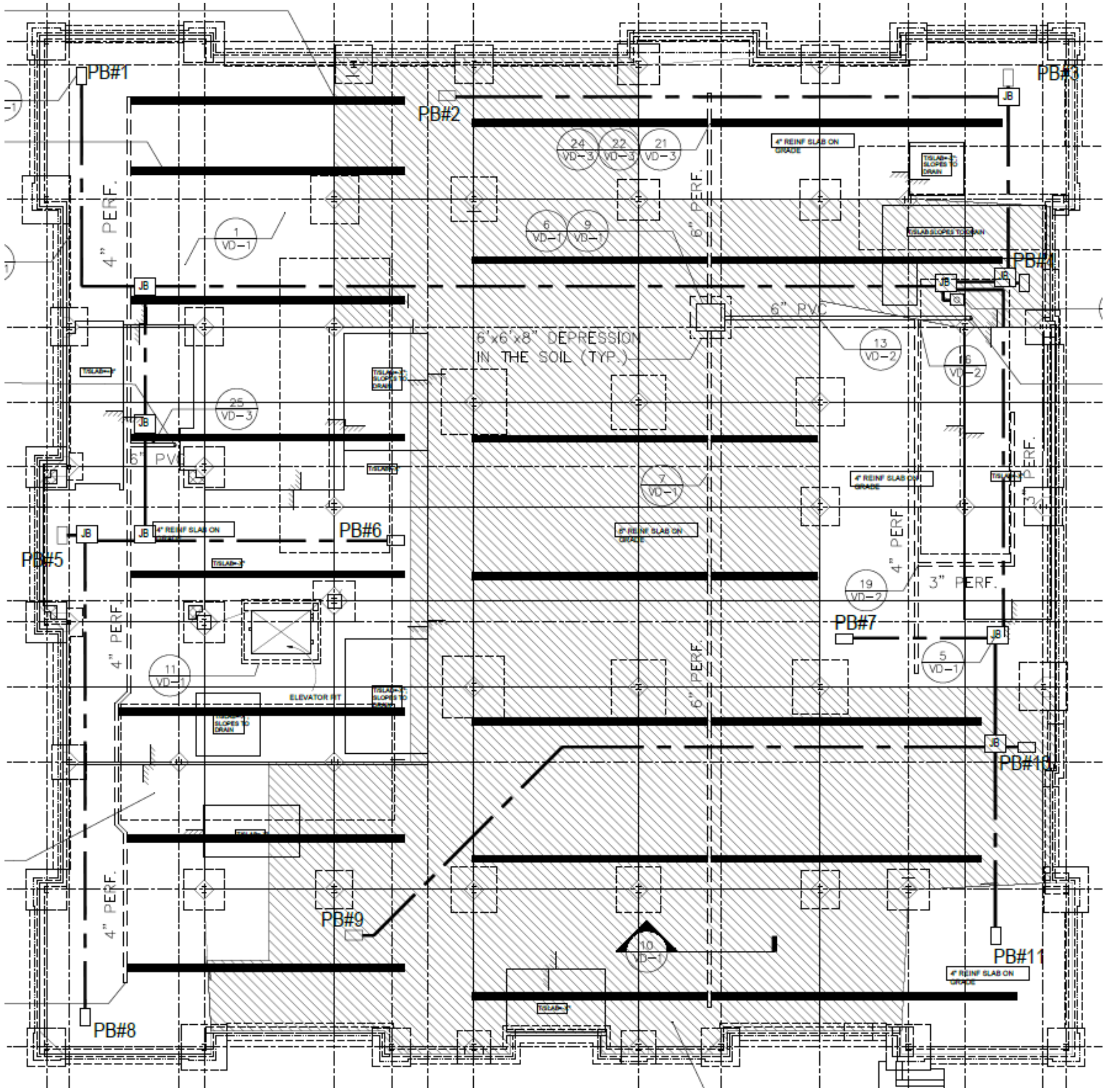
PVIMS Design

- Sub-slab venting system
  - Mirafi geotextile on soil
  - 5” Clean gravel substrate
    - (2) 6-inch risers
    - Plenum
    - 6-inch perforated trunk lines
    - TerraVent lines (low-profile)
- 11 sub-slab pressure monitoring and sampling points
- Composite spray-applied membrane
- Monitoring panel



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VIMS Membrane Specifications

Design Criteria & Best Practices

- Membrane Thickness:
  - 60-mil asphaltic spray applied, <u>OR</u>
  - 40-mil asphaltic spray applied with chemical resistant protection layers
- Chemically resistant to COCs
- Licensed Applicator of Manufacturer
- QA/QC Plan
  - Smoke Testing
  - Coupon Sampling
  - Documentation

VIMS Membrane Selection

Enhanced Chemical Resistance at Seals, Durability, Cost-efficiency

Composite Configuration:

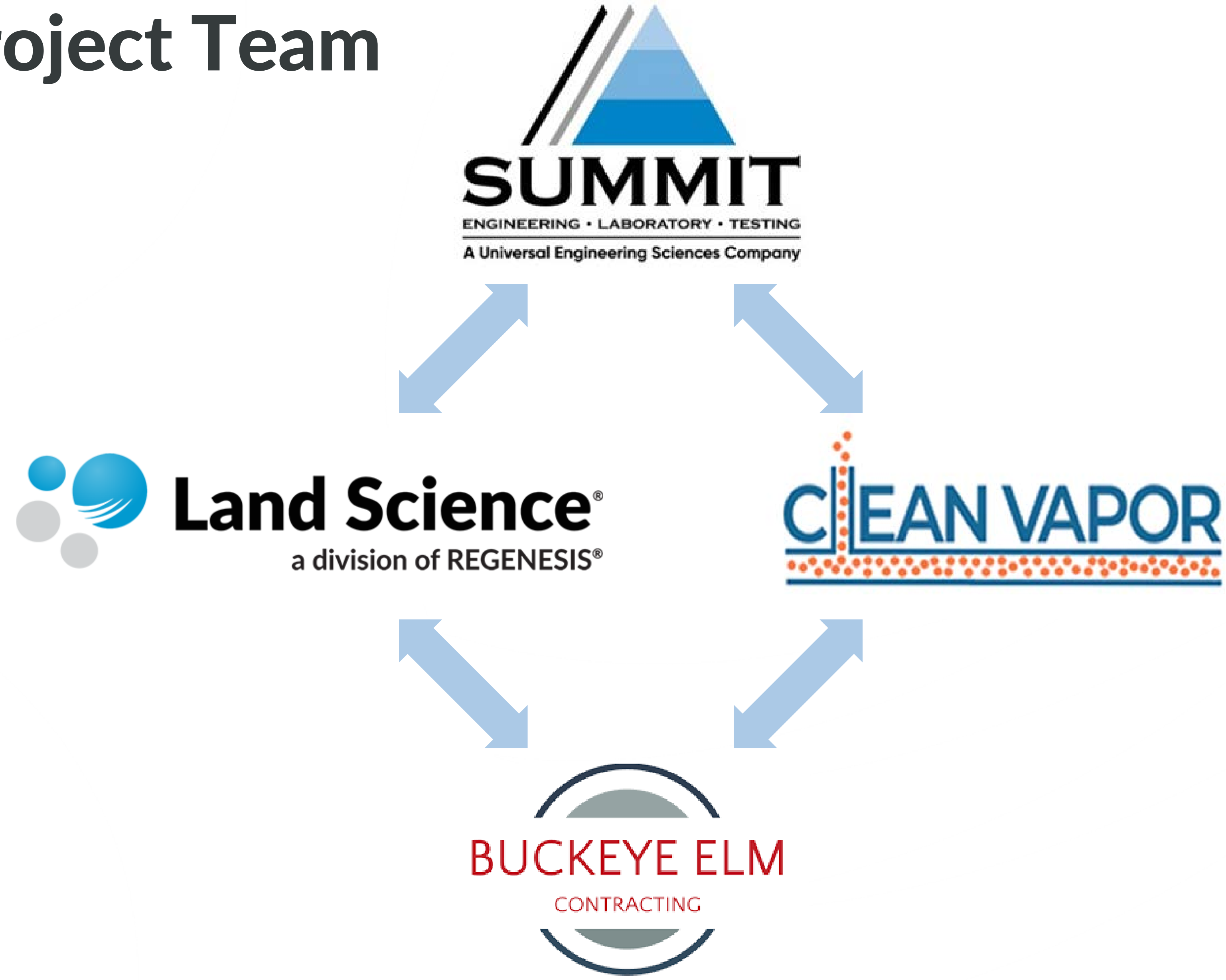
- 23-mil reinforced PE/geotextile Base
- Seamless 40-mil Nitrile-Advanced Asphaltic Layer
- 18-mil PE/geotextile Protection Layer

Certified Applicator:

BUCKEYE ELM
CONTRACTING

- 75 minutes from project site
- Responsible for membrane installation, smoke testing, & coupon sampling

VIMS Project Team




Detail Fabric
Cable Tie
Land Science Bond
Nitra-Core (40 MIL)
Nitra-Base
STEP 5

VIMS Inspections

Best Practices for your QA/QC Plan

- Certified Installer
- Third Party Certified Inspections
  - Smoke testing
  - Coupon sampling/thickness verification
- Pre-pour inspections

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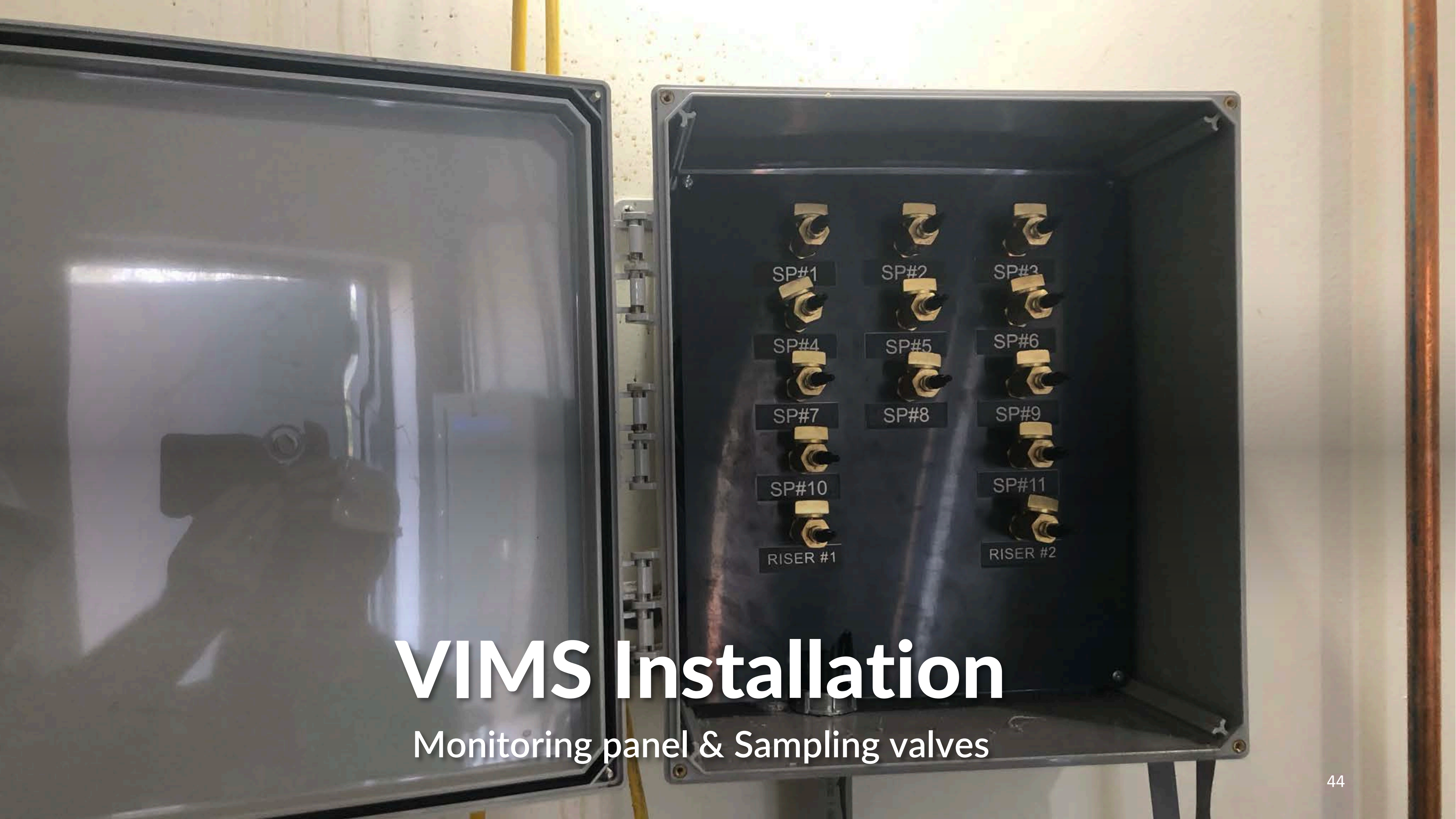
Land Science VMS Membrane Testing Log

Project Name		Date	
Inspector Name		Time	
Location		Temperature	
VMS System Installed		Barometric Pressure	

Building Square footage		Gallons Used	
Square footage for this report		Square feet per gallon	

Coupon Samples Taken		Smoke Test Conducted	
Coupon Samples Under the Specified Thickness		Duration of Smoke Test	
Coupon Samples Marked for Repair		Number of Areas Needed for Repair	

Indicate Areas Marked for Repair: (#) Coupon Sample Repair (^) Smoke Test Repair (*) Thickness measurement repair



VIMS Installation

Monitoring panel & Sampling valves

VIMS Commissioning & Performance Verification

- Negative pressure readings in riser monitoring point
- Indicates the passive mitigation system is "actively" applying a negative pressure to the sub-slab extraction network…

VIMS Commissioning & Performance Verification

- Negative pressure at the farthest extents of the sub-slab system

It's working!

Learning Points

- Weigh the options
- Build out a plan
- Assemble your Project Team
- Implement Industry Best-Practices
- Great chance for success!

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