



Volatilization to the Indoor Air Pathway “Moving Forward” November 8, 2017

**East and West Michigan Chapters of the AWMA and Environmental Law
Section of the State Bar of Michigan
Fall Joint Conference**

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Remediation and Redevelopment Division



Volatilization to the Indoor Air Pathway

A new Paradigm!



*A mind
is like a
parachute.*

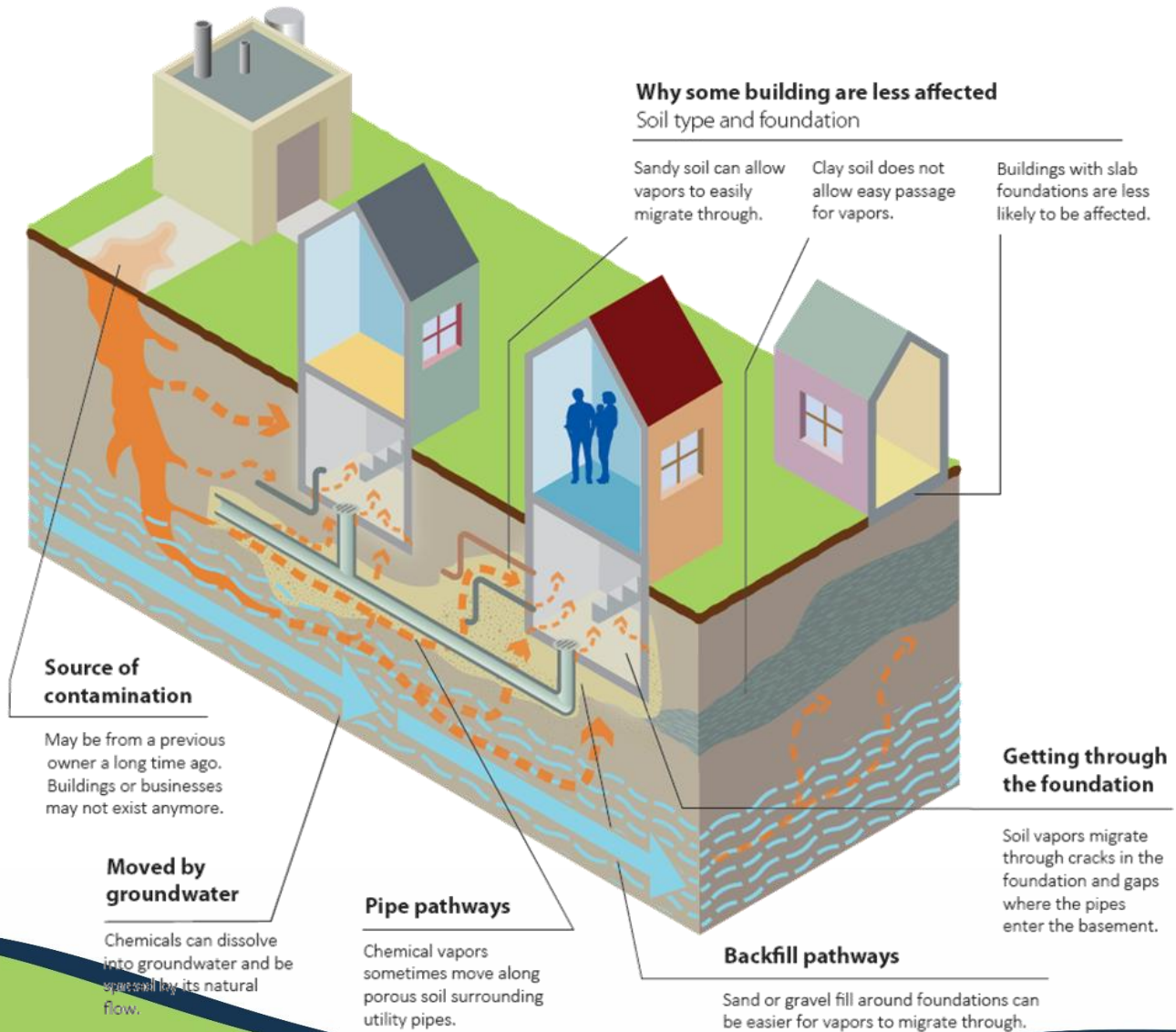
*It doesn't work
if it is not open.*

~ Frank Zappa



<http://www.flickr.com/photos/soldiersmediacenter/3532722761/>

Complex Pathway



Key Terms and Acronyms

- **VIAP** – Volatilization to the Indoor Air Pathway
- **VIAC** – Volatilization to the Indoor Air Criteria
- **VI** – Vapor Intrusion
- **CVI** – Chlorinated Vapor Intrusion
- **PVI** – Petroleum Vapor Intrusion
- **Vapor Source** – Means a hazardous substance in an environmental medium that may form vapors that have the potential to migrate.

Current Volatilization to Indoor Air Inhalation Criteria

- Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC)
 - R 299.14
- Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC)
 - R 299.24

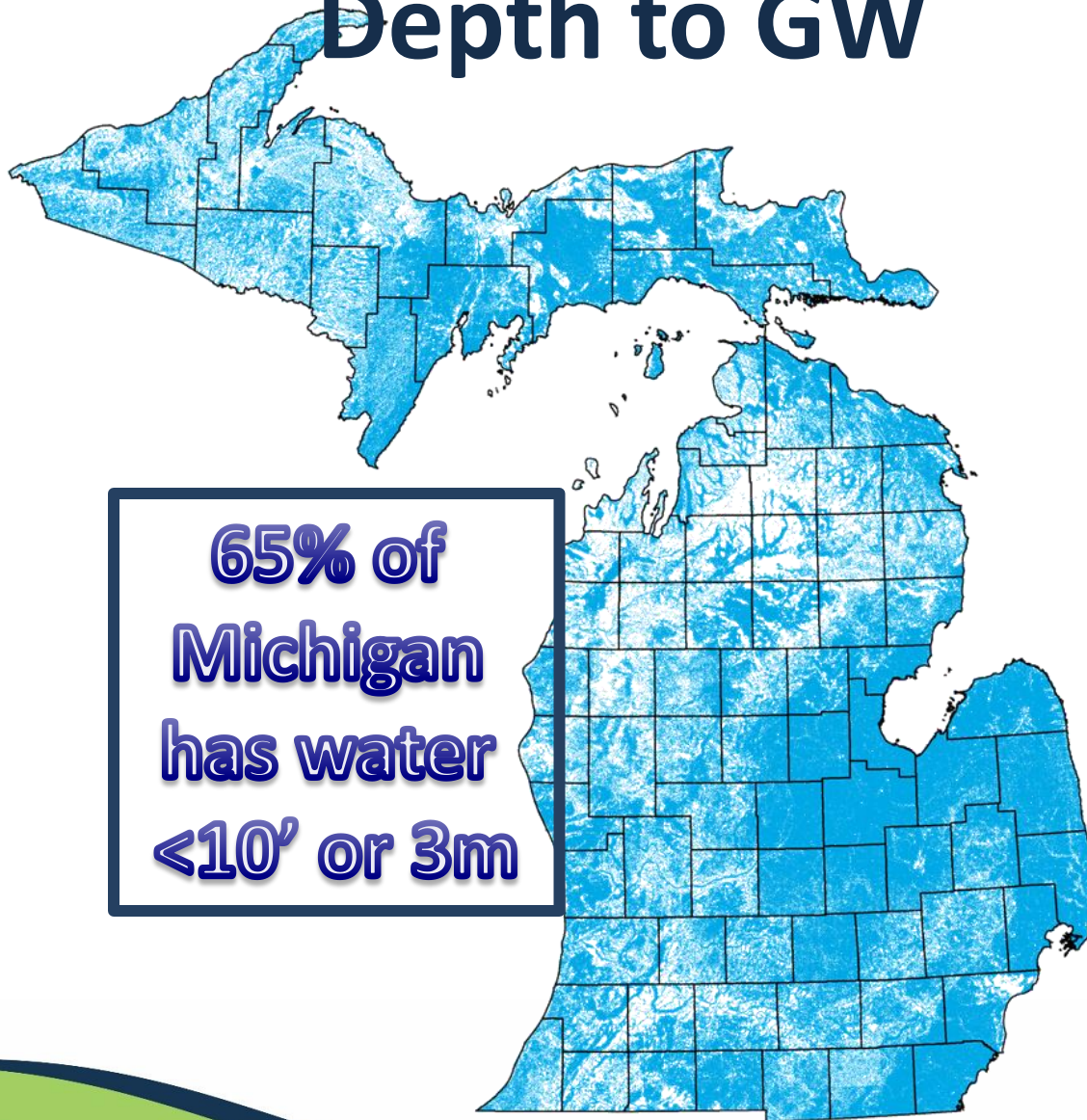
When GVIIC Do Not Apply

By Rule

- If any of the following conditions exist, the generic criteria shall not apply and a site specific evaluation shall be conducted:
 - There is a structure which ***does not have a concrete block or poured concrete floor and walls*** (future considerations as well)
 - The highest water table elevation, considering seasonal variation, ***is within three meters of the ground surface***
 - There is a ***sump present*** or other direct entry of contaminated groundwater into the basement

**Emphasis added*

Depth to GW



**65% of
Michigan
has water
<10' or 3m**

*Data from MSU
Extension 2015,
based on Public
Act 148 of 2003

When SVIIC Do Not Apply

By Rule

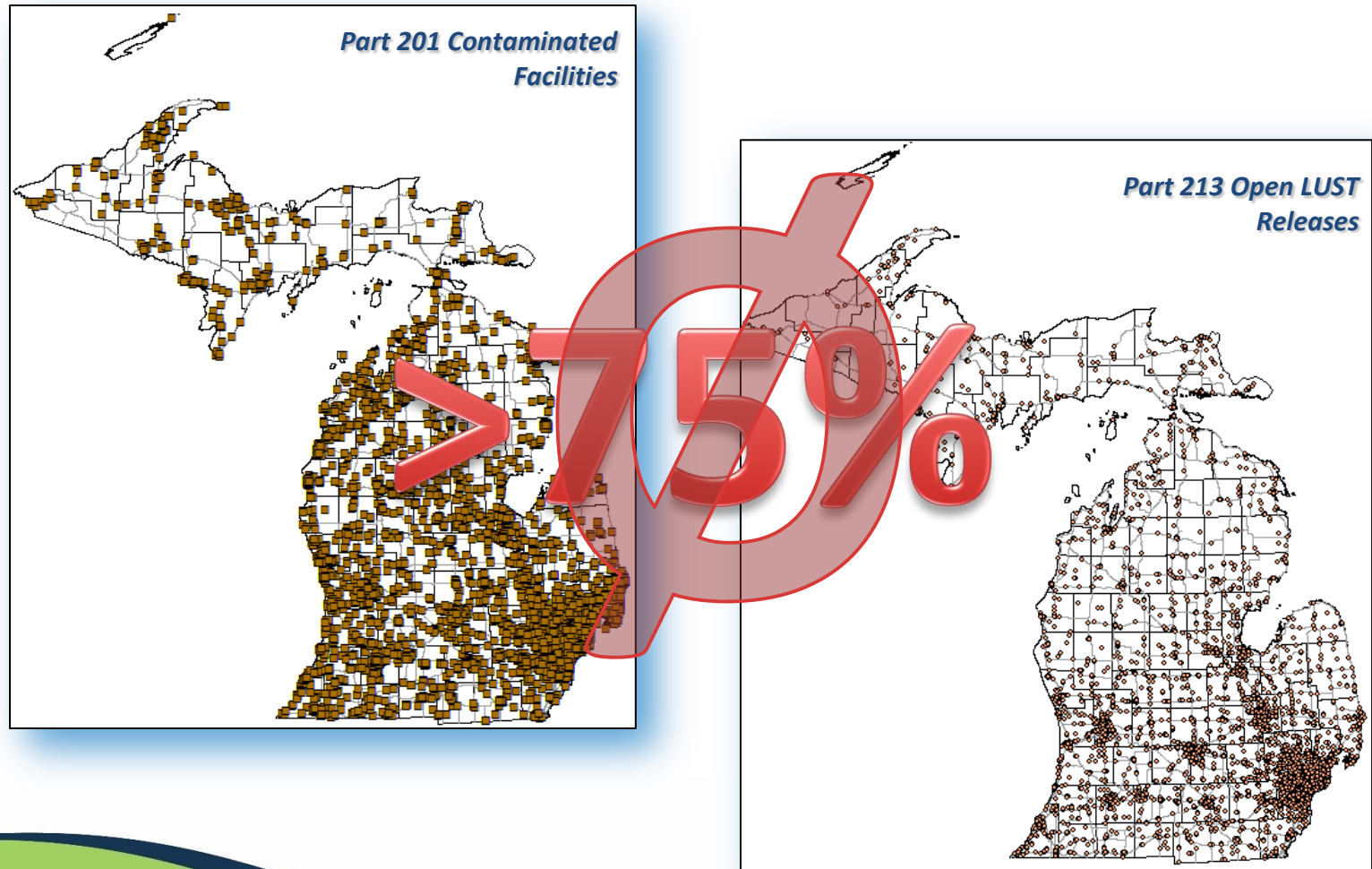
- If any of the following conditions exist, the generic criteria shall not apply and a site specific evaluation shall be conducted:
 - There is a structure which ***does not have a concrete block or poured concrete floor and walls*** (future considerations as well)
 - There is a ***sump present*** that is not completely isolated from the surrounding soil

**Emphasis added*

Other Considerations

- Also GVIIC and SVIIC do not apply when
 - May not be used for residual or free-phase light non-aqueous phase liquids (LNAPL and DNAPL)
 - Heterogeneous geologic materials and soil type
 - Large water table fluctuations
 - Other
- Often misapplied or used incorrectly
- Just meeting GVIIC and SVIIC may not be protective
- GVIIC and SVIIC are a poor predictors of an unacceptable risk

Current Application of GVIIC/SVIIC



Current Criteria

Summary

- GVIIC and SVIIC are the current criteria
 - Can use when they apply
- Current GVIIC and SVIIC (or the VIAC) often do not apply
 - Shallow groundwater (<3 meters)
 - May not apply to NAPL
 - Sumps
 - More

Current Criteria

Summary (cont.)

- No generic soil gas or vapor criteria
- Sites have observed that meeting GVIIC and SVIIC may not be protective of the indoor air
- GVIIC and SVIIC are a poor predictor of vapor migration

What is Site-Specific Criteria?

- Satisfy the requirements of section 20120b (and other applicable requirements)
- Need to better reflect the best available information concerning the toxicity or exposure risk posed by the hazardous substance or other factors
- Party proposing the action submits for DEQ review and approval
- Only way to get a vapor number

Site-Specific Criteria

- DEQ has assisted with over 273 site-specific requests since 5/18 when the generic criteria have not applied
- Submitted and reviewed alternate models
 - API's BioVapor Indoor Vapor Intrusion Model
 - AERMOD
 - Others

VIAP Site Screening Values

A Site-specific Approach

- Aligns with the methodology identified in the proposed rules as the best available science
 - Shallow groundwater, soil, and vapor
 - Initially developed for only 29 hazardous substances
 - Need limited site information
 - Considered protective for all uses
 - DEQ providing assistance using this methodology

VIAP Screening Values

CAS #	Hazardous Substance	Groundwater µg/L	Soil µg/kg	Vapor µg/m ³
67641	Acetone	50,000 (SE); st	2.6E+05 st	1.0E+06 st
7664417	Ammonia	1,900 (SE); st	NA	17,000 nc
71432	Benzene	1.0	50 (M);1.7 st	110

DEQ's Use of the Initial VIAP Site Screening Values

- State-funded site evaluations
- Brownfield program evaluations
- Evaluation of submitted reports
 - Establishes screening values when the generic criteria are not applicable
 - Not used to deny submittals if generic assumptions are applicable
 - Allows for the use of vapor data
 - If met, no further evaluation is necessary
 - If not met, state can provide site-specific criteria if requested, or party can develop their own site-specific criteria to determine if additional actions are needed

Evaluation Database

- Database supports:
 - Prioritizes potential VIAP sites
 - Prioritizes sites for notification to DHHS
 - Document resource needs
 - Document sites evaluated
- Includes sites that have undergone:
 - Site evaluation process
 - Site awareness DHHS
 - Site referral to DHHS

Process

Considers Things Like

Is someone working on the site?

Does the site contain hazardous substances?

What level of hazardous substance is there?

Are there people who may be more sensitive to an exposure present?

Are there receptors close by?

What kind of data is available?

Is the site well characterized?

Is the health department likely to be contacted?

Evaluation Data Base

Based on Data Through 11/6/2017

	Potentially High	Not Immediate or Unknown	Low or Unlikely to Occur	Total
TOTALS	159	136	117	412

1 of 4

Michigan Department of Environmental Quality
Remediation and Redevelopment Division
SCREENING FORM

FACILITY/SITE INFORMATION

Facility/Site ID: _____
Facility/Site Name: _____
Address: _____

City: _____
District: _____
County: _____
Latitude: _____
Longitude: _____

Screening Form Status: _____
Screening Form date: _____

Update to Screening Form date: _____
Revision to Screening Form date: _____
DEQ Project Manager Name: _____
Phone Number: _____
Facility/Site Status: _____
Age of Release: _____

Additional Regulatory Authority or Other: Part 201
date of last ATSDR consult: N/A

Ug/kg

50' 2006
100' 2003
40' 2003

2 of 4

Michigan Department of Environmental Quality
Remediation and Redevelopment Division
SCREENING FORM

Other: _____
able risk: Yes 19
Other: _____

Screening Values and Criteria

**Response
Action Levels**

**Interim
Action
Screening
Levels**

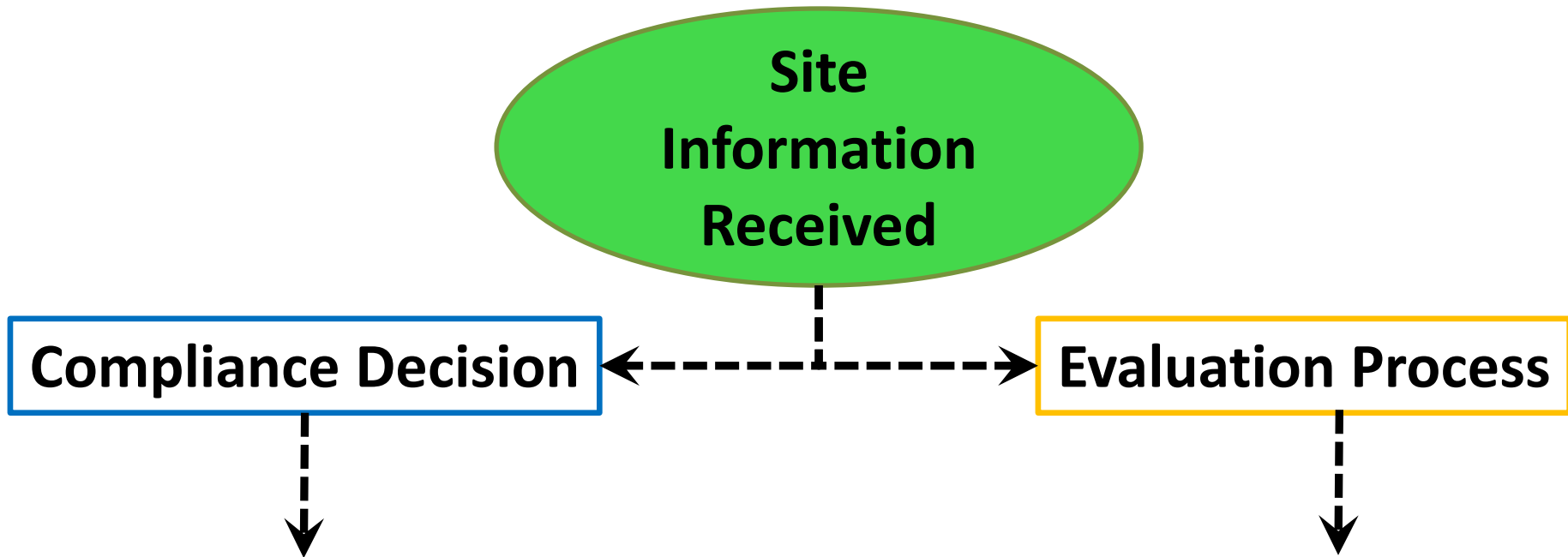
**Media
Specific
Screening
Values**

**VIAP Site
Screening
Values**

**Site-specific
Criteria**



Overview of the Process



DEQ and DHHS

Working Together, Working Cooperatively

- Similarities
 - Departments for the State of Michigan
 - Both are charged with protecting human health
- Differences
 - How we evaluate risk to human health
 - Long term potential risk vs current exposure
 - DEQ also addresses risk to the environment

Interim Action Screening Levels

“Evaluation Process”

- Collaboratively developed by DHHS and DEQ
- Used by DEQ, DHHS, and local health departments
- Media Specific:
 - Indoor Air,
 - Soil,
 - Groundwater, and
 - Vapor



MICHIGAN ASSOCIATION FOR LOCAL PUBLIC HEALTH

Interim Action Screening Levels

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY

Volatilization to Indoor Air
Recommendations for Interim Action Screening Levels and Time-Sensitive
Interim Action Screening Levels

Recommendations from the Toxics Steering Group
Volatilization to Indoor Air Workgroup
January 2017

Media-Specific Volatilization to Indoor Air Interim Action Screening Levels
August 2017

CAS #	Hazardous Substance	INDOOR AIR						SOIL VAPOR (INCLUDING SUBSLAB)					
		RES		NONRES		RES		NONRES		RES		NONRES	
		RIASL µg/m ³	TSRIASL µg/m ³	RIASL µg/m ³	TSRIASL µg/m ³	RIASL µg/m ³	TSRIASL µg/m ³	RIASL µg/m ³	TSRIASL µg/m ³	RIASL µg/m ³	TSRIASL µg/m ³	RIASL µg/m ³	TSRIASL µg/m ³
67641	Acetone	31,000	31,000	31,000	31,000	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
7664417	Ammonia	520	1,200	1,200	1,200	110	630	260	510	1,800	1,800	1,800	1,800
71432	Benzene	3.3	19.0	7.7	15	17,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
57749	Chlordane	0.20	0.20	0.28	0.56	6.7	6.7	9.3	19	19	19	19	19
108907	Chlorobenzene	52	160	77	150	480	1,700	5,200	2,600	5,100	15,000	15,000	15,000
75003	Chloroethane	4,200	13,000	6,100	12,000	36,000	1.4E+05	4.2E+05	2.0E+05	4.1E+05	1.2E+06	1.2E+06	1.2E+06
67663	Chloroform	1.1	11	2.6	5.2	52	37	370	87	170	1,700	1,700	1,700
74873	Chloromethane	94	280	140	280	410	3,100	9,400	4,600	9,200	14,000	14,000	14,000
541731	1,3-Dichlorobenzene	3.1	9.3	4.6	9.2	28	100	310	150	310	920	920	920
106467	1,4-Dichlorobenzene	6.5	65	15	30	300	220	2,200	510	1,000	10,000	10,000	10,000
75343	1,1-Dichloroethane	16	160	37	74	740	530	5,300	1,200	2,500	25,000	25,000	25,000
75354	1,1-Dichloroethylene	210	630	310	620	1,900	7,000	21,000	10,000	20,000	61,000	61,000	61,000
66592	cis-1,2-Dichloroethylene	8.3	25	12	24	72	280	830	410	820	2,500	2,500	2,500
605	trans-1,2-Dichloroethylene	270	790	790	790	790	9,000	26,000	26,000	26,000	26,000	26,000	26,000
67	Ethanol	19,000	19,000	19,000	19,000	19,000	6.3E+05	6.3E+05	6.3E+05	6.3E+05	6.3E+05	6.3E+05	6.3E+05
100	Ethylbenzene	10	100	24	48	480	340	3,400	800	1,600	16,000	16,000	16,000
110	n-Hexane	730	2,200	1,100	2,200	6,600	24,000	73,000	36,000	72,000	21E+05	21E+05	21E+05
7440	Mercury (total)	0.31	0.93	0.46	0.92	2.8	10	31	15	31	92	92	92
107	Hydrotect-butyl ether	98	980	230	460	4600	3300	33,000	7700	15,000	1.5E+05	1.5E+05	1.5E+05

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Interim Action Screening Levels

- Identifies indoor air concentrations for 29 hazardous substances
- Intended to assist with risk evaluation by:
 - Determining if potentially unsafe levels of contaminants are present in the indoor air
 - Determining whether interim action to reduce potential exposure is needed
 - If interim action is needed, assist in determining how quickly those actions should be completed

Interim Action Screening Levels

- More information check out the Listserv note dated August 07, 2017
 - *Release of Michigan Department of Environmental Quality (DEQ) Volatilization to Indoor Air Interim Action Screening Levels*



Use of the Interim Action Screening Levels

- DEQ:
 - Evaluation of sites for discussion and notification to DHHS
 - Interim response decisions
 - Emergency action decisions
- DHHS and Local Health Departments:
 - Evacuation decisions
 - Initial evaluation of whether people can stay in buildings until mitigation is completed
 - Initial evaluation of short/long term health considerations; education

Tiered Approach For the VIAP

Conceptual Site Model
(CSM)



VI Tier 1

Generic Screening Levels

VI Tier 2

Unrestricted Residential Criteria

VI Tier 3A

Generic Criteria

VI Tier 3B

Site-specific Criteria

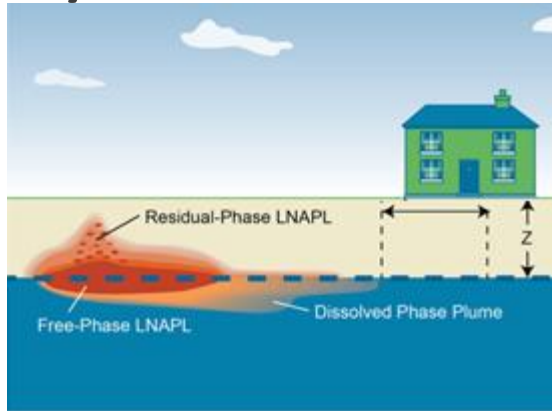
Degree of Uncertainty

Available Data

- Common in modern risk-based guidance
- Intended to promote:
 - Efficiency
 - Better characterization
- Other key features:
 - Ability to self implement through VI Tier 3A
 - Flexible

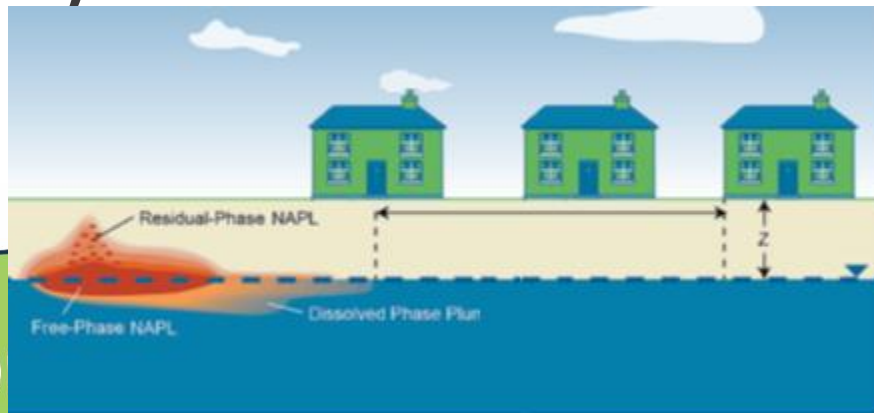
Lateral Inclusion Zone

Petroleum Vapor Intrusion (PVI) – 30'



- The horizontal distance beyond a vapor source that may make a property or structure vulnerable to the migration of vapors

Chlorinated Vapor Intrusion (CVI) – 100'



D

1st Step in the VI Tiered Approach

VI Tier 1

Generic Screening Levels



- Applicable to all sites with limited data and information
- If your samples meet the screening levels, you are done
- If concentrations exceed:
 - Go to VI Tier 2 or VI Tier 3A
 - Implement a response action and/or restriction(s)
 - “Site-specific” or VI Tier 3B

VI Tier 2

Unrestricted Residential Criteria

VI Tier 3A

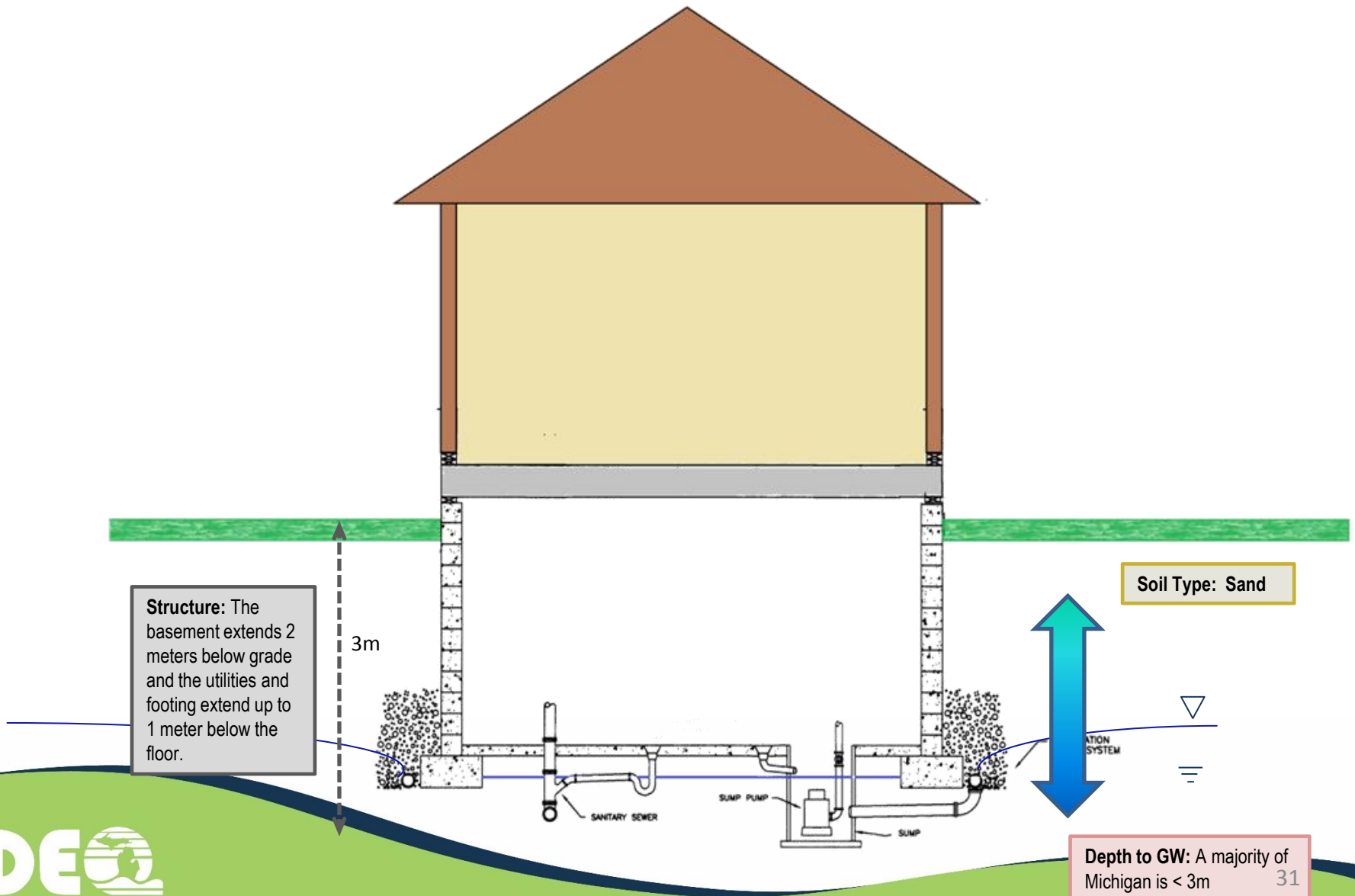
Generic Criteria

VI Tier 3B

Site-specific Criteria

***NOT FACILITY STATUS** – However, a person may use the screening level as the criterion to evaluate the pathway when limited or no information is available

VI Tier 1



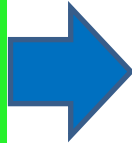
VI Tier 2 – Facility-specific Information

VI Tier 1

Generic Screening Levels

VI Tier 2

Unrestricted Residential Criteria



- Exceed the VI Tier 1
- Want to apply facility-specific inputs (including location)

AND

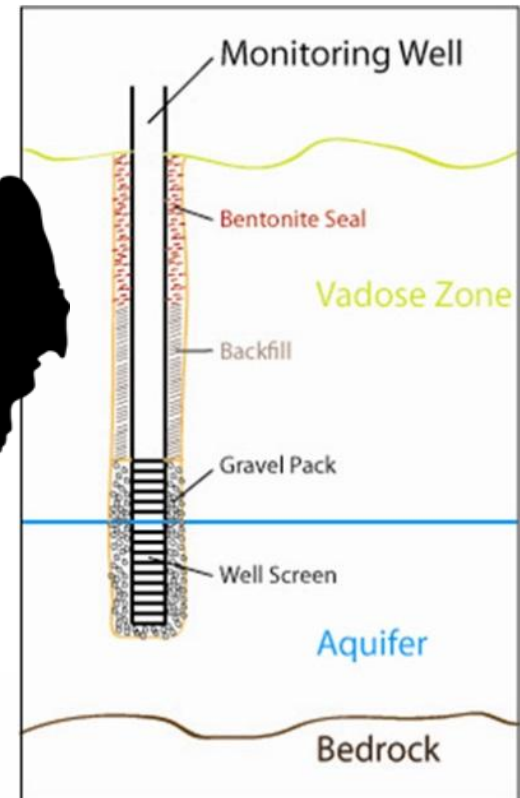
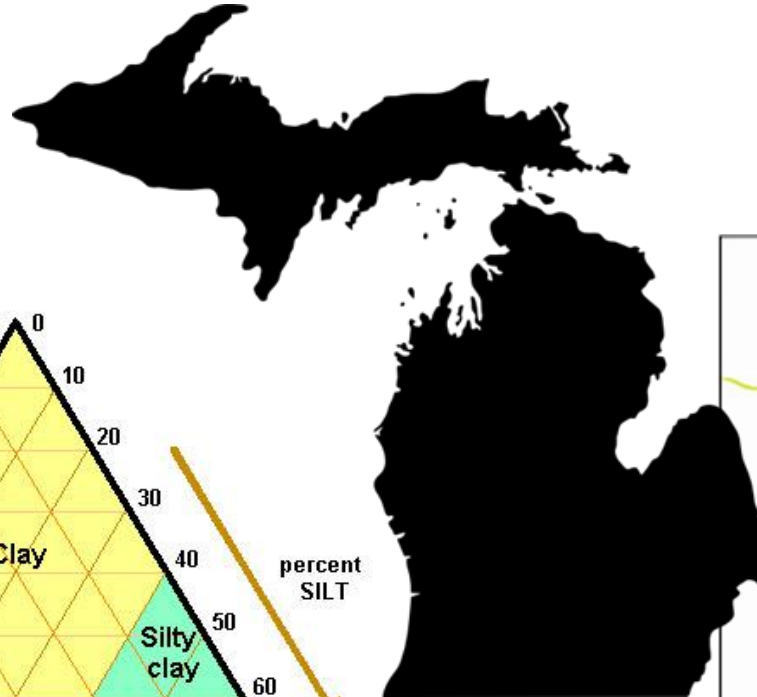
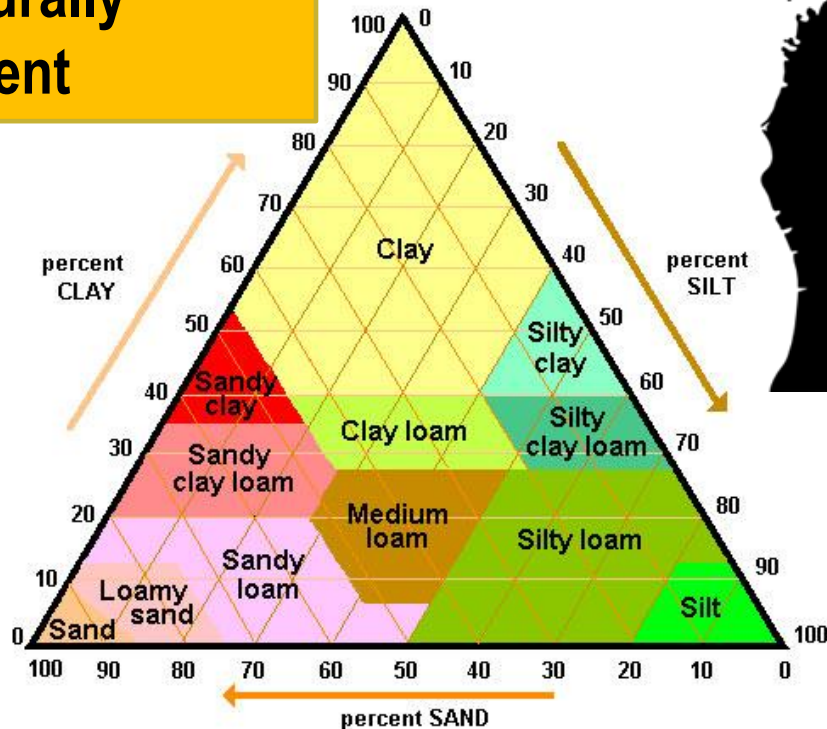
- The soil type is different

OR

- The depth to groundwater is greater than 3m

What is Facility-specific Information for VI Tier 2?

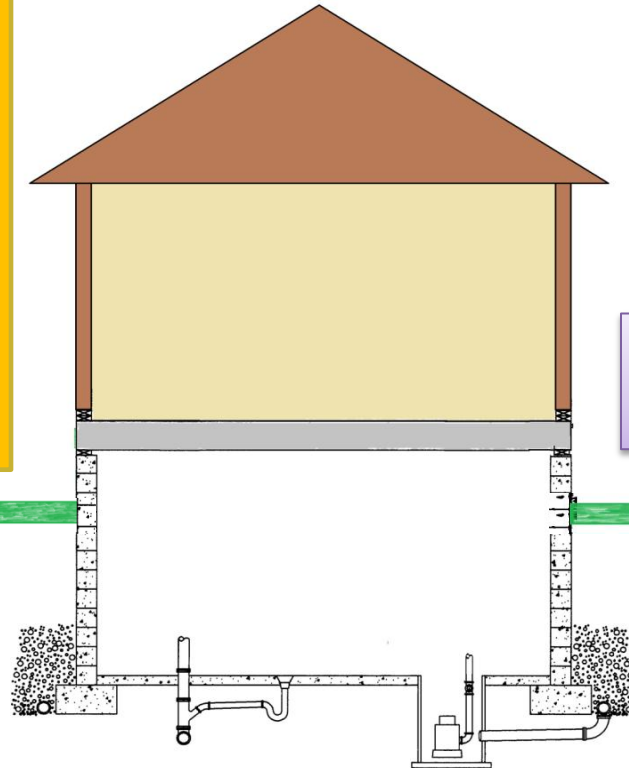
Modifications so that the site matches what is “naturally” present



VI Tier 2

Unrestricted Residential Criteria

Once the site matches what is “naturally” present, facility determination is made.



USDA Soil Classifications

Facility-specific inputs align a property with natural soil type, depth to groundwater, and location considerations

Soil Type: ??

Site Location:

Further north impacts the soil temp
Colder = Higher values

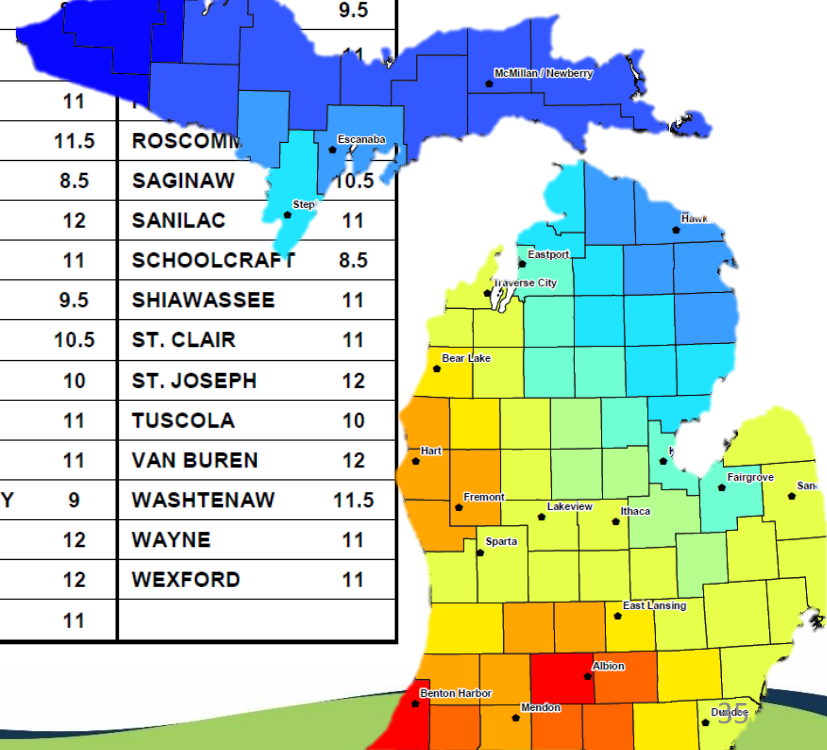
Depth to GW:

Sites with >3m depth to groundwater can evaluate deeper depths

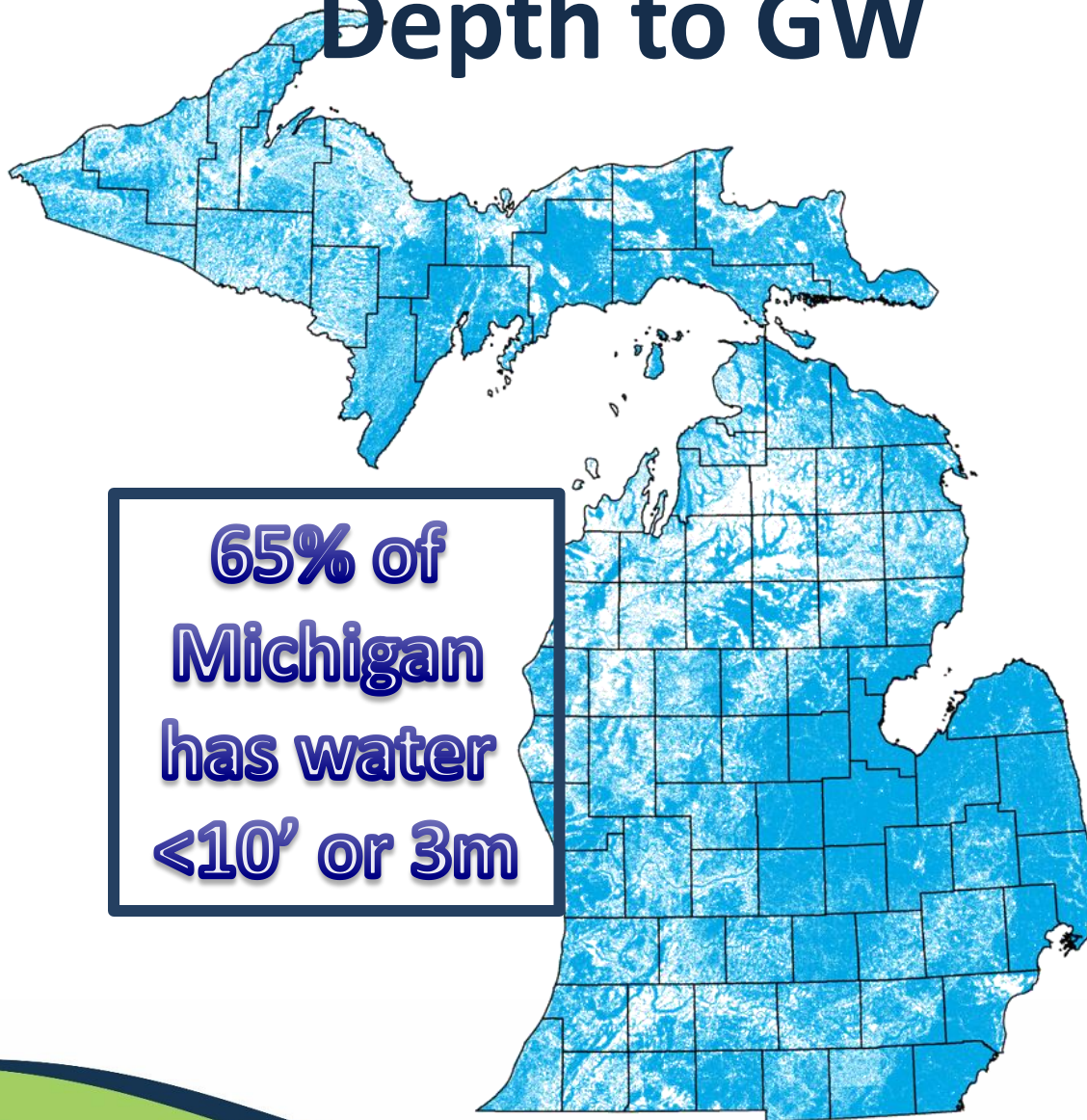
County Specific Temperature

Table 3
Facility Specific Temperatures by County (degrees Celsius)

County	Temp	County	Temp	County	Temp	County	Temp
ALCONA	9	DICKINSON	9	LAKE	11.5	OCEANA	12
ALGER	8.5	EATON	12	LAPEER	11	OSHEWA	9.5
ALLEGAN	11.5	EMMET	9.5	LEELANAU	11	ONTONAGON	8
ALPENA	9	GENESEE	10.5	LENAAWEE	11.5	OSCEOLA	11
ANTRIM	10	GLADWIN	10	LIVINGSTON	11	OSHTON	9.5
ARENAC	9.5	GOGEBIC	8	LUCE	9.5		
BARAGA	8.5	GRAND TRAVERSE	11	MACKINAC	11		
BARRY	12	GRATIOT	11	MACOMB	11		
BAY	10	HILLSDALE	12.5	MANISTEE	11.5	ROSCOMBE	10.5
BENZIE	11	HOUGHTON	8	MARQUETTE	8.5	SAGINAW	11
BERRIEN	13	HURON	11	MASON	12	SANILAC	11
BRANCH	12.5	INGHAM	11.5	MECOSTA	11	SCHOOLCRAFT	8.5
CALHOUN	13	IONIA	11	MENOMINEE	9.5	SHIAWASSEE	11
CASS	12.5	IOSCO	9.5	MIDLAND	10.5	ST. CLAIR	11
CHARLEVOIX	9.5	IRON	8.5	MISSAUKEE	10	ST. JOSEPH	12
CHEBOYGAN	9	ISABELLA	10.5	MONROE	11	TUSCOLA	10
CHIPPEWA	8.5	JACKSON	12.5	MONTCALM	11	VAN BUREN	12
CLARE	10.5	KALAMAZOO	12	MONTMORENCY	9	WASHTENAW	11.5
CLINTON	11	KALKASKA	10	MUSKEGON	12	WAYNE	11
CRAWFORD	9.5	KENT	11	NEWAYGO	12	WEXFORD	11
DELTA	9	KEWEENAW	8	OAKLAND	11		



Depth to GW



**65% of
Michigan
has water
<10' or 3m**

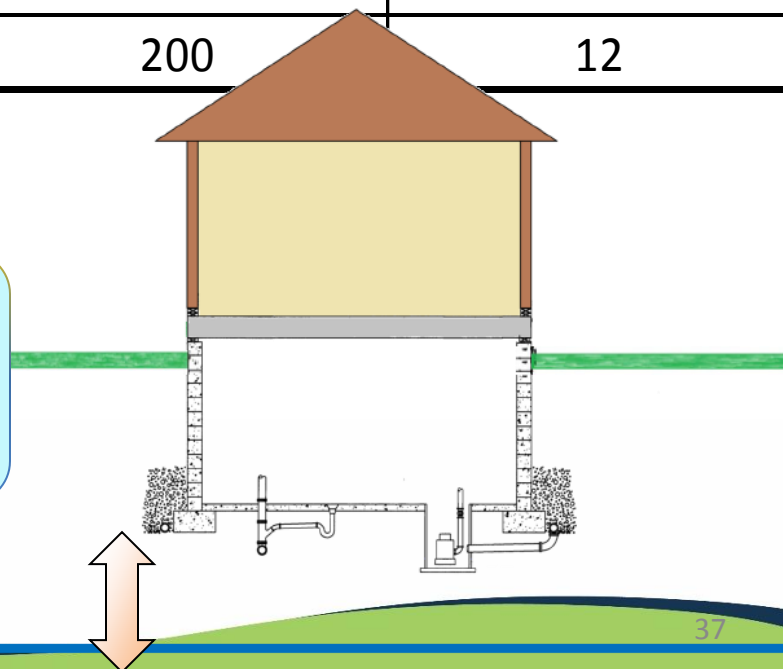
*Data from MSU
Extension 2015,
based on Public
Act 148 of 2003

Depth to Groundwater

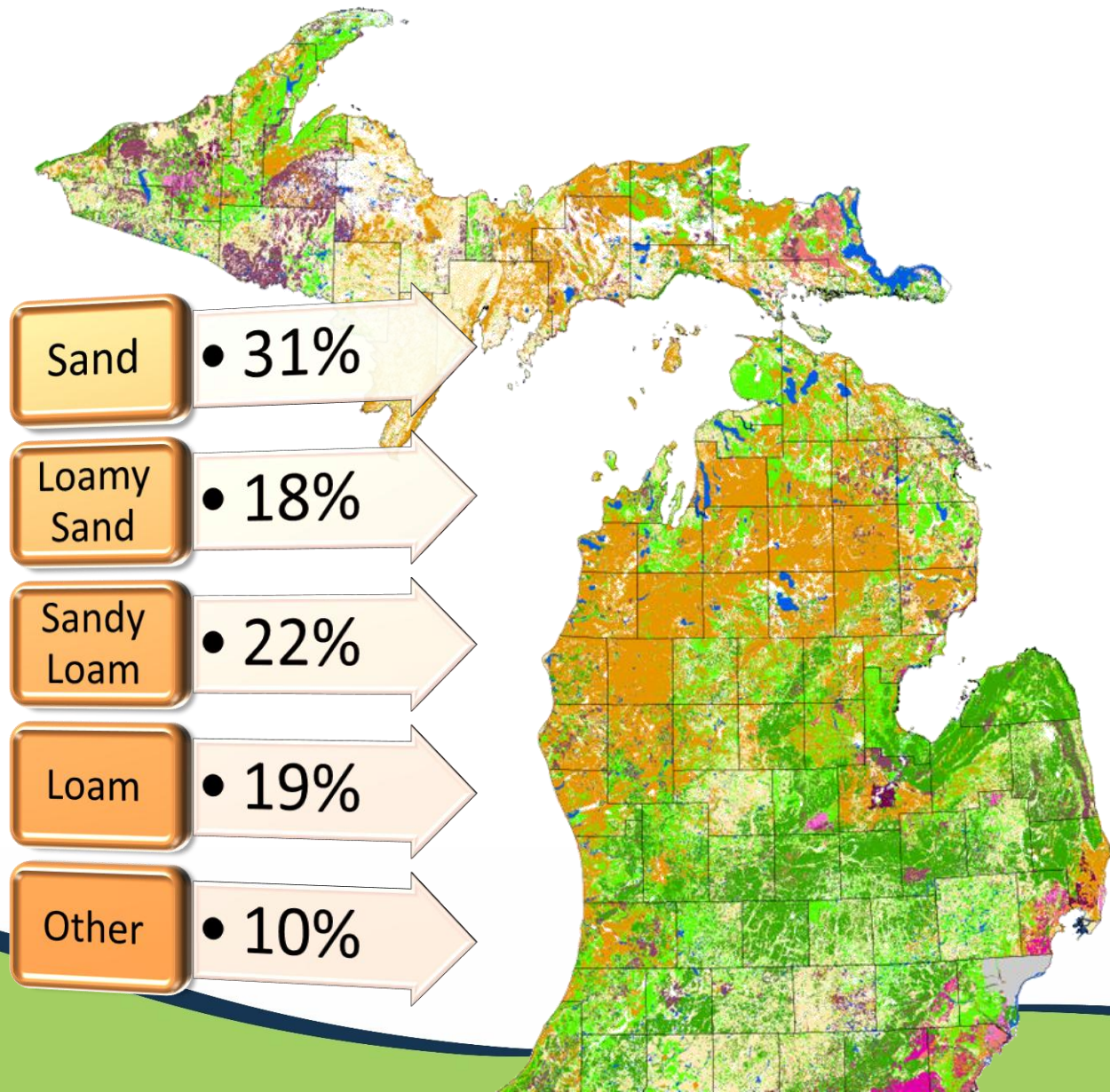
Single Parameter Sensitivity Analysis

Hazardous Substance	Benzene	Tetrachloroethylene	Trichloroethylene
CAS #	71432	127184	79016
Depth to GW	$\mu\text{g/L}$	$\mu\text{g/L}$	$\mu\text{g/L}$
<3m	1	1.5	0.073
Just >3.0m	14	96	6.1
5m	18	130	7.8
10m	27	200	12

Deeper the groundwater is,
the more a hazardous
substance is likely to diffuse
before entering a structure



USDA Soil Classifications



Soil-type Identifies the Parameters

TABLE 1.

Generic Input Values for United States Department of Agriculture (USDA) Soil Conservation Service Soil Textural Classifications

Soil Texture (USDA)	Soil Texture Abbreviation (USDA)	Soil Total Porosity ^{A,B} n (cm ³ /cm ³)	Saturated Water Content ^{A,C} θ_s (cm ³ /cm ³)	Residual Water Content ^{A,B} θ_r (cm ³ /cm ³)	Soil Water-Filled Porosity ^A θ_w (cm ³ /cm ³)	Soil Air-Filled Porosity ^{A,D} θ_a (cm ³ /cm ³)	van Genuchten parameters ^{A,B}			Mean Particle Diameter ^{A,E} (cm)	Dry Bulk Density ^{A,E} ρ_b (g/cm ³)	Saturated Hydraulic Conductivity ^A K_s (cm/h)
							α_1 (1/cm)	N	M			
Clay	C	0.459	0.459	0.098	0.215	0.244	0.01496	1.253	0.2019	0.0092	1.43	0.61
Clay loam	CL	0.442	0.442	0.079	0.168	0.274	0.01581	1.416	0.2938	0.016	1.48	0.34
Loam	L	0.399	0.399	0.061	0.148	0.251	0.01112	1.472	0.3207	0.02	1.59	0.5
Loamy sand	LS	0.39	0.39	0.049	0.076	0.314	0.03475	1.746	0.4273	0.04	1.62	4.38
Silt	SI	0.489	0.489	0.05	0.167	0.322	0.00658	1.679	0.4044	0.0046	1.35	1.82
Silty loam	SIL	0.439	0.439	0.065	0.18	0.259	0.00506	1.663	0.3987	0.011	1.49	0.76
Silty clay	SIC	0.481	0.481	0.111	0.216	0.265	0.01622	1.321	0.243	0.0039	1.38	0.4
Silty clay loam	SICL	0.482	0.482	0.09	0.198	0.284	0.00839	1.521	0.3425	0.0056	1.63	0.46
Sand	S	0.375	0.375	0.053	0.054	0.321	0.03524	3.177	0.6852	0.044	1.66	26.78
Sandy clay	SC	0.385	0.385	0.117	0.197	0.188	0.03342	1.208	0.1722	0.025	1.63	0.47
Sandy clay loam	SCL	0.384	0.384	0.063	0.146	0.238	0.02109	1.33	0.2481	0.029	1.63	0.55
Sandy loam	SL	0.387	0.387	0.039	0.103	0.284	0.02667	1.449	0.3099	0.03	1.62	1.6

A - From User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. United States Environmental Protection Agency, Office of Emergency and Remedial Response. February 22, 2004.

B - Hers, I. June 3, 2002 Technical Memorandum to Debbie Newberry, United States Environmental Protection Agency, Office of Solid Waste. Input Parameters for Office of Solid Waste and Emergency Response Wide Guidance for Vapor Intrusion Pathway.

C - Saturated water content is assumed to be equal to the water soil total porosity because the saturated water between drainage and wetting conditions varies but is always less than the fully saturated water content which is equal to the soil total porosity.

D - The air-filled porosity is calculated as the total porosity minus soil water-filled porosity.

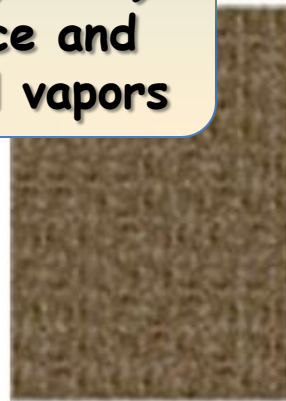
E - Nielson, K. K., and V. C. Rogers. 1990. Radon transport properties of soil classes for estimating indoor radon entry. In: F. T. Cross (ed), Proceedings of the 29th Hanford Symposium of Health and the Environment. Indoor Radon and Lung Cancer: Reality or Myth? Part 1. Battelle Press, Richland, Washington.

Soil Type

Single Parameter Sensitivity Analysis

Hazardous Substance	Benzene	Tetrachloroethylene	Trichloroethylene
CAS #	71432	127184	79016
UNITS	µg/kg	µg/kg	µg/kg
Sand	1.7	6.2	0.33
Loamy Sand	11	41	2.3
Sandy Loam	33	120	7.0
Loam	120	450	27

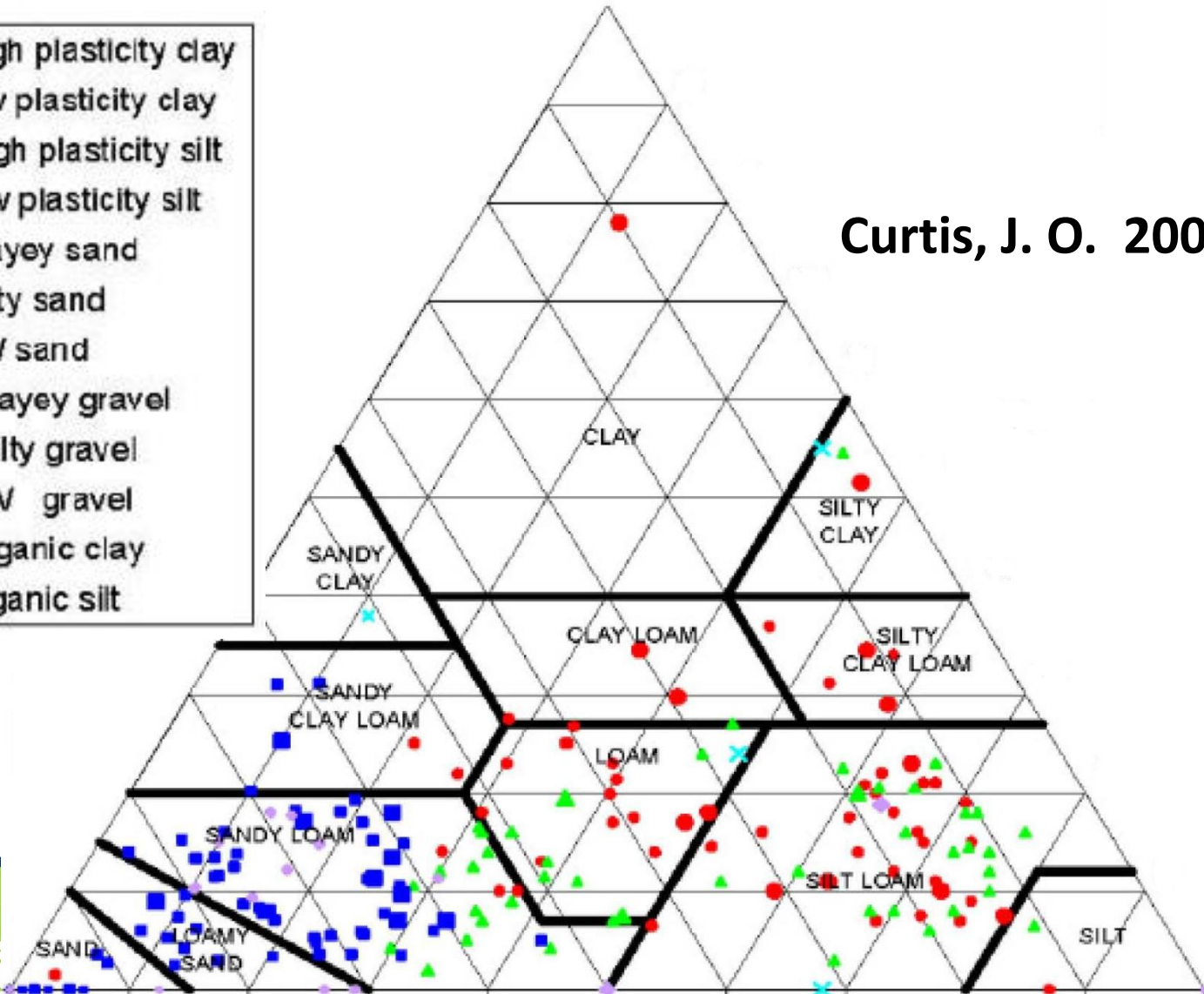
Larger particles (e.g., sand)
means more pore space and
easier migration of soil vapors



USDA vs USCS Comparison Study

- CH, high plasticity clay
- CL, low plasticity clay
- ▲ MH, high plasticity silt
- ▲ ML, low plasticity silt
- SC, clayey sand
- SM, silty sand
- SP, SW sand
- ◆ GC, clayey gravel
- ◆ GM, silty gravel
- ◆ GP, GW gravel
- ✕ OH organic clay
- ✕ OL organic silt

Curtis, J. O. 2005.

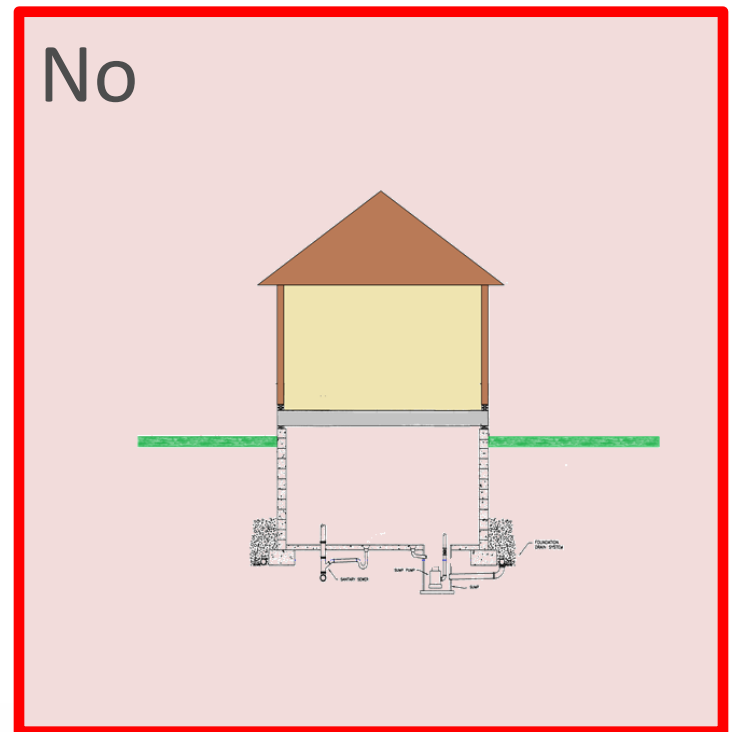
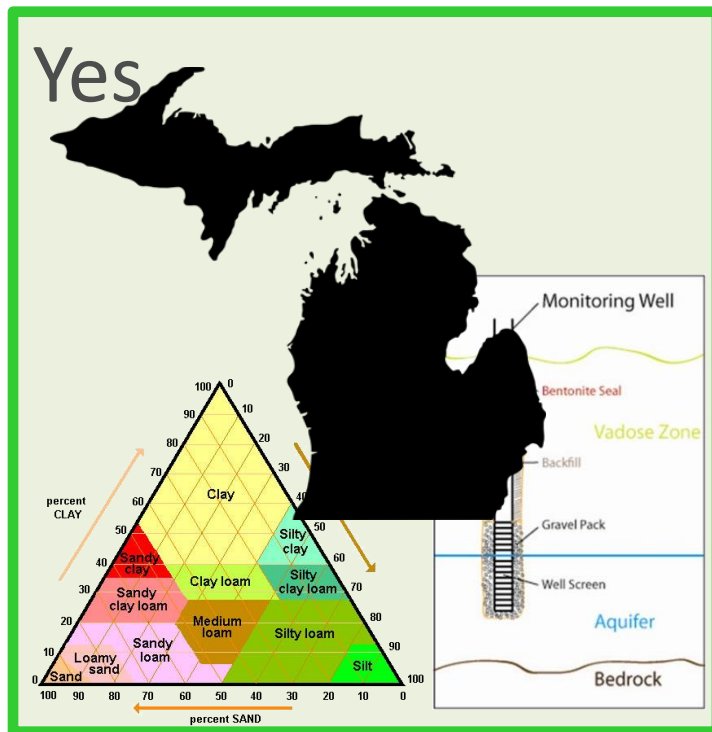


Use of Available Soil Information

- Though historic soil type information typically cannot be used; it can be very helpful
 - Provides a guide on the variation of soil types that can be expected
 - Complete an analysis of whether the collection of the USDA soil type matters prior to entering the field
 - Aid in guiding where to collect soil type information

VI Tier 2 in Review

- Unrestricted Residential Generic Criteria



VI Tier 3A

VI Tier 1

Generic Screening Levels

VI Tier 2

Unrestricted Residential Criteria

VI Tier 3A

Generic Criteria

VI Tier 3B

Site-specific Criteria

- Residential/Nonresidential
 - Exceed VI Tier 1 or VI Tier 2
- AND**
- Structure is not a residential house with a basement
 - Different foundation
 - Slab-on-grade
 - Uninhabitable basement
 - Different building
 - High-rise apartment (residential)
 - Former residential, now nonresidential
 - <50,000 square feet
 - >50,000 square feet
 - Both
 - Ability to self implement

VI Tier 3A



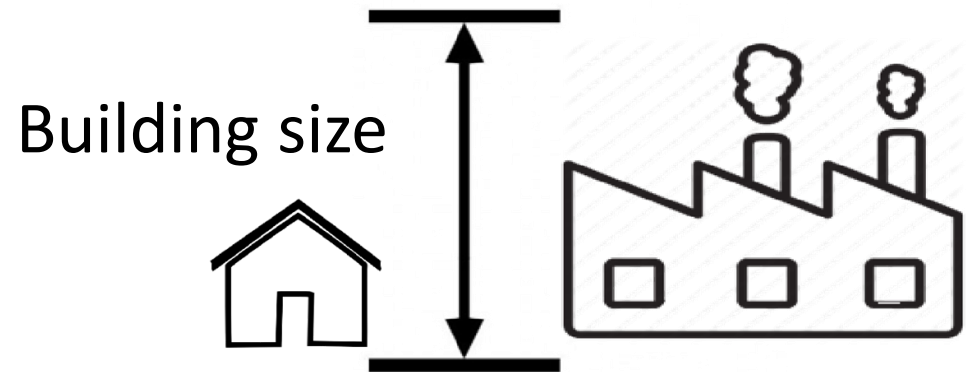
*Pictures from Wikimedia

Changes in VI Tier 3A

Air exchange rate



*Wikimedia, 2017

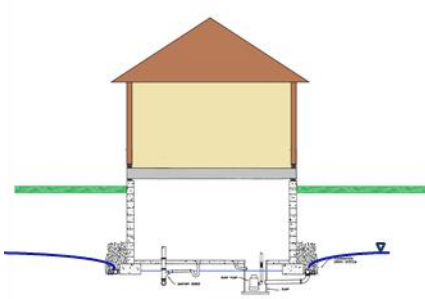


Building foundation

*Residential/Nonresidential

VI Tiered Process

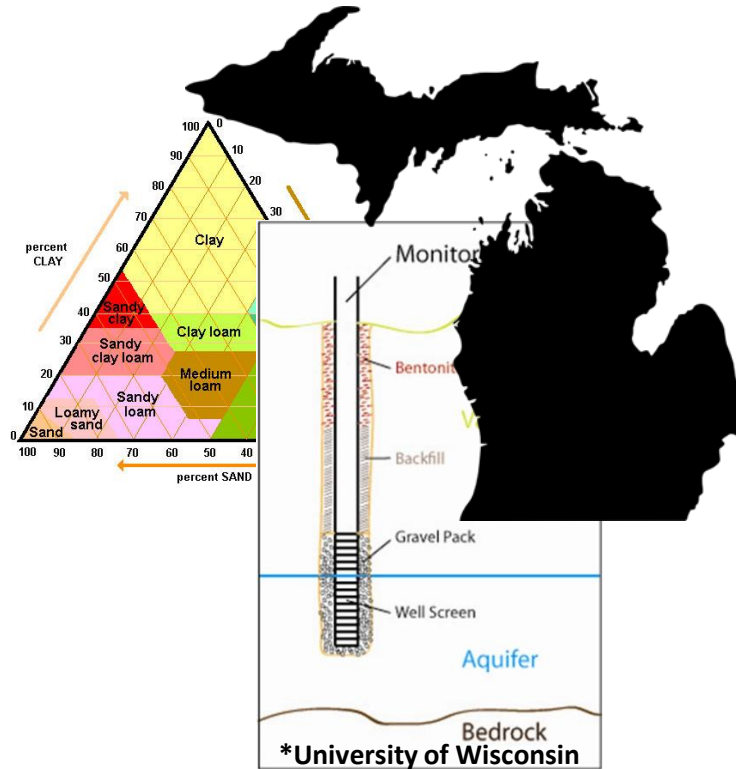
VI Tier 1



Generic Screening
Level

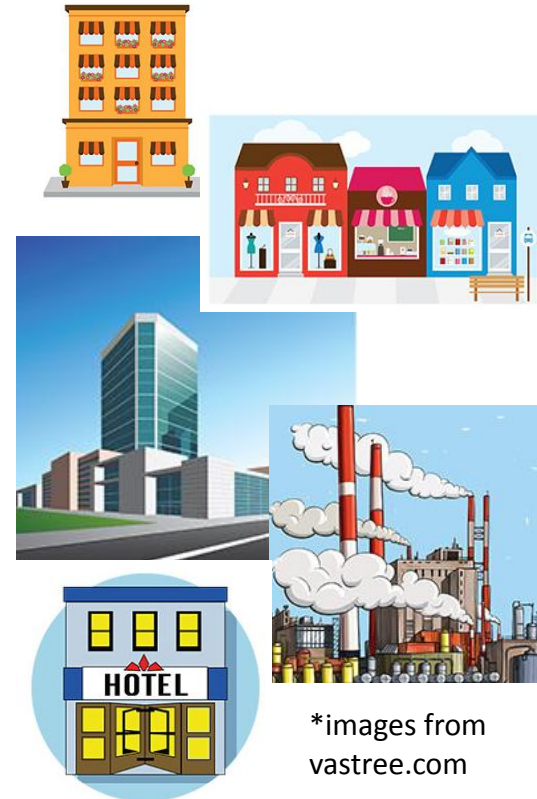


VI Tier 2



Facility-specific inputs
to establish
Generic Unrestricted
Residential Criteria

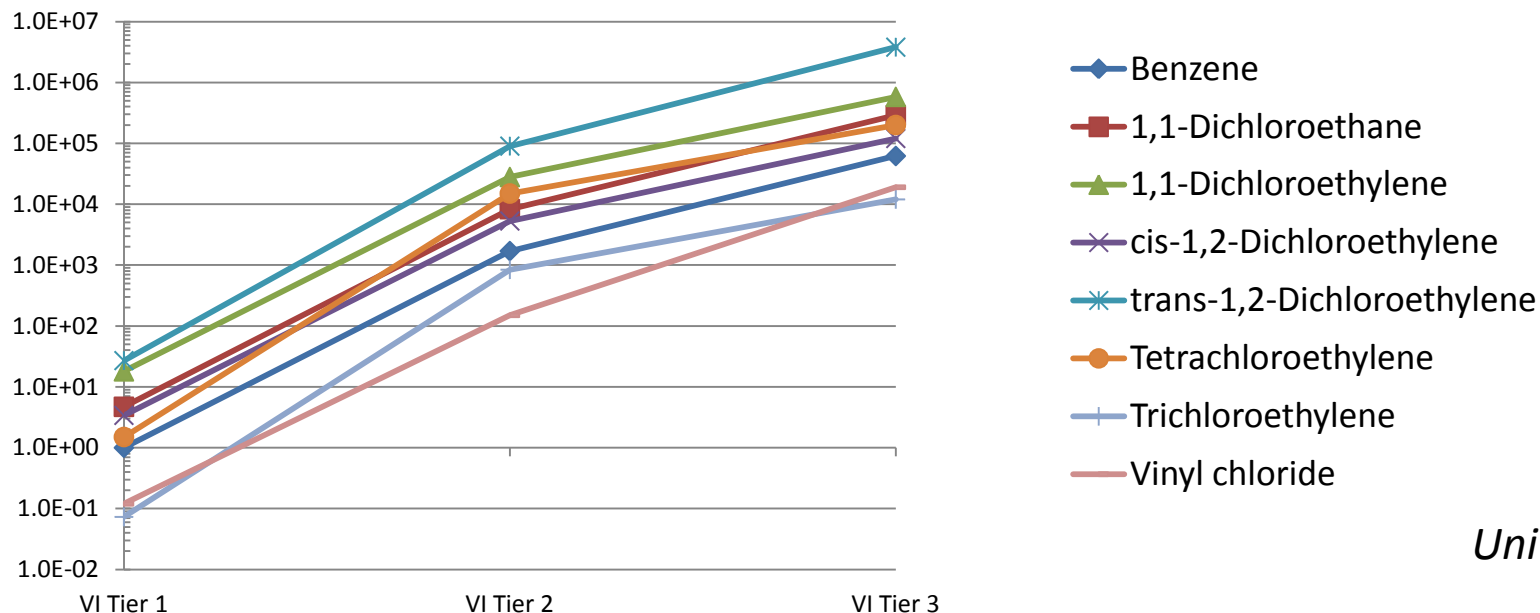
VI Tier 3A



Facility-specific inputs
to establish
Generic Restricted
Criteria

Values that Align with Site Conditions

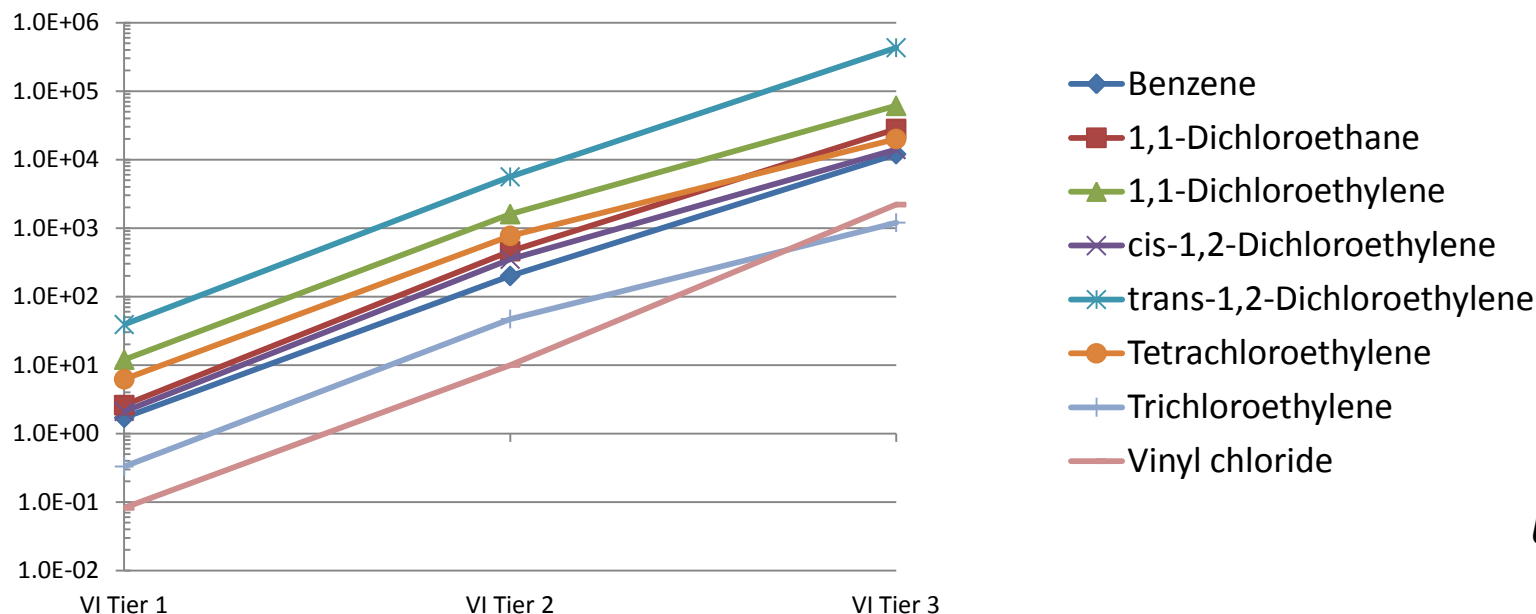
Groundwater



	Groundwater			
	Facility		Response Action	
Benzene	1	1,700	1	62,000
1,1-Dichloroethane	4.7	8,300	4.7	290,000
1,1-Dichloroethylene	18	28,000	18	580,000
cis-1,2-Dichloroethylene	3.4	5,300	3.4	120,000
trans-1,2-Dichloroethylene	27	90,000	27	3.80E+06
Tetrachloroethylene	1.5	15,000	1.5	200,000
Trichloroethylene	0.073	840	0.73	12,000
Vinyl chloride	0.12	150	0.12	19,000

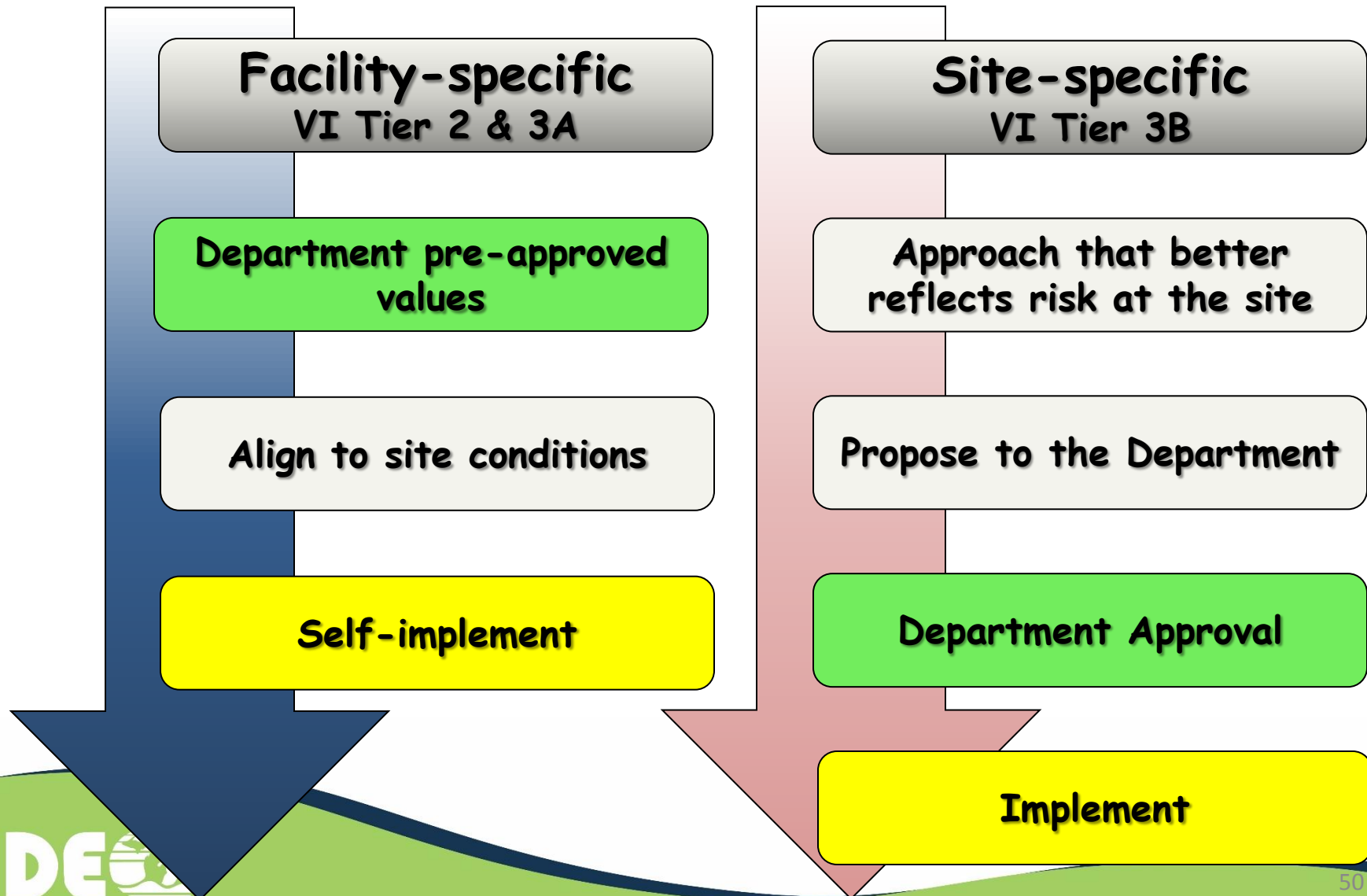
Values that Align with Site Conditions

Soil



	Soil			
	Facility		Response Action	
Benzene	1.7	200	1.7	12,000
1,1-Dichloroethane	2.6	460	2.6	28,000
1,1-Dichloroethylene	12	1,600	12	61,000
cis-1,2-Dichloroethylene	2.1	350	2.1	14,000
trans-1,2-Dichloroethylene	39	5,600	39	430,000
Tetrachloroethylene	6.2	770	6.2	20,000
Trichloroethylene	0.33	47	0.33	1,200
Vinyl chloride	0.082	10	0.082	2,200

Facility-specific vs Site-specific



VI Tier 3B - Site-Specific

VI Tier 1

Generic Screening Levels

VI Tier 2

Unrestricted Residential Criteria

VI Tier 3A

Generic Criteria

VI Tier 3B

Site-specific Criteria

- Optional – NOT a requirement
- Want to capture or consider:
 - Multiple soil types present
 - Different soil parameters
 - Greater air exchange
 - Alternate approach
 - Evaluating petroleum
 - Evaluating NAPL
 - New method or model
- Requires DEQ approval

Remediation and Redevelopment Division

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