Mitigating Vapor Intrusion

Bill Wertz, Chief

Remedial Section B

NYSDEC

Mitigation of the Exposure Pathway

- Delineating the Mitigation Area
- Verifying the Efficacy of the Mitigation Systems
- Operation and Maintenance

Delineating the Mitigation Area

The VI Exposure Pathway is Complex

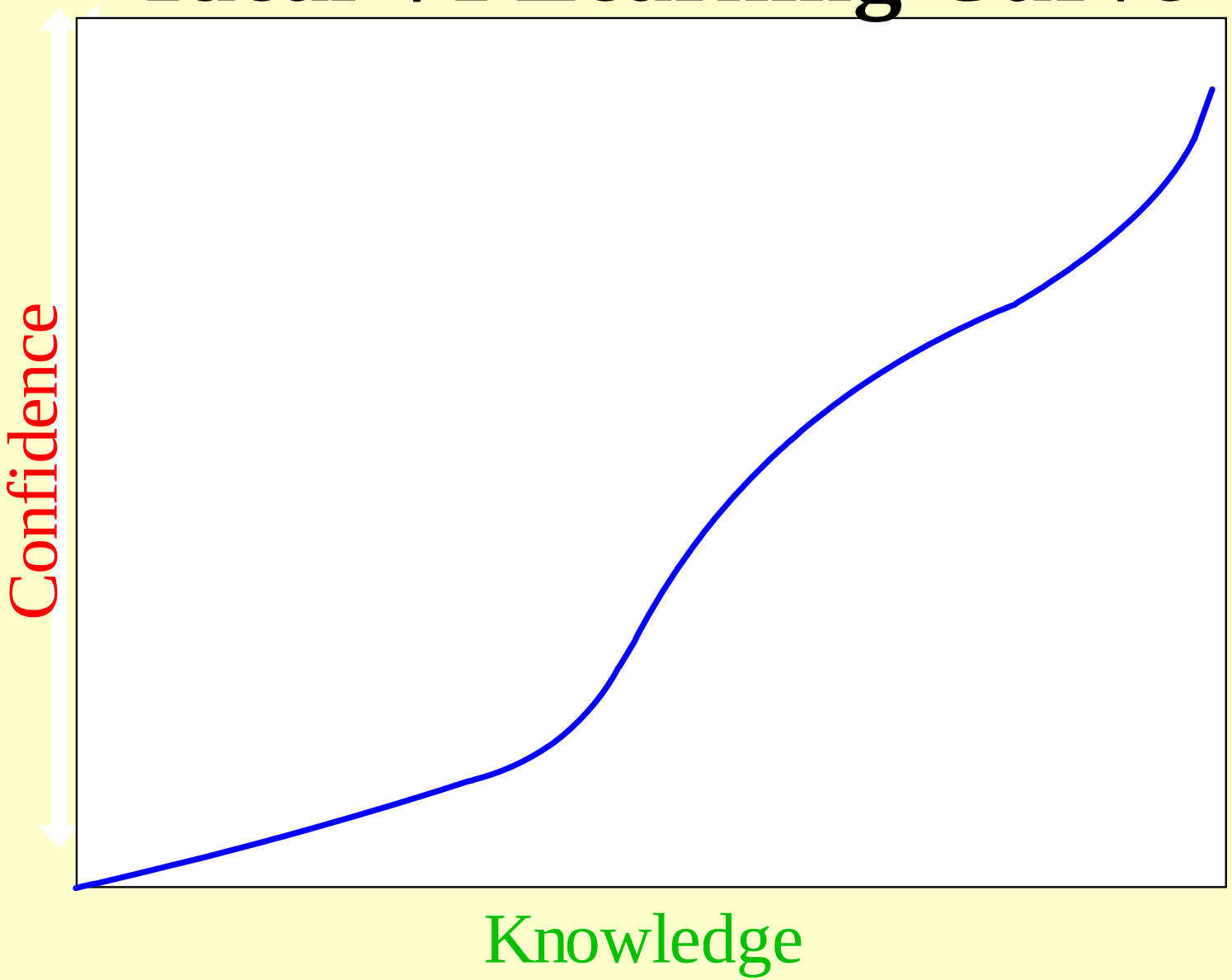
Reliable Prediction is Difficult

Temporal Variability

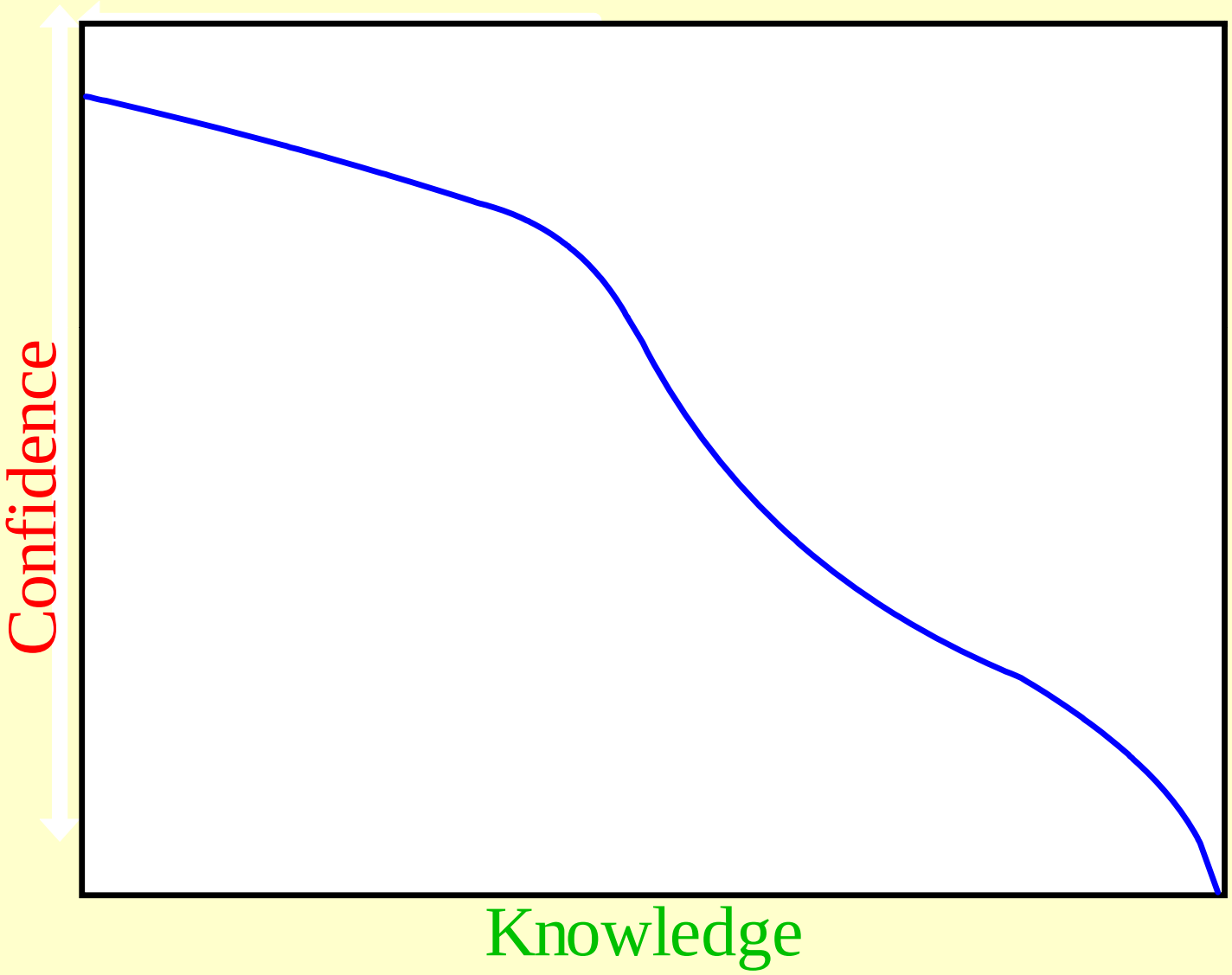
Spatial Variability

Structure Variability

Ideal VI Learning Curve



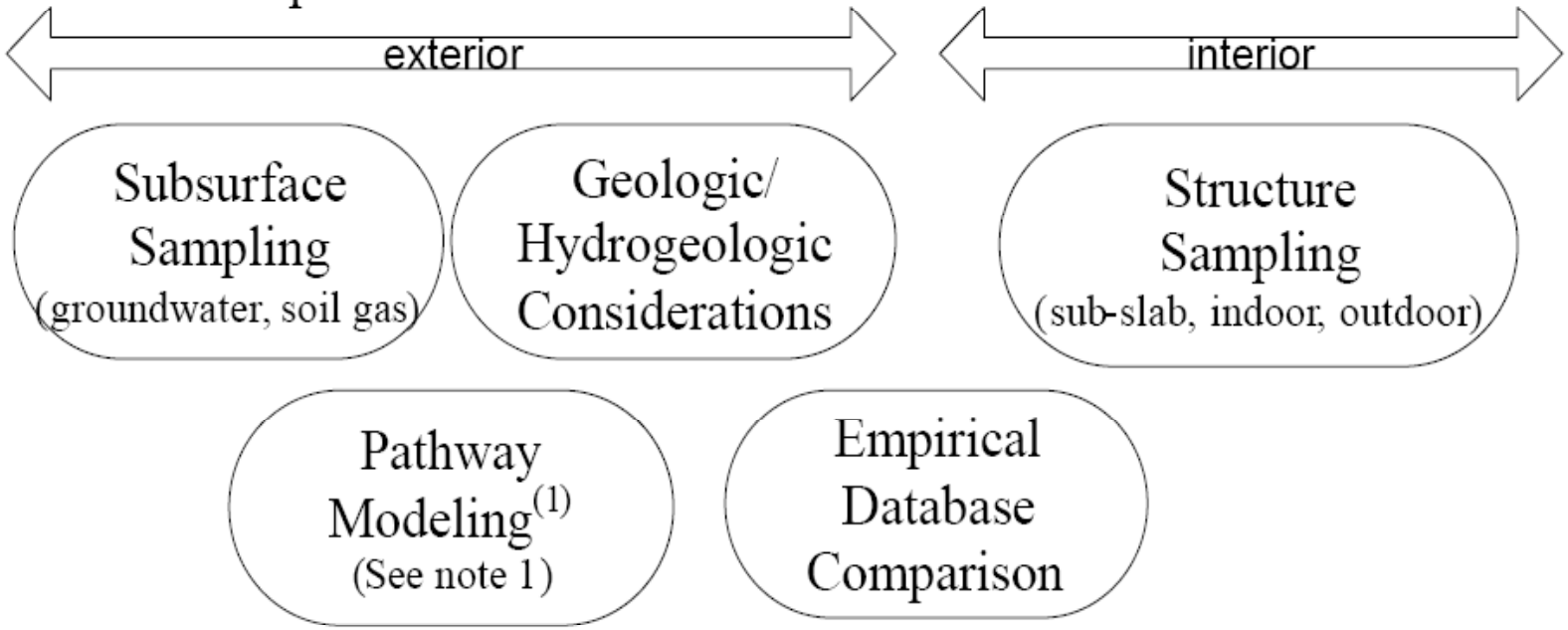
Actual VI Learning Curve



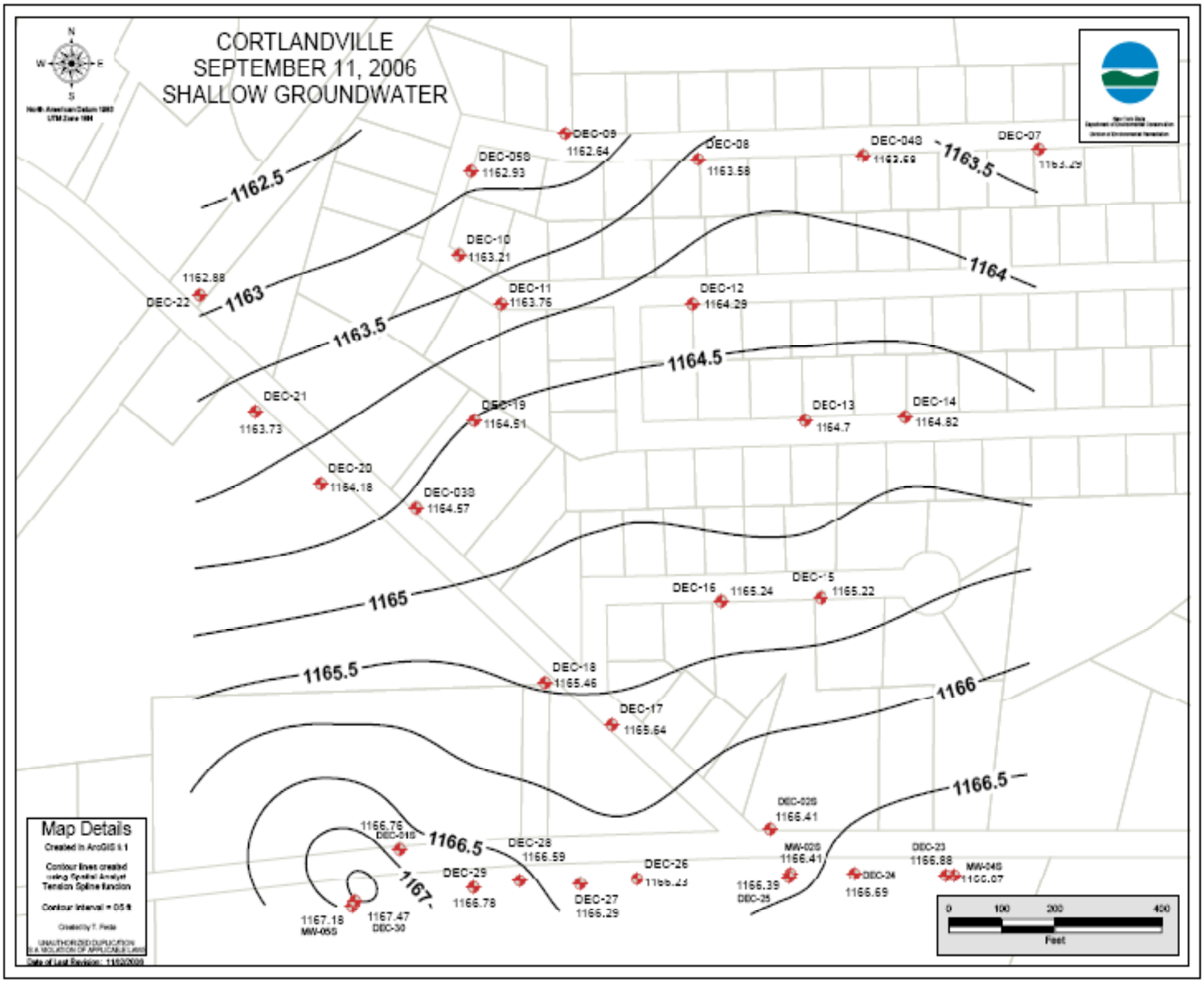
Upstate NY Glacial Outwash Valley Site

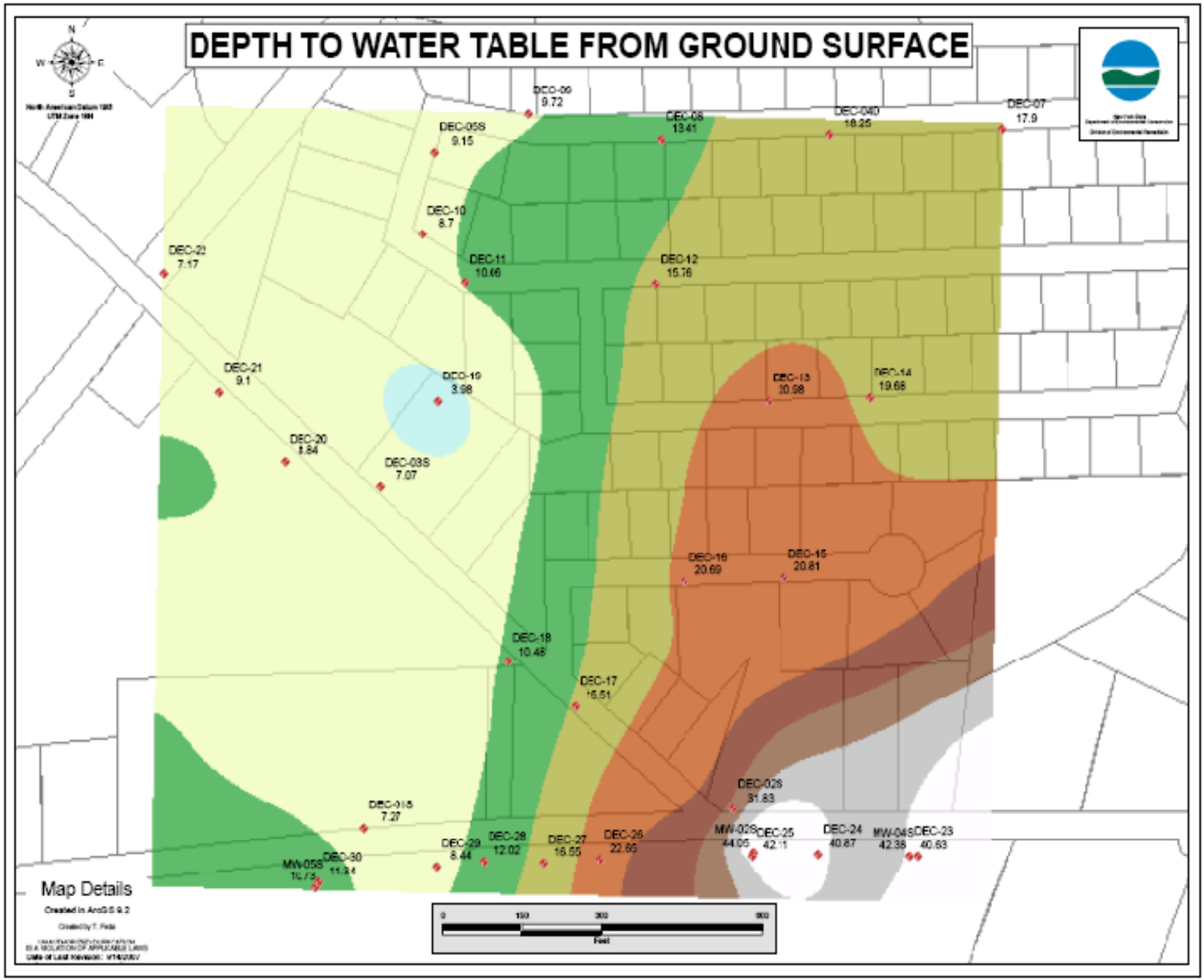
Pathway Assessment

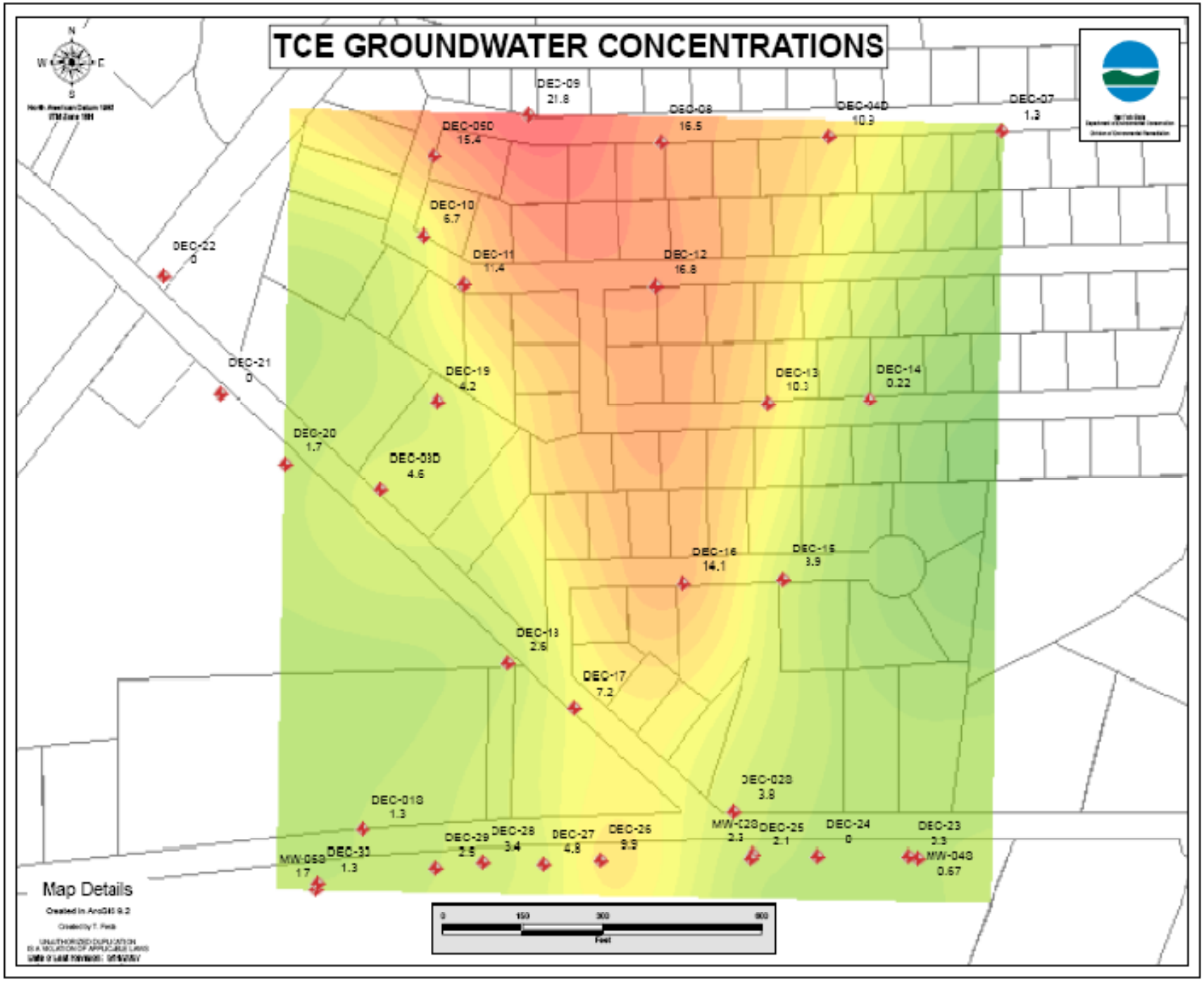
Iterative Multiple Lines of Evidence Evaluation



Start with worst case subsurface conditions and buildings most likely to be impacted. Consider consistency among lines of evidence. Continue the evaluation until all potentially impacted buildings or areas are addressed


CORTLANDVILLE
SEPTEMBER 11, 2006
SHALLOW GROUNDWATER
N
W
E
S
1162.5
1163
1163.5
1164
1164.5
1165
1165.5
1166
1166.5
1167
DEC-09
1162.64
DEC-05S
1162.93
DEC-08
1163.58
DEC-04S
DEC-07
DEC-10
1163.21
1162.88
DEC-22
DEC-11
1163.76
DEC-12
1164.29
DEC-21
1163.73
DEC-19
1164.91
DEC-13
1164.7
DEC-14
1164.82
DEC-20
1164.18
DEC-03S
1164.57
DEC-16
1165.24
DEC-15
1165.22
DEC-18
1165.46
DEC-17
1165.64
DEC-02S
1166.41
MW-02S
1166.41
DEC-23
1166.88
MW-04S
1166.07
DEC-24
1166.69
1166.39
DEC-25
DEC-26
1166.23
DEC-28
1166.59
DEC-29
1166.78
DEC-27
1166.29
1166.76
DEC-01S
1167.18
MW-05S
1167.47
DEC-30
Map Details
Created in ArcGIS 9.1
Contour lines created using Spatial Analyst Tension Spline function
Contour Interval = 0.5 ft
Created by T. Peila
UNAUTHORIZED DUPLICATION IS A VIOLATION OF APPLICABLE LAWS
Date of Last Revision: 11/2/2006
0
100
200
400
Feet


DEPTH TO WATER TABLE FROM GROUND SURFACE
N
W
E
S
DEC-09
9.72
DEC-05S
9.15
DEC-08
13.41
DEC-04D
18.25
DEC-07
17.9
DEC-10
8.7
DEC-22
7.17
DEC-11
10.66
DEC-12
15.76
DEC-21
9.1
DEC-19
3.98
DEC-13
20.98
DEC-14
19.68
DEC-20
8.84
DEC-03S
7.07
DEC-16
20.69
DEC-15
20.81
DEC-18
10.48
DEC-17
16.51
DEC-02S
31.83
DEC-01S
7.27
MW-05S
DEC-30
11.24
DEC-29
8.44
DEC-28
12.02
DEC-27
16.55
DEC-26
22.65
MW-02S
44.06
DEC-25
42.1
DEC-24
40.87
MW-04S
42.38
DEC-23
40.63
Map Details
Created in ArcGIS 9.2
Created by T. Pete
Date of Last Revision: 1/14/2007
0
150
300
600
Feet


TCE GROUNDWATER CONCENTRATIONS
N
W
E
S
DEC-09
21.8
DEC-08
16.5
DEC-04D
10.9
DEC-07
1.3
DEC-05D
15.4
DEC-10
6.7
DEC-22
0
DEC-11
11.4
DEC-12
16.8
DEC-21
0
DEC-19
4.2
DEC-13
10.3
DEC-14
0.22
DEC-20
1.7
DEC-03D
4.6
DEC-16
14.1
DEC-15
3.9
DEC-18
2.6
DEC-17
7.2
DEC-02D
3.8
DEC-01D
1.3
MW-02S
2.3
DEC-25
2.1
DEC-24
0
DEC-23
3.3
DEC-29
2.5
DEC-28
3.4
DEC-27
4.8
DEC-26
9.9
MW-05S
1.7
DEC-31
1.3
MW-04S
0.67
Map Details
Created in ArcGIS 9.2
Created by T. Peck
UNAUTHORIZED DUPLICATION
IS A VIOLATION OF APPLICABLE LAWS
0
150
300
600
Feet

Source Characteristics:

Source medium			Source	Groundwater	Site Specific Inputs
Groundwater concentration		(ug/L)	Cmedium	**13**	
Depth below grade to water table		(m)	Ls	**4.64**	
Average groundwater temperature		(^{o}C)	Ts	15	*15*
	Calc: Source vapor concentration	(ug/m3)	Cs	3434	

Chemical:

Chemical Name			Chem	Trichloroethylene	
	CAS No.		CAS	79016	

Toxicity Factors

Unit risk factor		(ug/m^3)$^{-1}$	URF	1.10E-04	*1.10E-04*
Reference concentration		(ug/m^3)	RfC	4.00E+01	*4.00E+01*

Building Characteristics:

Building setting			Bldg_Setting	Residential	*Residential*	
Foundation type			Found_Type	Basement w/ slab	*Basement w/ slab*	Site Specific Inputs
	Depth below grade to base of foundation	(m)	Lb	**2.00**	*2.00*	
	Foundation thickness	(m)	Lf	0.10	*0.10*	
	Fraction of foundation area with cracks	(-)	eta	1.00E-03	*1.00E-03*	

EPA J&E 2006 BETA

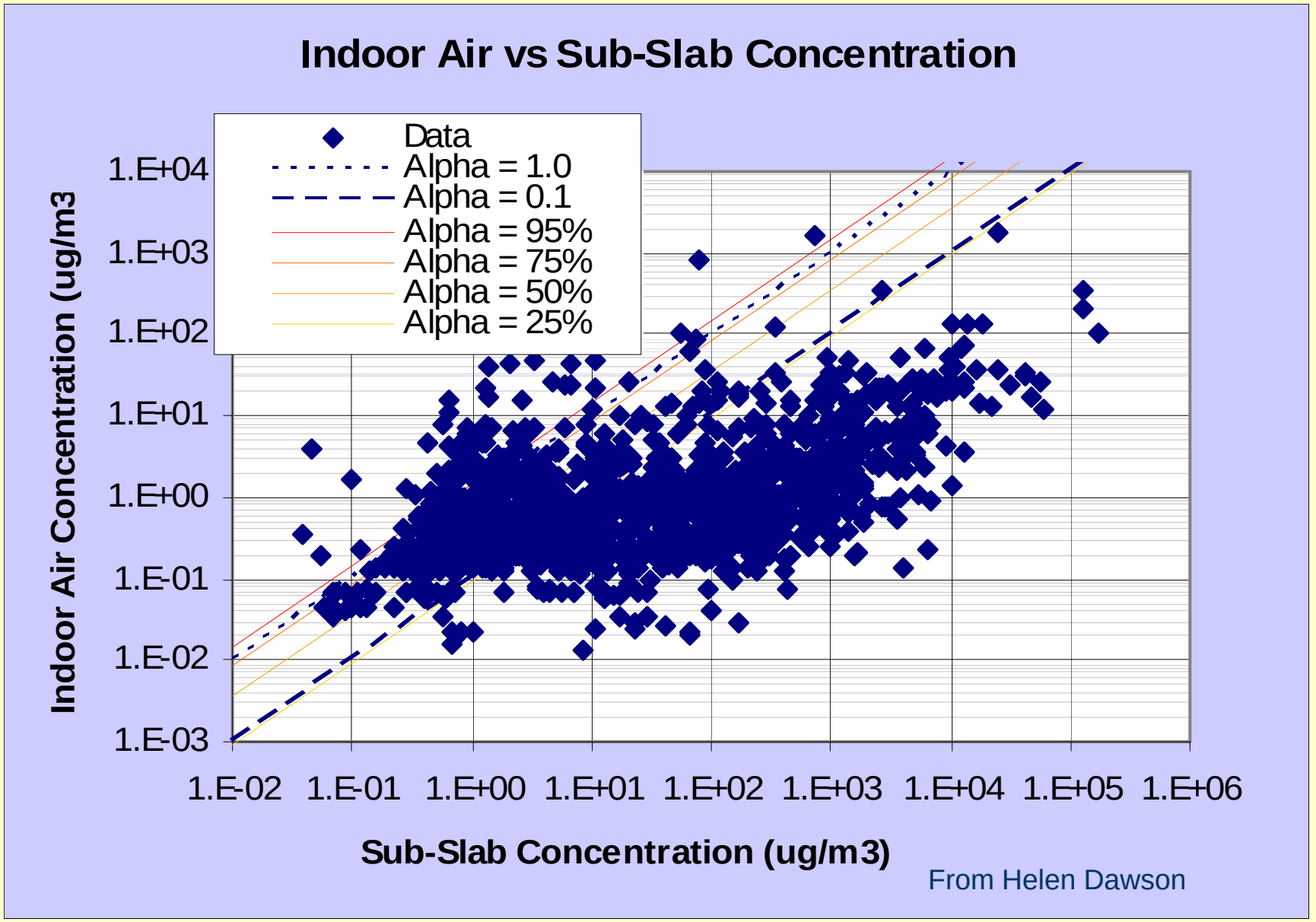
Site Specific Outputs

Source to Indoor Air Attenuation Factor			
Ground water to indoor air attenuation coefficient	**(-)**	**alpha**	**5.97E-04**
Predicted Indoor Air Concentration			
Indoor air concentration due to vapor intrusion	**(ug/m3)**	**Cia**	**2.05E+00**

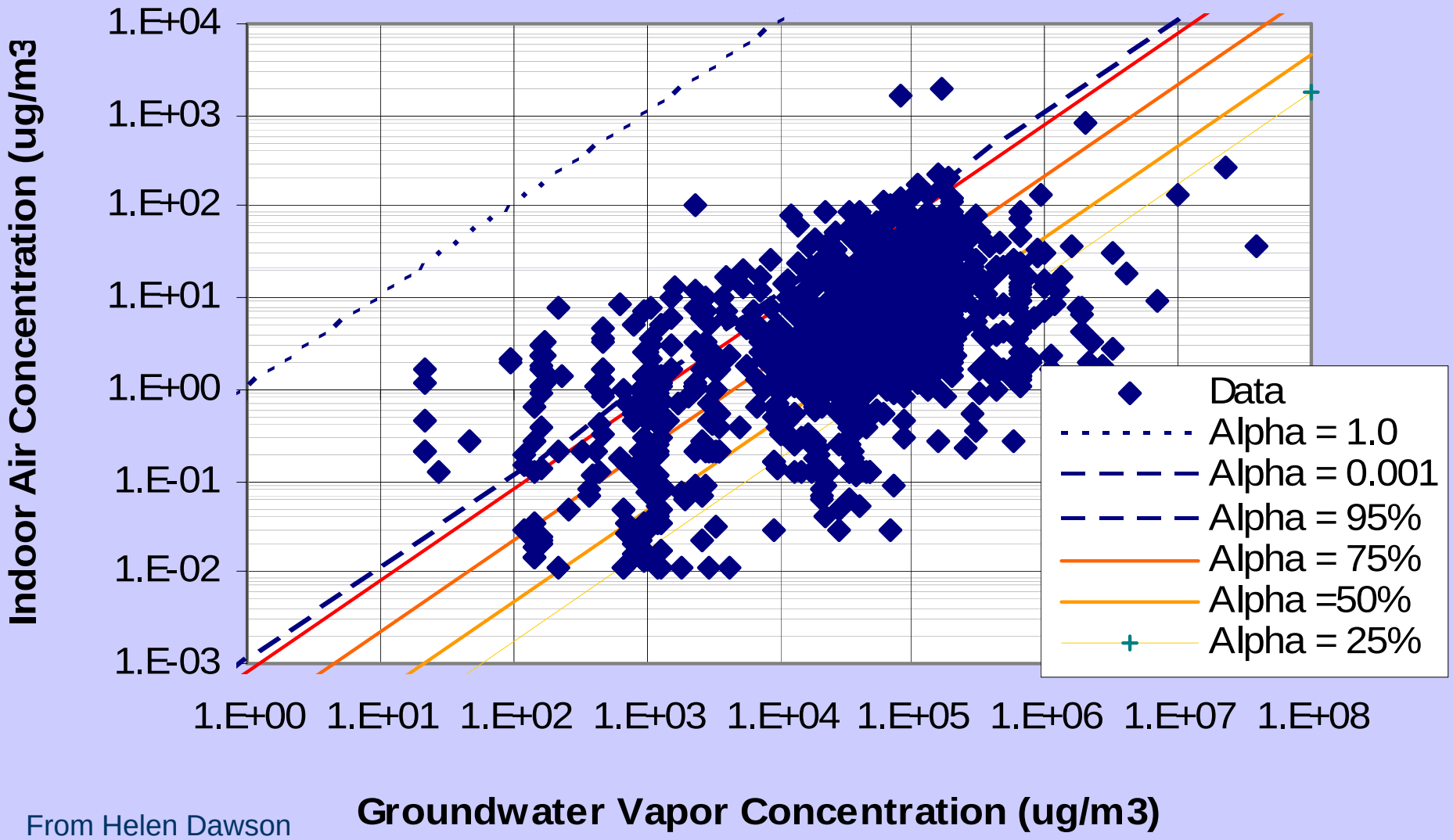
EPA J&E 2006
BETA

STRUCTURE SAMPLES

Think in Terms of a Patchy Fog,
Not a Uniform Blanket


Indoor Air vs Sub-Slab Concentration
Data
Alpha = 1.0
Alpha = 0.1
Alpha = 95%
Alpha = 75%
Alpha = 50%
Alpha = 25%
Indoor Air Concentration (ug/m3
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
Sub-Slab Concentration (ug/m3)
From Helen Dawson

Indoor Air vs Groundwater Vapor Concentration



From Helen Dawson

From Helen Dawson

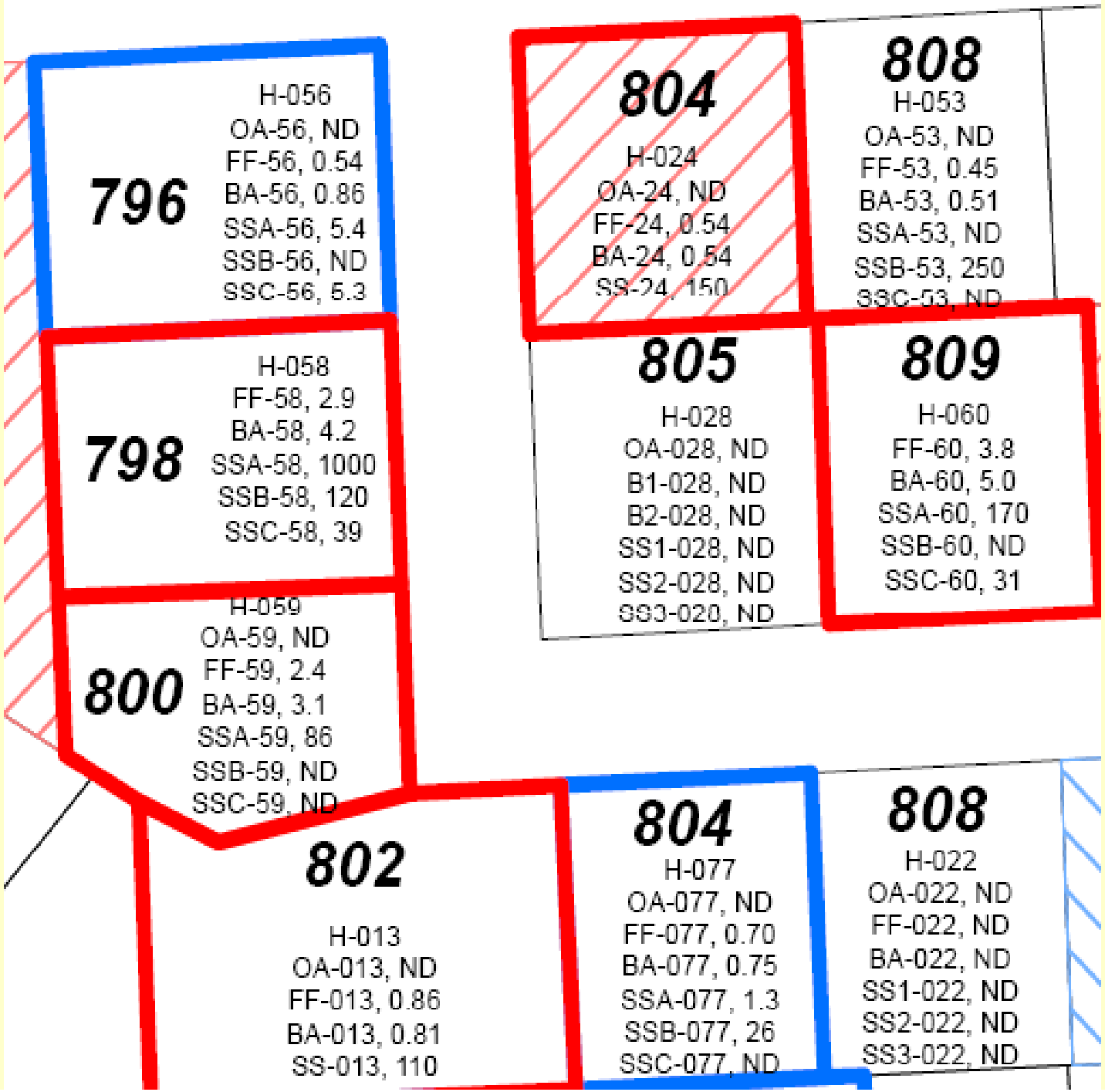

796
H-056
OA-56, ND
FF-56, 0.54
BA-56, 0.86
SSA-56, 5.4
SSB-56, ND
SSC-56, 5.3
798
H-058
FF-58, 2.9
BA-58, 4.2
SSA-58, 1000
SSB-58, 120
SSC-58, 39
800
H-059
OA-59, ND
FF-59, 2.4
BA-59, 3.1
SSA-59, 86
SSB-59, ND
SSC-59, ND
802
H-013
OA-013, ND
FF-013, 0.86
BA-013, 0.81
SS-013, 110
804
H-024
OA-24, ND
FF-24, 0.54
BA-24, 0.54
808
H-053
OA-53, ND
FF-53, 0.45
BA-53, 0.51
SSA-53, ND
SSB-53, 250
805
H-028
OA-028, ND
B1-028, ND
B2-028, ND
SS1-028, ND
SS2-028, ND
809
H-060
FF-60, 3.8
BA-60, 5.0
SSA-60, 170
SSB-60, ND
SSC-60, 31
804
H-077
OA-077, ND
FF-077, 0.70
BA-077, 0.75
SSA-077, 1.3
SSB-077, 26
SSC-077, ND
808
H-022
OA-022, ND
FF-022, ND
BA-022, ND
SS1-022, ND
SS2-022, ND
SS3-022, ND

FIGURE 1

TCE Results

Vapor Intrusion

or

Indoor Source ?

What's IN Neighboring Homes?

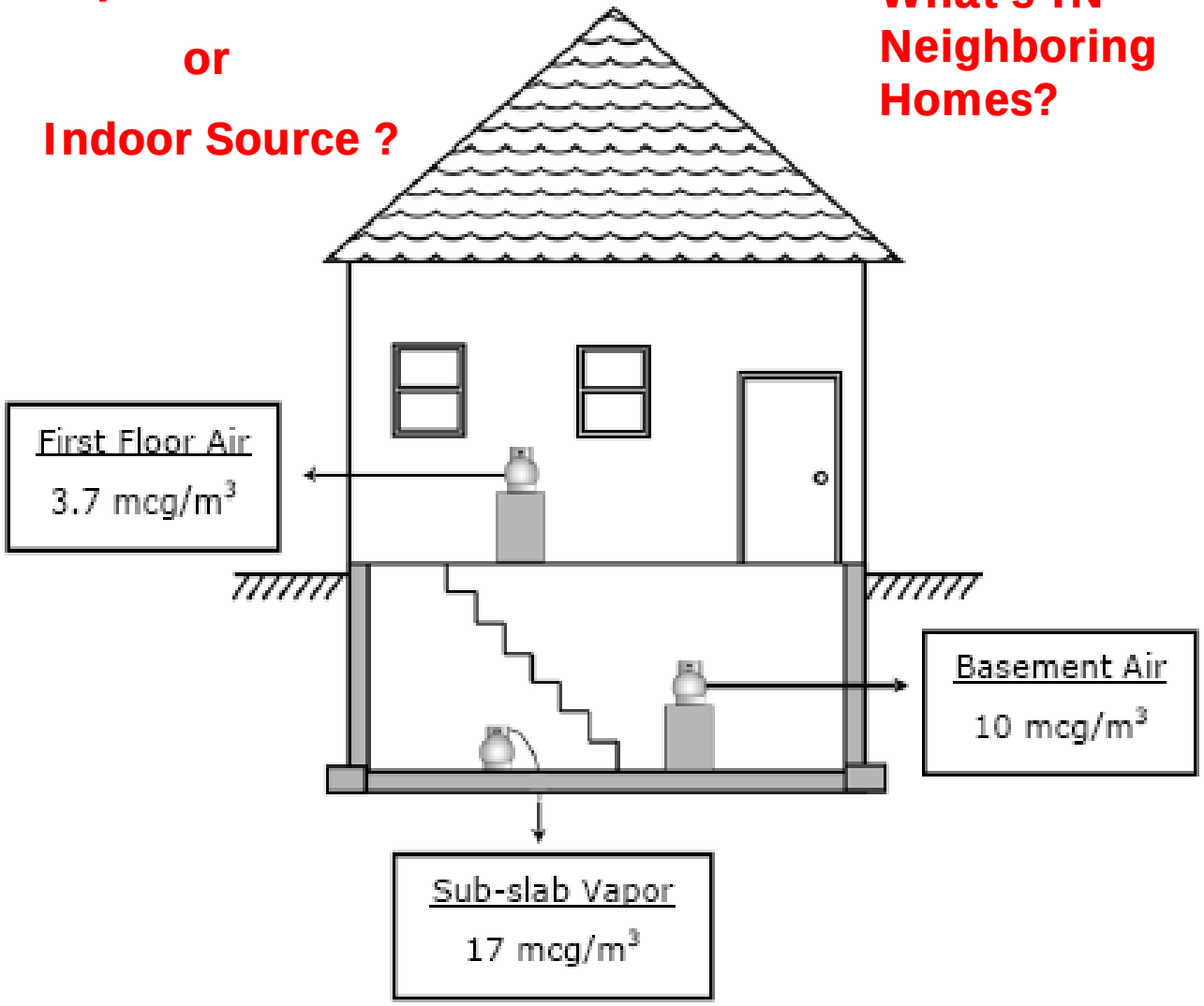
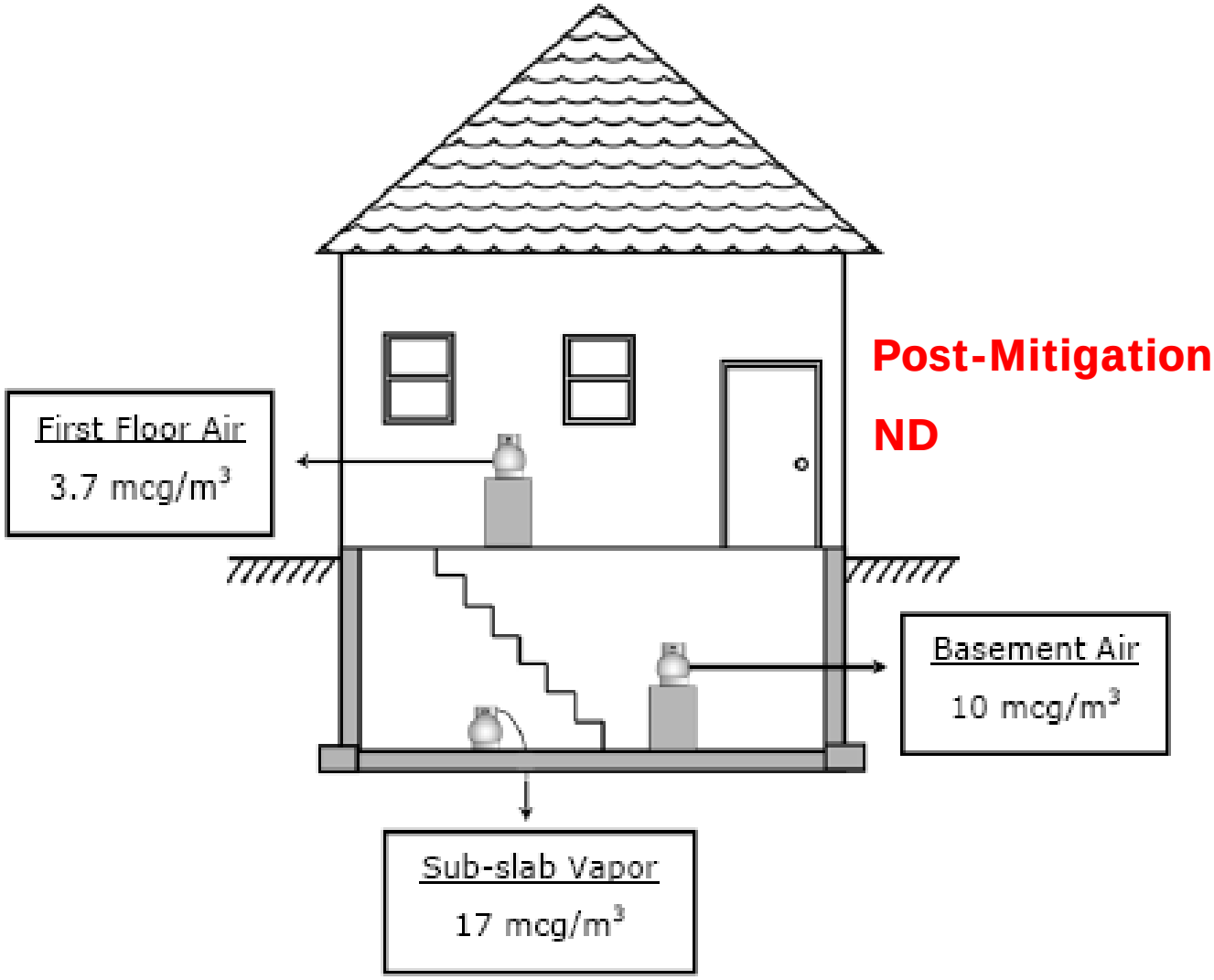


FIGURE 1
TCE Results



SUB-SLAB SAMPLES

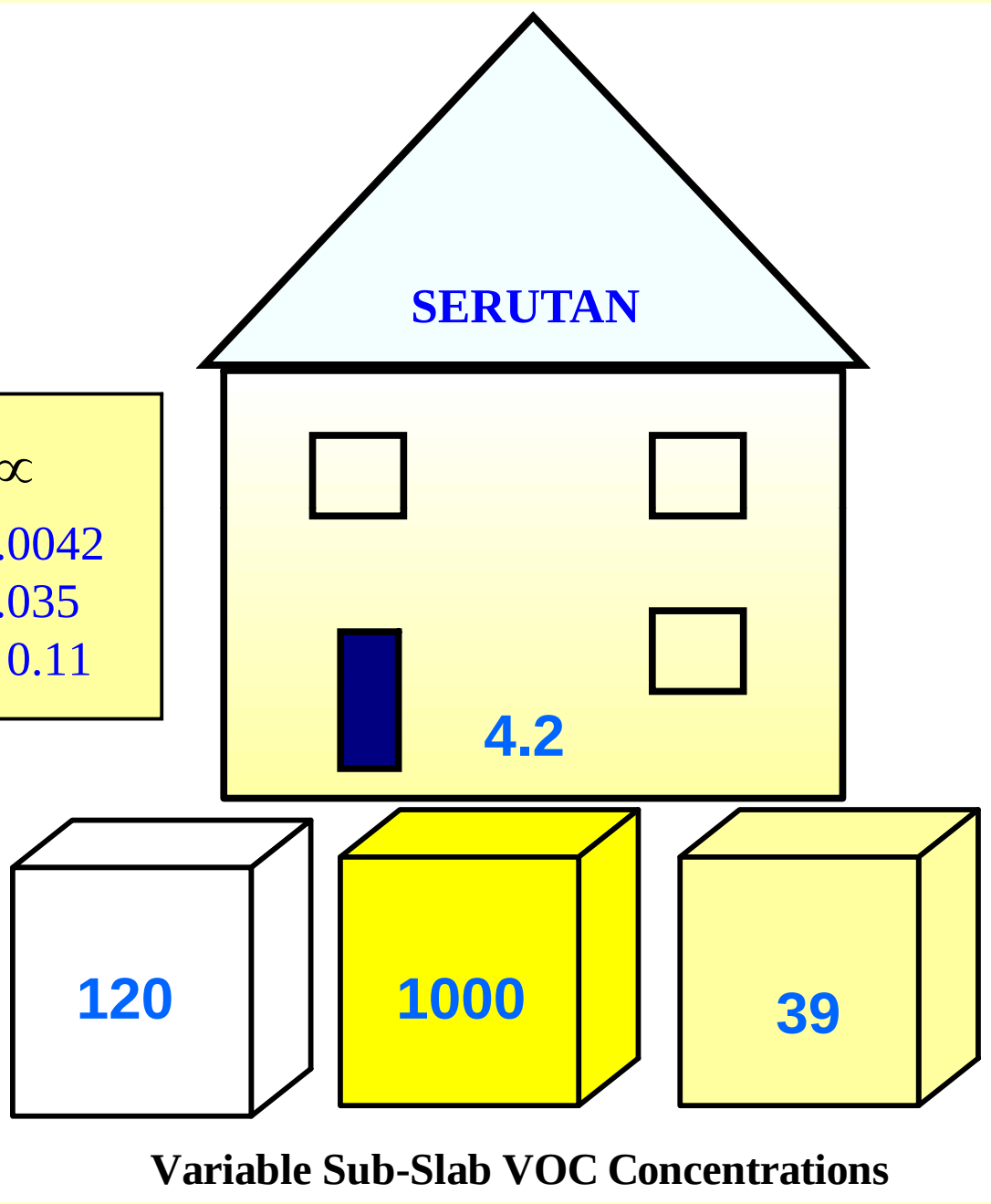
- IS ONE ENOUGH ?
- ARE THREE TOO MANY ?
- WHAT IS THE ALPHA?

Subslab ∝

4.2 / 1000 = .0042

4.2 / 120 = .035

4.2 / 39 = 0.11



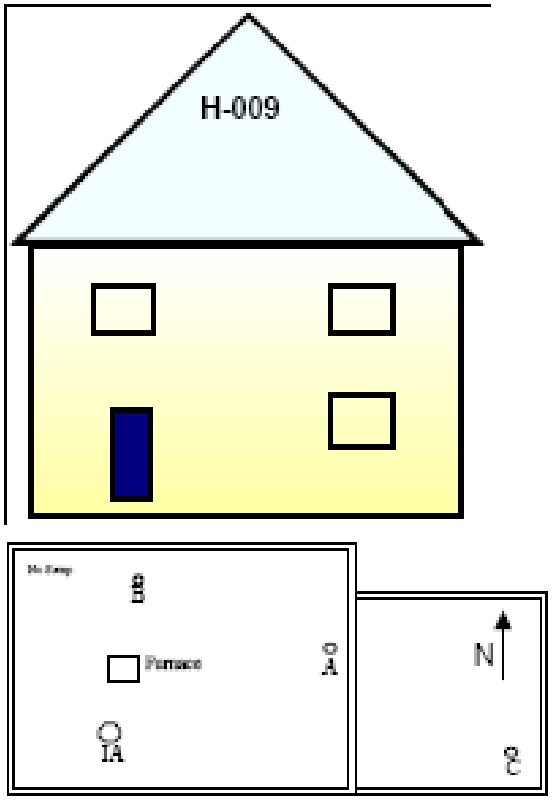
Variable Sub-Slab VOC Concentrations

Preliminary Results

Endicott

OUTDOOR

	TCE	PCE	TCA
10/6/2006	0.21 UJ	0.27 UJ	0.22 UJ
11/6/2006	0.21 UJ	0.34	0.22 UJ
12/12/2006	0.21 U	0.27 U	0.22 U
1/11/2007	0.21 U	0.27 U	0.22 U
2/15/2007	0.21 U	0.27 U	0.22 U



INDOOR

	TCE	PCE	TCA
10/6/2006	0.21 UJ	0.27 UJ	0.22 UJ
11/6/2006	0.21 UJ	0.35	0.22 UJ
12/12/2006	0.21 U	0.27 U	0.22 U
1/11/2007	0.21 U	0.27 U	0.22 U
2/15/2007	0.21 U	0.27 U	0.22 U

SUBSLAB A

	TCE	PCE	TCA
10/6/2006	170	1.7 U	26
11/6/2006	200	1.7 U	38
12/12/2006	250	2.0 U	60
1/11/2007	210 D	1.4	60
2/15/2007	240	2.0 U	71
DUP 2/15/2007	160	1.1 U	48

SUBSLAB B

	TCE	PCE	TCA
10/6/2006	0.86 UJ	1.1 UJ	0.87 UJ
11/6/2006	0.86 UJ	1.1 UJ	0.87 UJ
12/12/2006	0.86 U	1.1 U	0.87 U
1/11/2007	0.91	1.4	0.87 U
2/15/2007	0.86 U	1.1 U	0.87 U

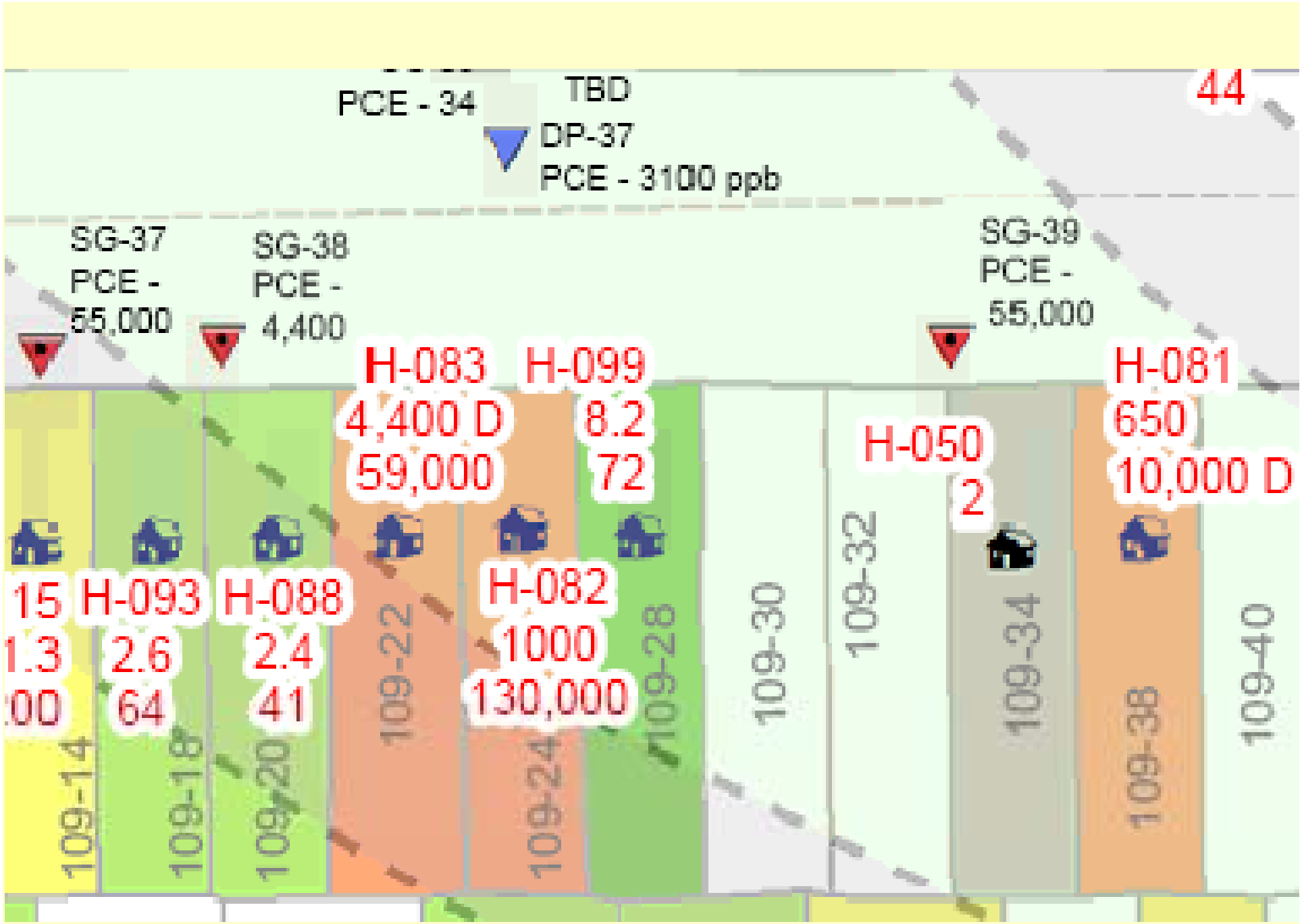
SUBSLAB C

	TCE	PCE	TCA
10/6/2006	110	2	20
11/6/2006	110	1.4 U	28
12/12/2006	97	1.1 U	31
DUP 12/12/2006	110	1.1 U	33
1/11/2007	70	1.1 U	24
2/15/2007	75	1.1 U	30

Bottom Line

- The J&E (and default assumptions) gets you in the ballpark, but it doesn't accurately portray what you might see at any given structure.
- The database illustrates the range of variability that you will need to address when making risk management decisions.

If you think that those data are noisy,
check this out!


PCE - 34
TBD
DP-37
PCE - 3100 ppb
44
SG-37
PCE -
55,000
SG-38
PCE -
4,400
SG-39
PCE -
55,000
H-083
4,400 D
59,000
H-099
8.2
72
H-050
2
H-081
650
10,000 D
15
1.3
00
H-093
2.6
64
H-088
2.4
41
H-082
1000
130,000
109-14
109-18
109-20
109-22
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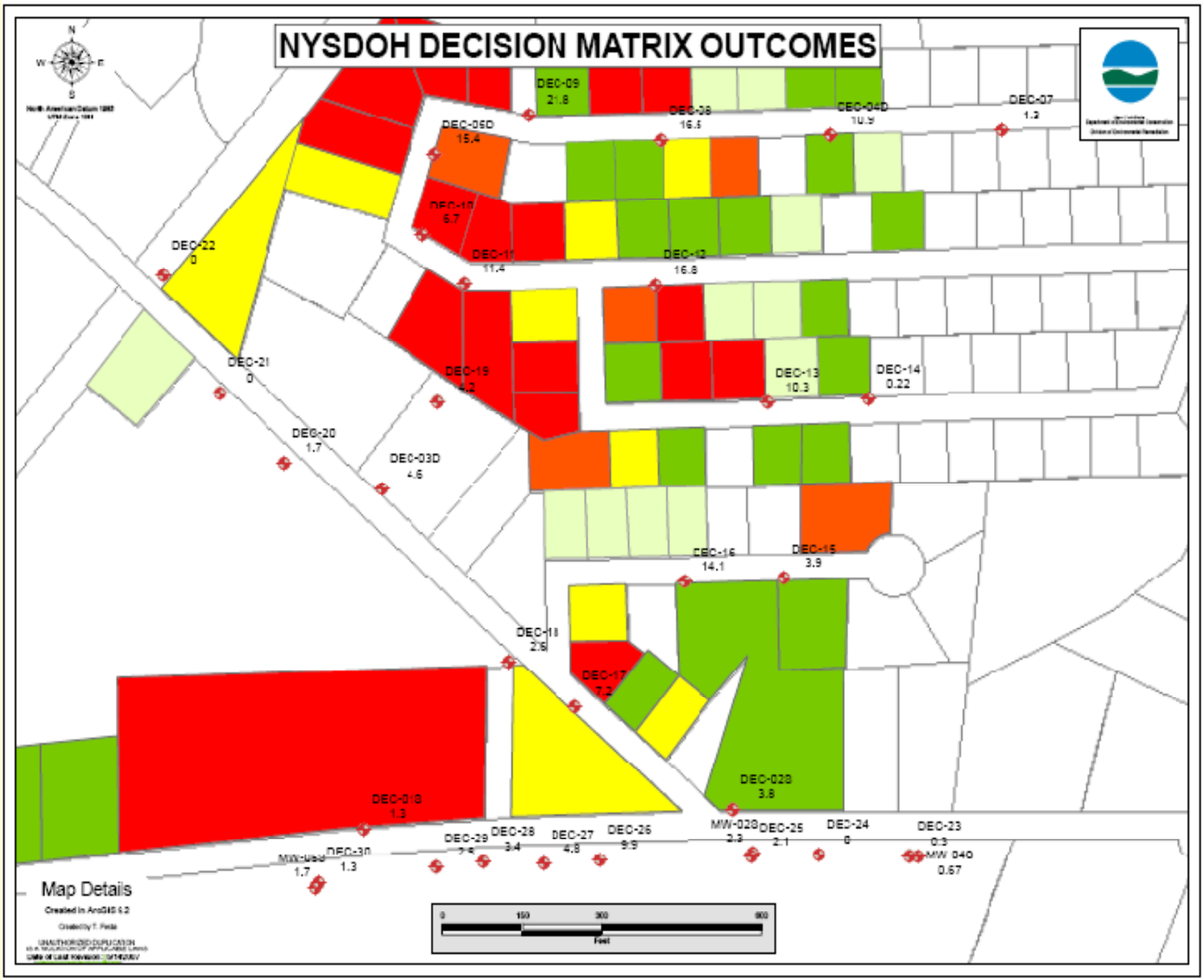
109-34
109-38
109-40

Putting It All Together
Using Multiple Lines of Evidence to Manage VI Risks


NYSDOH DECISION MATRIX OUTCOMES
DEC-09
21.8
DEC-08
16.5
DEC-07
1.2
DEC-05D
15.4
DEC-10
6.7
DEC-11
11.4
DEC-12
16.8
DEC-22
0
DEC-21
0
DEC-19
4.2
DEC-13
10.3
DEC-14
0.22
DEC-20
1.7
DEC-03D
4.6
DEC-16
14.1
DEC-15
3.9
DEC-18
2.6
DEC-17
7.2
DEC-02D
3.8
DEC-01D
1.3
DEC-30
1.3
DEC-29
DEC-28
3.4
DEC-27
4.8
DEC-26
MW-02B
2.3
DEC-25
2.1
DEC-24
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DEC-23
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MW-040
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Created in ArcGIS 9.2
Created by T. Peila
UNAUTHORIZED DUPLICATION
Date of Last Revision: 07/14/2007
0
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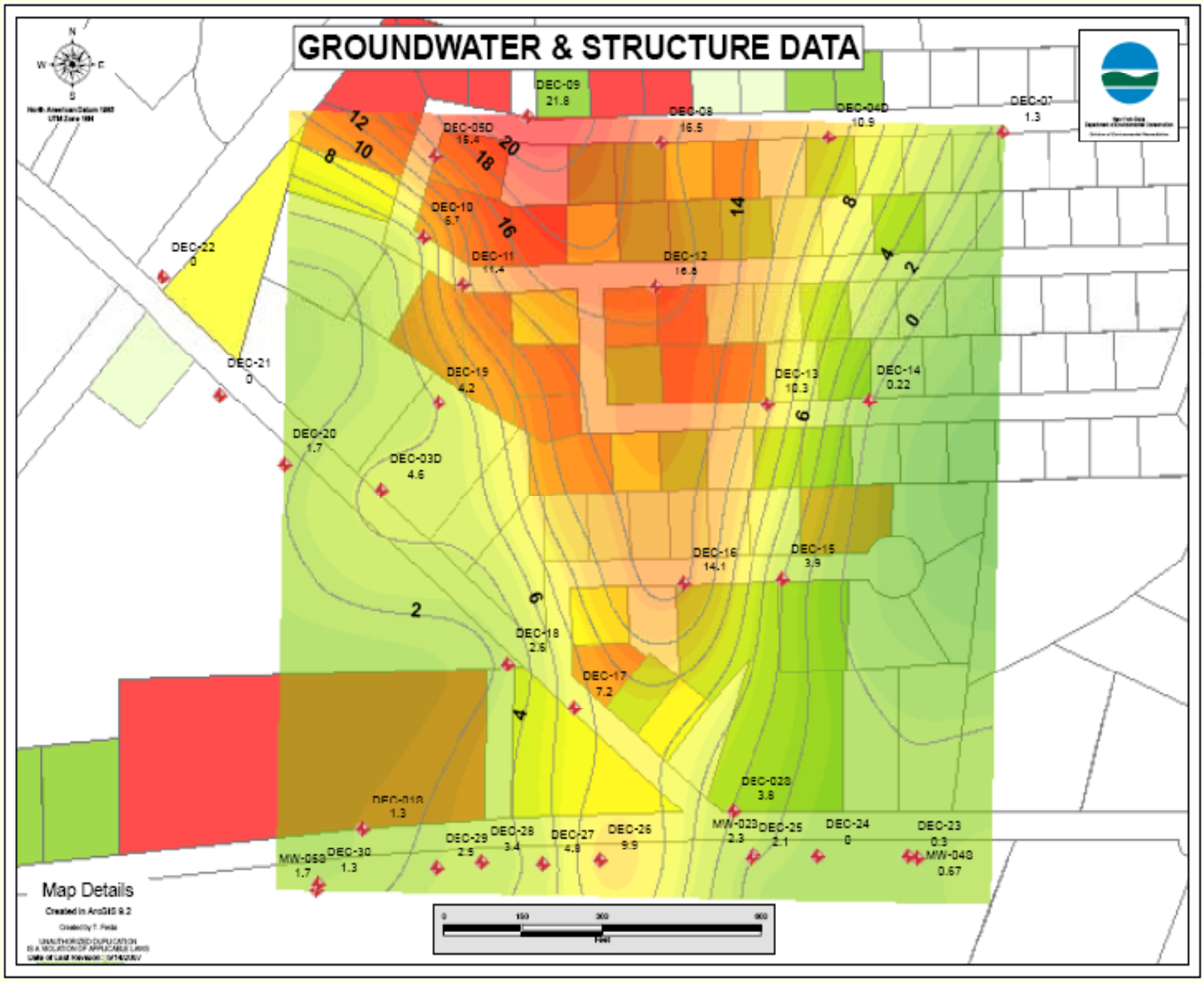
600
Feet


GROUNDWATER & STRUCTURE DATA
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DEC-04D
10.9
DEC-07
1.3
DEC-05D
15.4
DEC-10
6.7
DEC-11
11.4
DEC-12
16.8
DEC-22
0
DEC-21
0
DEC-19
4.2
DEC-13
10.3
DEC-14
0.22
DEC-20
1.7
DEC-03D
4.6
DEC-16
14.1
DEC-15
3.9
DEC-18
2.6
DEC-17
7.2
DEC-02D
3.8
DEC-01D
1.3
MW-05D
1.7
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1.3
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3.4
DEC-27
4.8
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9.9
MW-02D
2.3
DEC-25
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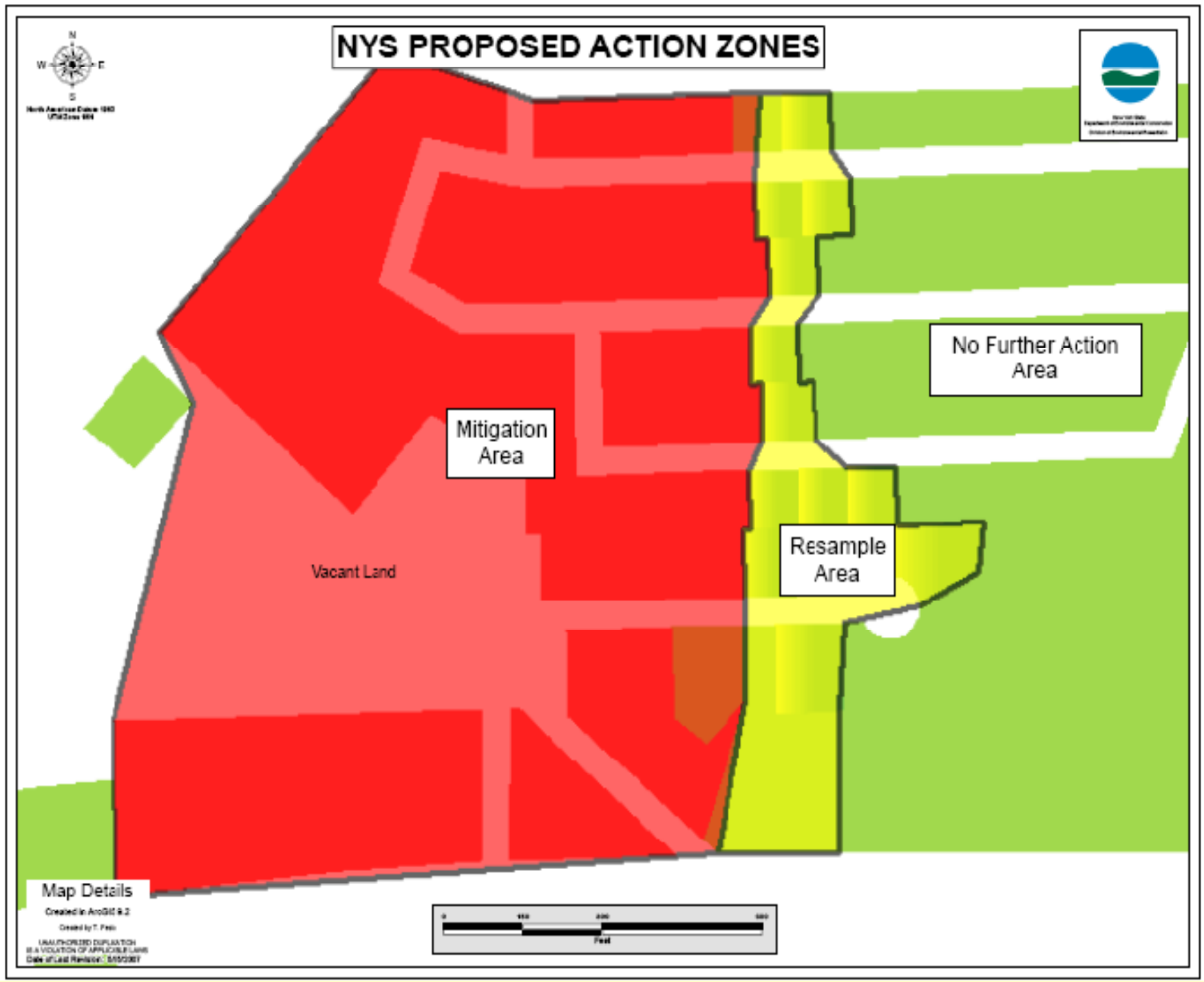
0
DEC-23
0.3
MW-04D
0.67
12
10
8
20
18
16
14
8
4
2
0
6
6
2
4
Map Details
Created in ArcGIS 9.2
UNAUTHORIZED DUPLICATION
IS A VIOLATION OF APPLICABLE LAWS
0
150
300
600
FEET


NYS PROPOSED ACTION ZONES
No Further Action Area
Mitigation Area
Resample Area
Vacant Land
Map Details

Now That You've Identified Which Structures to Mitigate,

How Do You Do It?

Mitigation objective

To minimize exposures associated with soil vapor intrusion

Methods of mitigation

Most effective mitigation methods involve

- sealing
- actively manipulating pressure differential between building's interior and exterior

Appropriate method depends on building design

- full basement or slab-on-grade
- crawlspace
- earthen floor
- multiple foundation types

Basement slab or slab-on-grade foundation

- sub-slab depressurization system (SSD)
  + sealing
- if shown to be not practicable,
  - HVAC modification
  - SVE system
  - other

Crawlspace foundation

- sub-membrane depressurization system (SMD) + sealing
- if shown to be not practicable,
  - HVAC modification
  - crawlspace ventilation + sealing
  - SVE system
  - other

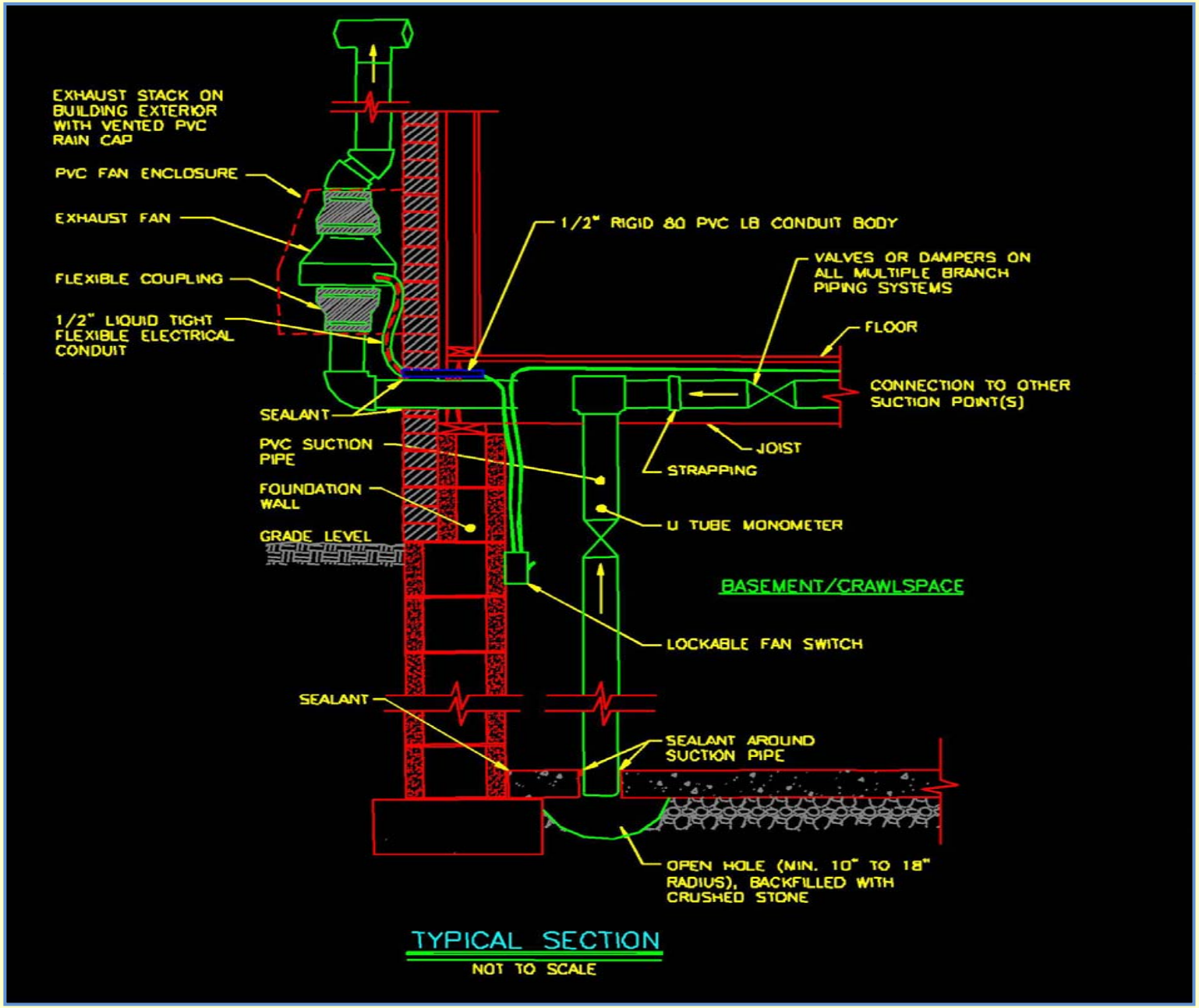
Basement with dirt floor

- new slab + SSD system — Preferred
- SMD system + vapor retarder

Multiple foundation types

- combination of the methods discussed

Example: SSD system -- Basement



Example: SSD system -- Basement

Typical Mitigation Costs for Homes

- $1600 - $2500 Simple SSD
- > $25,000 Complex Case


CHARD PARK


12.04.2006 12:24


homasote
Ultra/R
12.04.2006 17:02


12.05.2006 15:21

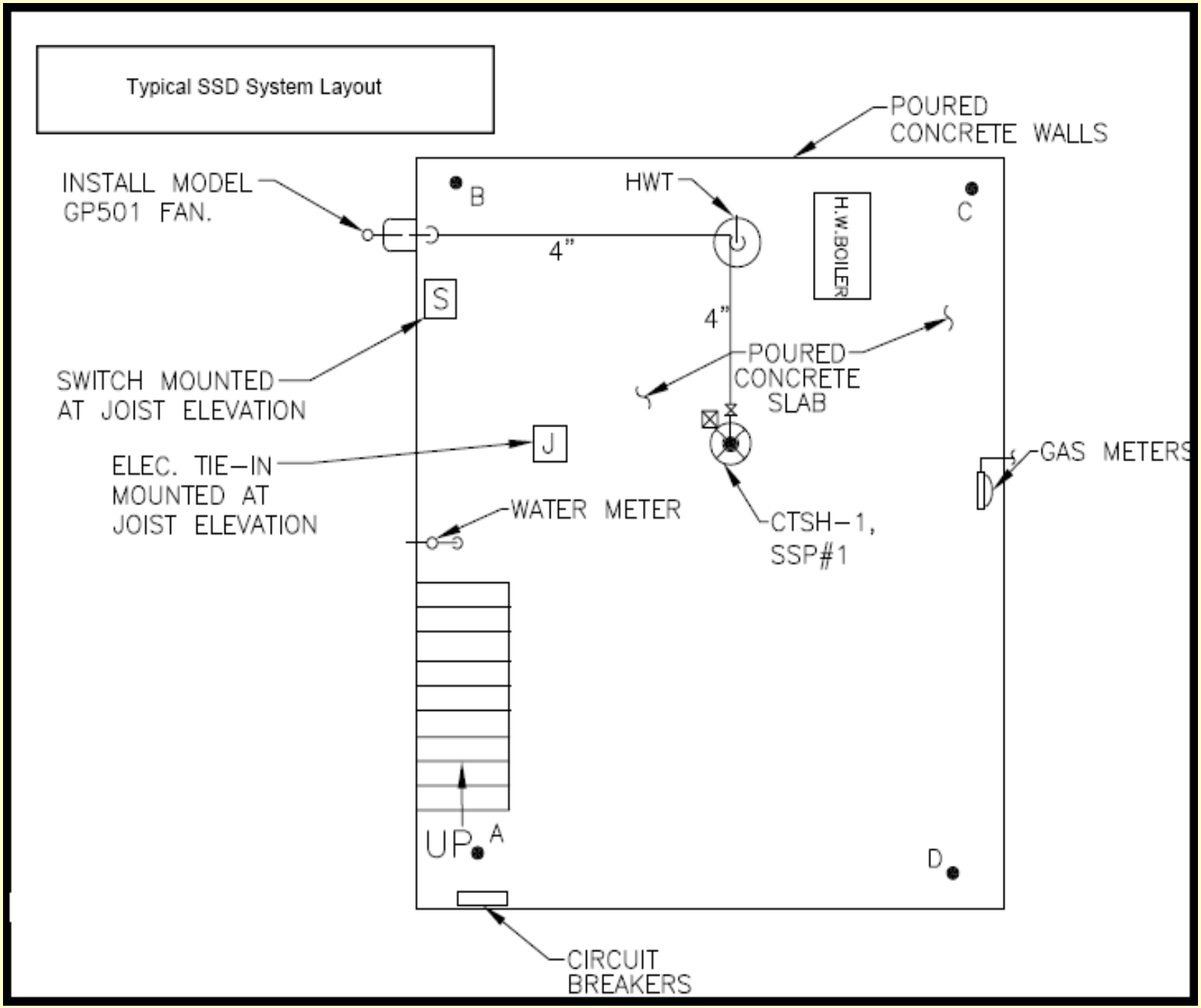

AdvanTech
AdvanTech
AdvanTech
AdvanTech

Verifying the Efficacy of the Mitigation Systems

- Physical Measurements
- Chemical Measurements

Physical Measurements

- Suction Point – Fan Operating Parameters
- Indoor/Substructure Pressure Differentials
- Smoke Testing – Visual Confirmation of Airflow
- Backdraft Test

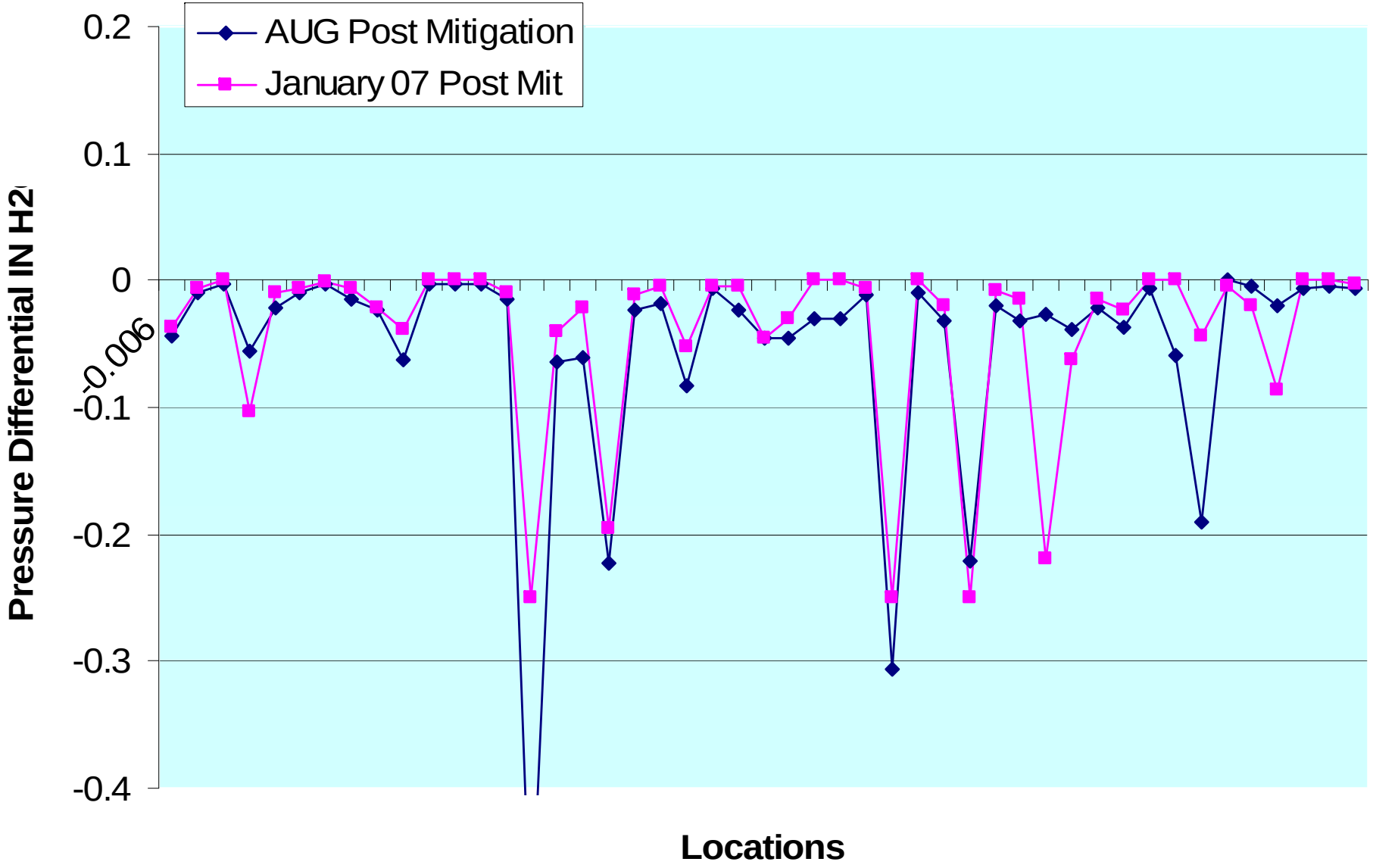

Typical SSD System Layout
POURED CONCRETE WALLS
INSTALL MODEL GP501 FAN.
B
HWT
C
H.W.BOILER
4"
S
4"
SWITCH MOUNTED AT JOIST ELEVATION
POURED CONCRETE SLAB
J
ELEC. TIE–IN MOUNTED AT JOIST ELEVATION
GAS METERS
WATER METER
CTSH–1, SSP#1
UP
A
D
CIRCUIT BREAKERS

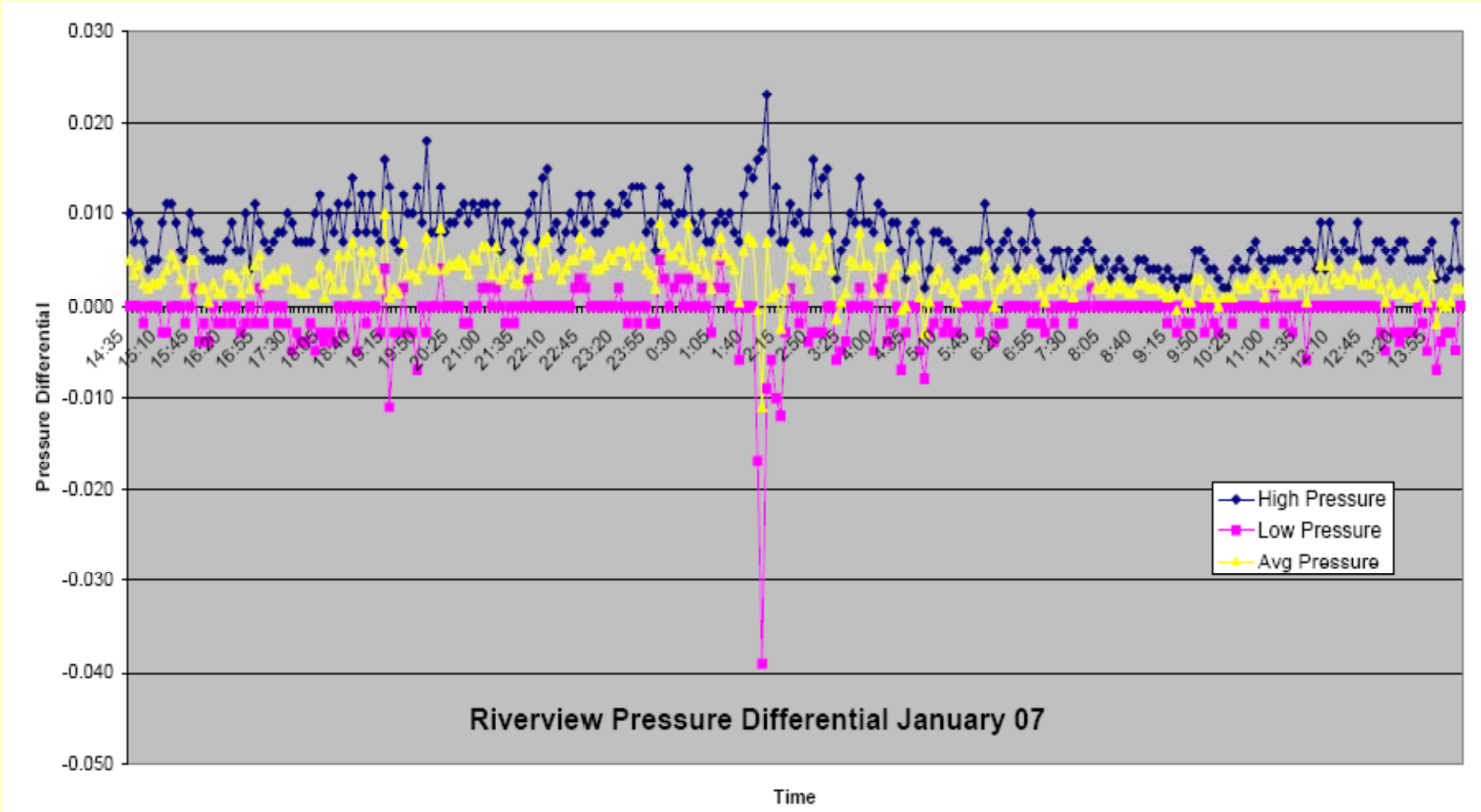
Example:

Manometer and labeling

Example: Communication testing

Post Mitigation PFE

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0.010
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
Pressure Differential
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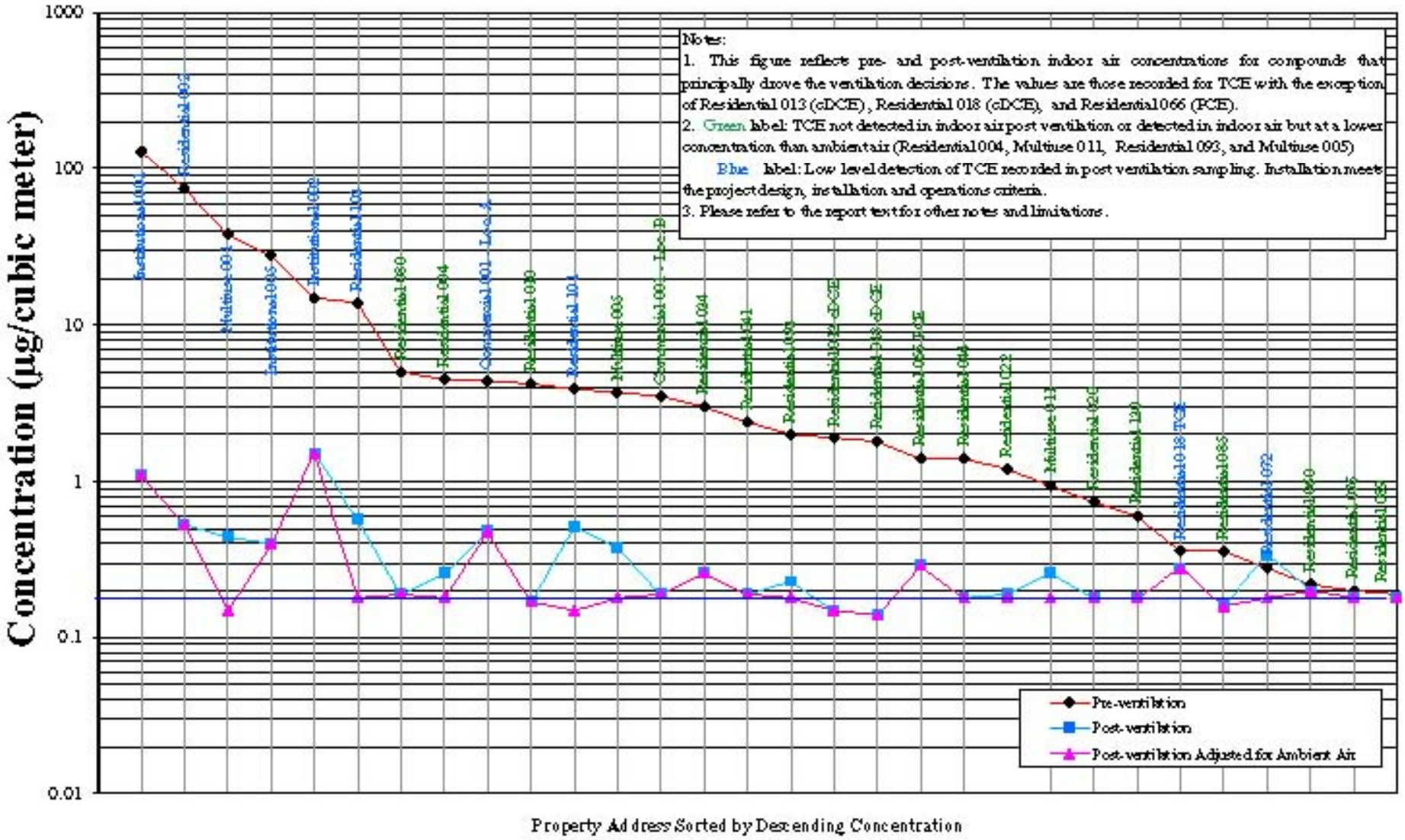
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
0:30
1:05
1:40
2:15
2:50
3:25
4:00
4:35
5:10
5:45
6:20
6:55
7:30
8:05
8:40
9:15
9:50
10:25
11:00
11:35
12:10
12:45
13:20
13:55
High Pressure
Low Pressure
Avg Pressure
Riverview Pressure Differential January 07
Time

Chemical Measurements

Post-Ventilation VOC Sampling

Pre & Post Mitigation Radon

Summary of Pre- and Post-Ventilation Indoor Air Data



PreMit_Radon	PostMit_Radon
6.6	1.4
22.5	0.3
4.8	1.6
8	2.5
0.4	0.6
11.5	0.6
4.4	1.3
13.9	1
8	2
7.4	2.8
10.7	9
TCE 8.1	4.9

Operation and Maintenance

OM&M Key Components

- Annual Communication
  - Properties with Systems
  - Properties without Systems
- Routine System Checks
  - ~ 18 months

OM&M Key Components

- Ensure ongoing system performance through appropriate system checks and maintenance
  - annual communication
  - system inspections ~18 months
- Provide timely response when problems or complaints arise (800 phone number)

OM&M Key Components

- Track and respond to need for new systems (vacant properties)
- Track and respond to need for system modifications (structural changes)

OM&M Key Components

- Track and respond to declines – annual letter (or new owner) with system offer
- Energy cost reimbursement program

Conclusion

Vapor Intrusion Exposures Require a Comprehensive Approach

Identify

Mitigate

Maintain

Monitor