An Evaluation of Soil Gas Results from Michigan, Indiana, and Ohio

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Presented today by Cheryl and Paul R.

SME

Discussion points

- **Study questions**
- **Projects included and data review process**
- **Review of TO15 detections**
- **Review of TO15 exceedances**
- **Evaluation of Vapor Intrusion (VI) Screening Levels (SLs) for soil and GW as indicators of soil gas impacts**
- **Conclusions**

Study questions

What were the range and average number of soil gas detections across all projects reviewed?

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Did it matter what type of site the samples were collected from?

Former gas station

Dry cleaner

Former manufacturing

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How often were compounds detected in soil gas as well as soil and GW?

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What were the range and average number of soil gas detections across all projects reviewed?

Did it matter which lab performed the analyses?

Did it matter what type of site the samples were collected from?

How often were soil gas SLs exceeded?

How often were compounds detected in soil gas as well as soil and GW?

Were soil and groundwater VI SLs indicators of soil gas impacts?

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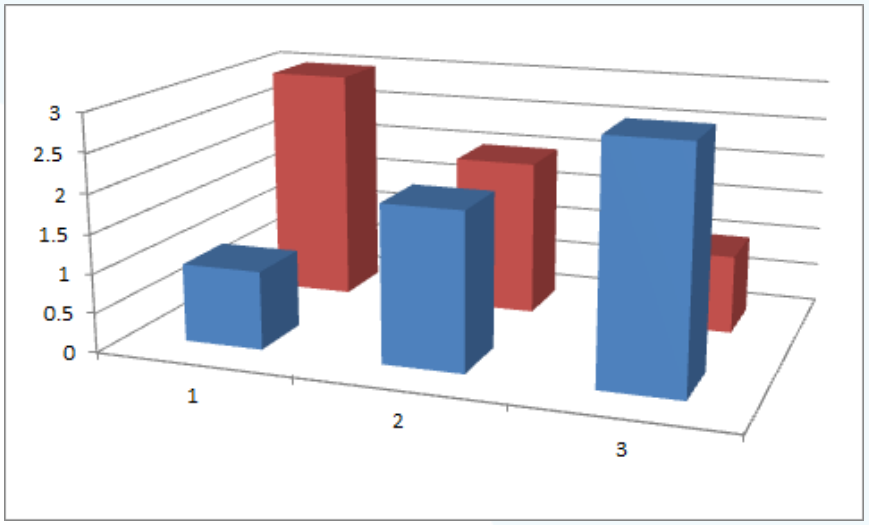
Quick note…



Looking at multiple projects and comparing data between them

Data review across multiple projects

33 qualified projects

Began with ~ 45 projects

"Qualifying" criteria:

Full TO-15 list

Full VOC list for soil/GW

Limited elevated RLs for most of the dataset

Ended up with 33 projects

27 with soil, GW, and soil gas results

1 project w/ no soil data

5 projects w/ no GW data

Data review across multiple projects

33 qualified projects

Hundreds of soil gas samples

Data review across multiple projects

33 qualified projects

Hundreds of soil gas samples

3 states

13 projects in Michigan
14 projects in Indiana
6 projects in Ohio

Many EPA & CMI

Data review across multiple projects

33 qualified projects

Hundreds of soil gas samples

3 states

3 labs

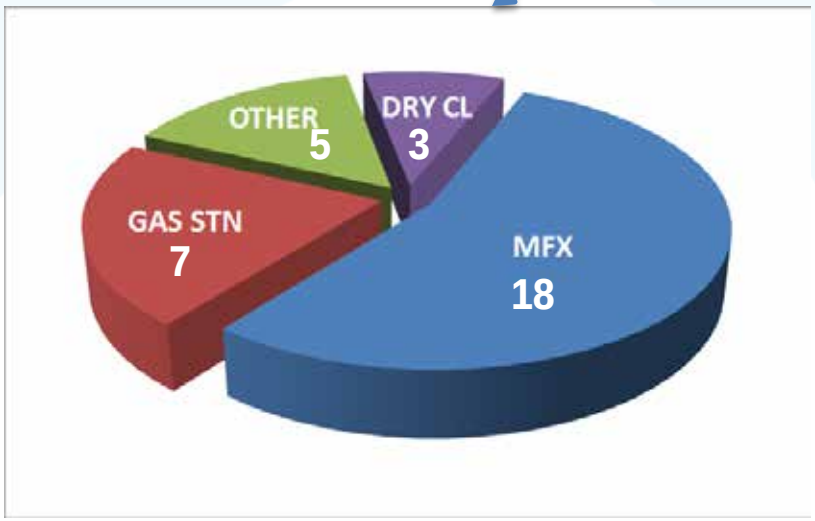
“Lab 1”

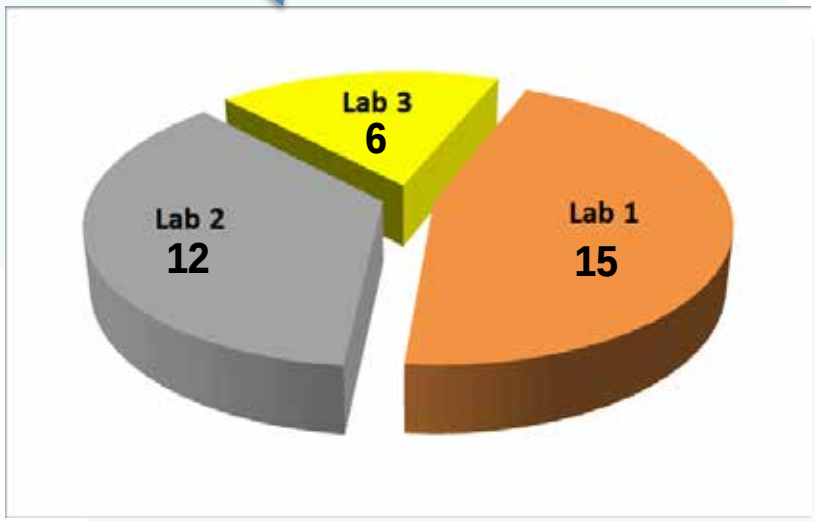
“Lab 2”

“Lab 3”

How we categorized the projects

Projects categorized by type of site and by lab





MFX = auto parts, tool&die, foundry, cardboard box/paper, etc.

OTHER = dump, painting/printing, film processing, etc.

How we collected the samples

- **Soil gas** samples collected from both sub-slab and deep locations

  mostly Bottle-Vac® containers in Michigan

  mostly Summa canisters in Indiana and Ohio

- **Soil** samples obtained from soil borings

- **Groundwater** samples obtained from temporary or permanent monitoring wells

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Sample chemical analyses

Soil gas samples were analyzed for VOCs via EPA Method TO-15

Soil and groundwater samples were analyzed for VOCs via EPA Method 8260

TO-15 Compounds

Hydrocarbons	Hydrocarbons Containing Oxygen	Halogenated VOCs	Halogenated VOCs (contd)	Misc.
Benzene	Acetone	Benzyl Chloride	trans-1,2-Dichloroethene	Carbon Disulfide
1,3-Butadiene	2-Butanone	Bromodichloromethane	1,2-Dichloropropane	
Cyclohexane	1,4-Dioxane	Bromoform	cis-1,3-Dichloropropene	
Ethylbenzene	Ethyl Acetate	Bromomethane	trans-1,3-Dichloropropene	
4-Ethyltoluene	2-Hexanone	Carbon Tetrachloride	Ethylene Dibromide	
n-Heptane	Isopropanol	Chlorobenzene	Hexachlorobutadiene	
n-Hexane	4-Methyl-2-pentanone	Chloroethane	Methylene Chloride	
Methane	MTBE	Chloroform	1,1,2,2-Tetrachloroethane	
2-Methylnaphthalene	Tetrahydrofuran	Chloromethane	Tetrachloroethene	
Naphthalene	Vinyl Acetate	Dibromochloromethane	1,2,4-Trichlorobenzene	
Propylene		1,2-Dichlorobenzene	1,1,1-Trichloroethane	
Styrene		1,3-Dichlorobenzene	1,1,2-Trichloroethane	
Toluene		1,4-Dichlorobenzene	Trichloroethene	
1,2,4-Trimethylbenzene		Dichlorodifluoromethane	Trichlorofluoromethane	
1,3,5-Trimethylbenzene		1,1-Dichloroethane	1,1,2-Trichlorotrifluoroethane	
m&p-Xylene		1,2-Dichloroethane	Vinyl Chloride	
o-Xylene		1,1-Dichloroethene		
Xylenes		cis-1,2-Dichloroethene		

Example TO-15 list (Lab 1)

60 compounds comprised of:
18 hydrocarbons,
10 hydrocarbons containing oxygen,
34 halogenated VOCs,
plus one miscellaneous

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TO-15 (gas) vs 8260 (soil/GW)

TO-15 VOCs not in 8260 list	8260 VOCs not in TO-15 List
Benzyl Chloride	Acrylonitrile
1,3-Butadiene	Bromobenzene
Cyclohexane	Bromochloromethane
1,4-Dioxane	n-Butylbenzene
Ethyl Acetate	sec-Butylbenzene
4-Ethyltoluene	tert-Butylbenzene
n-Heptane	2-Chlorotoluene
Hexachlorobutadiene	1,2-Dibromo-3-chloropropane (SIM)
n-Hexane	Dibromomethane
Isopropanol	Isopropylbenzene
Propylene	n-Propylbenzene
Tetrahydrofuran	1,1,1,2-Tetrachloroethane
1,1,2-Trichlorotrifluoroethane	1,2,3-Trichloropropane
Vinyl Acetate	1,2,3-Trimethylbenzene

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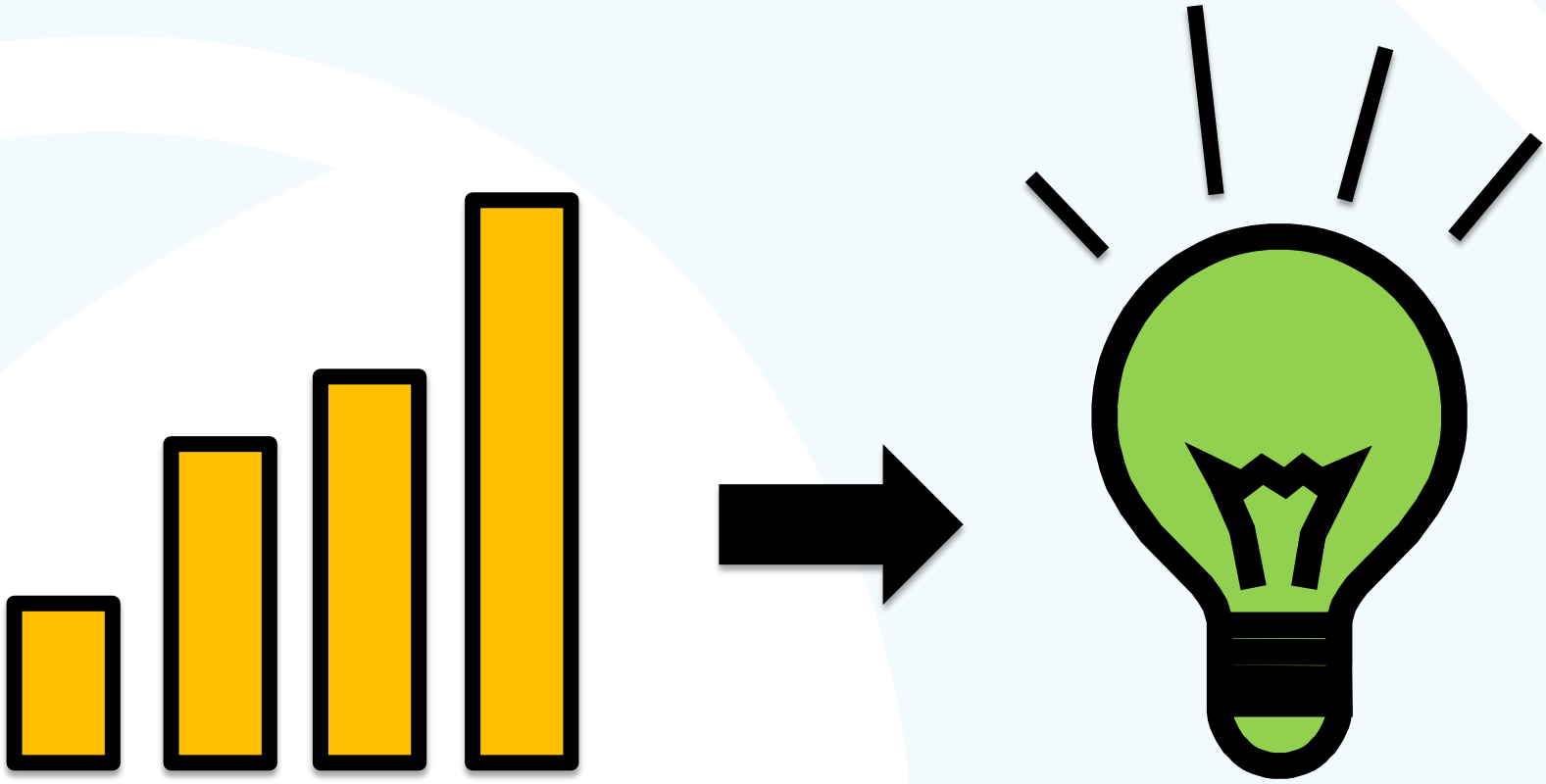
Varies by lab; lists above are based on lab 1's compound lists

TO-15 results… lots of compounds detected

Constituent	Nonresidential Sub-Slab Soil Gas Criteria for Vapor Intrusion	Sample Identification	VP6	VP6	VP6-DUP 1	VP6	VP6-DUP 1	VP6	VP6-DUP 1	VP7	VP7	VP7	VP7	VP8	VP8	VP8	VP8	VP9	VP9	VP9	VP9
		Date	2/22/2012	5/22/2012	5/22/2012	9/18/2012	9/18/2012	11/20/2012	11/20/2012	2/22/2012	5/22/2012	9/18/2012	11/20/2012	2/22/2012	5/22/2012	9/18/2012	11/20/2012	2/22/2012	5/22/2012	9/18/2012	11/20/2012
Acetone	520,000		66	130	75	36	<6.3	<28	<28	93	<15	<3.7	<3.7	66	<10	<5.0	<5.6	<4.5	<9.6	<2.8	<4.6
Benzene	160		3.8	4.7	3.5	3.6	0.54	4.2	3.4	1.1	0.90	0.44	0.46	1.8	1.2	<0.38	0.78	1.1	0.81	0.42	0.51
Bromodichloromethane	36		<0.37	<0.37	<0.37	<0.37	<0.37	<2.8	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37
Bromomethane	270		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
2-Butanone	350,000		110	14	9.3	2.1	<1.1	<28	1.6	4.2	<1.1	<1.1	<1.1	3.5	1.4	<1.1	<1.1	<1.1	1.1	<1.1	<1.1
Carbon Disulfide	47,000		4.9	<2.5	<2.5	1.2	<0.51	<26	<2.6	<2.5	<2.5	<0.51	<2.6	<2.5	<2.5	<0.51	<2.6	<2.5	<2.5	<0.51	<2.6
Carbon Tetrachloride	110		<0.38	<0.38	<0.38	<0.38	<0.38	<2.7	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
Chlorobenzene	3,200		4.8	<0.38	<0.38	<0.38	0.87	<2.8	<0.38	2.9	<0.38	0.74	0.39	2.7	<0.38	0.75	<0.38	2.2	<0.38	0.47	0.40
Chloroethane	790,000		<0.51	0.82	0.68	0.86	<0.37	<2.6	0.77	<0.51	<0.35	<0.35	<0.35	<0.51	<0.35	<0.35	<0.35	<0.51	<0.35	<0.35	<0.35
Chloroform	370		<0.33	<0.33	<0.33	<0.33	<0.33	<2.8	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Cyclohexane	360,000		11	<2.5	<2.5	2.6	2.66	<28	<28	0.44	<2.5	0.60	<2.8	<0.34	<2.5	0.53	<2.8	<0.34	<2.5	0.42	<2.8
1,2-Dichlorobenzene	10,000		<0.38	<0.55	<0.55	<0.38	<0.38	<2.8	<0.38	<0.38	<0.55	<0.38	<0.38	<0.38	<0.55	<0.38	<0.38	<0.38	<0.55	<0.38	<0.38
1,3-Dichlorobenzene	100		<0.38	<0.55	<0.55	<0.38	<0.38	<2.8	1.7	<0.38	<0.55	<0.38	1.1	<0.38	<0.55	<0.38	1.4	<0.38	<0.55	<0.38	0.81
1,4-Dichlorobenzene	100		<0.38	<0.55	<0.55	<0.38	<0.38	<2.8	<0.38	<0.38	<0.55	<0.38	<0.38	<0.38	<0.55	<0.38	<0.38	<0.38	<0.55	<0.38	<0.38
Dichlorodifluoromethane	2,100,000		<0.39	<0.51	<0.48	<0.51	<0.49	<2.8	<0.49	<0.46	<0.53	<0.53	<0.46	<0.46	<0.49	<0.54	<0.49	<0.49	<0.47	<0.54	<0.51
1,1-Dichloroethane	26,000		48	100	94	130	<0.37	86	100	0.91	0.56	0.83	0.80	0.42	<0.37	0.59	0.44	<0.37	<0.37	<0.37	<0.37
1,2-Dichloroethane	41		0.38	0.39	0.39	<0.37	<0.37	<2.8	0.38	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37
1,1-Dichloroethene	10,000		4.8	2.3	1.8	2.9	<2.8	<28	2.5	0.54	<0.36	<2.8	<0.36	<0.53	<0.36	<2.8	<0.36	<0.53	<0.36	<2.8	<0.36
cis-1,2-Dichloroethene	1,800		<0.38	<0.38	<0.38	<0.38	<0.38	<2.8	<0.38	<0.38	<0.38	<0.38	0.48	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
trans-1,2-Dichloroethene	3,700		<0.33	<0.33	<0.33	<0.33	<0.33	<2.8	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
1,4-Dioxane	No Criteria		6.8	6.5	6.7	3.9	0.37	6.4	3.5	0.52	<0.37	0.37	<0.55	0.95	<0.37	0.37	<0.55	<0.37	<0.37	0.37	<0.55
Ethyl Acetate	180,000		<0.99	1.2	<0.99	0.87	<0.99	<28	<2.8	<0.99	<0.99	<0.99	<2.8	<0.99	<0.99	<0.99	<2.8	<0.99	<0.99	<0.99	<2.8
Ethylbenzene	3,200		1.6	1.6	1.5	1.8	<0.38	<2.8	1.1	0.63	<0.38	<0.38	0.45	0.62	0.45	<0.38	0.52	0.42	<0.38	<0.38	0.63
Ethylene Dibromide	1		<0.36	<0.36	<0.36	<0.36	<0.36	<2.8	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36
4-Ethyltoluene	No Criteria		4.1	3.3	3.8	1.8	<0.38	<2.8	1.5	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
n-Heptane	180,000		2.1	2.1	1.9	1.2	<0.35	<2.8	1.4	1.4	<0.35	<0.33	<0.35	1.9	<0.35	<0.33	<0.35	<0.35	<0.35	<0.33	<0.35
n-Hexane	12,000		2.8	3.4	1.7	3.7	2.46	4.7	3.8	0.79	<0.33	<2.9	2.2	0.90	<0.33	<2.9	2.4	0.60	<0.34	<2.9	0.45
2-Hexanone	2,000		4.8	<1.1	<1.1	<1.1	<1.1	<2.9	<1.1	<1.1	<1.1	<2.8	<1.1	<1.1	<1.1	<2.8	<1.1	<1.1	<1.1	<2.8	<1.1
Isopropyl Alcohol	No Criteria		140	<16	<9.7	47	<2.9	<54	22	100	<9.1	<0.38	31	70	<15	<0.38	31	<9.5	<12	<0.38	<13
Methylene Chloride	4,500		4.6	<2.7	16	<2.8	<2.8	<13	<1.3	<2.6	<2.7	<0.35	<1.3	24	<2.7	<0.35	<0.38	<2.6	<2.7	<0.35	<1.3
4-Methyl-2-pentanone	150,000		30	1.6	1.3	0.43	<0.38	<2.8	<0.38	<0.38	<0.38	<5.8	<0.38	<0.38	<0.38	<5.8	<0.38	<0.38	<0.38	<5.8	<0.38
MTBE	170,000		<0.35	<0.35	<0.35	<0.35	<0.35	<2.8	<0.35	<0.35	<0.35	<2.8	<0.35	<0.35	<0.35	<2.8	<0.35	<0.35	<0.35	<2.8	<0.35
Napthalene	69		NE	NE	NE	<5.75	<5.75	<14	<1.44	NE	NE	<5.75	<1.44	NE	NE	<5.75	<1.44	NE	NE	<5.75	<1.44
Propylene	No Criteria		1,100	<0.53	<0.53	1.45	<2.8	44	35	3	<0.53	<0.38	<1.3	<2.7	<0.53	<0.38	<1.3	<2.7	<0.53	<0.38	<1.3
Styrene	1,800		0.63	0.63	0.71	<0.38	<0.38	<2.8	<0.38	0.51	<0.38	<0.38	0.41	<0.38	<0.38	<0.38	<1.3	<0.38	<0.38	<0.38	<0.38
1,1,2,2-Tetrachloroethane	11		<0.38	<0.38	<0.38	<0.38	<0.38	<2.8	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
Tetrachloroethene	1,200		460	1,100	1,200	820	5.2	670	680	15	13	11	9.0	5.9	5.8	7.0	6.0	<0.37	<0.37	0.64	<0.37
Tetrahydrofuran	730		2.1	<2.7	<2.7	<1.1	<1.1	<2.9	<1.1	1.2	<2.7	<1.1	<1.1	1.2	<2.7	<1.1	<1.1	<1.1	<2.7	<1.1	<1.1
Toluene	280,000		30	10	9.3	6.4	0.86	7.2	7.6	2.9	0.98	0.46	2.0	2.6	1.8	0.80	2.6	1.2	1.1	0.67	2.9
1,2,4-Trichlorobenzene	10,000		<5.5	<2.6	<2.6	<5.5	<5.5	<2.8	<0.38	<5.3	<2.6	<5.5	<0.38	<5.3	<2.6	<5.5	<0.38	<5.3	<2.6	<5.5	<0.38
1,1,1-Trichloroethane	38,000		530	1,100	940	1,300	5.3	1,500	850	20	19	24	17	8.4	9.8	14	9.4	0.86	<0.37	1.3	<0.37
1,1,2-Trichloroethane	50		<0.38	<0.38	<0.38	<0.38	<0.38	<2.8	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
Trichloroethene	77		11	2.5	1.9	2.7	1.8	7.0	5.5	7.4	1.9	1.5	9.3	8.1	1.8	0.72	11	6.6	1.7	0.46	2.3
Trichlorofluoromethane	2,100,000		<0.53	0.40	<0.36	0.57	<0.53	<0.36	<0.36	<0.53	<0.35	0.60	<0.34	<0.53	<0.38	0.58	<0.34	<0.53	<0.34	<0.53	<0.34
1,1,2-Trichlorotrifluoroethane	2,100,000		<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36
1,2,4-Trimethylbenzene	9,300		30	30	30	16	2.1	8.7	11	1.7	1.2	0.97	0.61	1.8	3.3	<0.38	0.67	2.6	1.0	1.7	1.0
1,3,5-Trimethylbenzene	9,300		17	17	18	8.6	<0.38	6.2	7.4	0.42	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38	<0.38
Vinyl Acetate	12,000		<2.0	<1.1	<1.1	<5.5	<5.5	<28	<2.8	<2.0	<1.1	<5.5	<2.8	<2.0	<1.1	<5.5	<2.8	<2.0	<1.1	<5.5	<2.8
Vinyl Chloride	380		<0.35	<0.35	<0.35	<0.35	<0.35	<2.6	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
Xylenes	4,800		20.5	14.2	14.2	7.3	2.4	<8.9	8.9	3.9	1.89	0.68	2.52	3.8	3.2	1.52	3.5	2.9	1.94	0.44	3.4

What did our 33 projects tell us?



Idea for graphic: http://sparksheet.com/moving-from-data-to-insights/

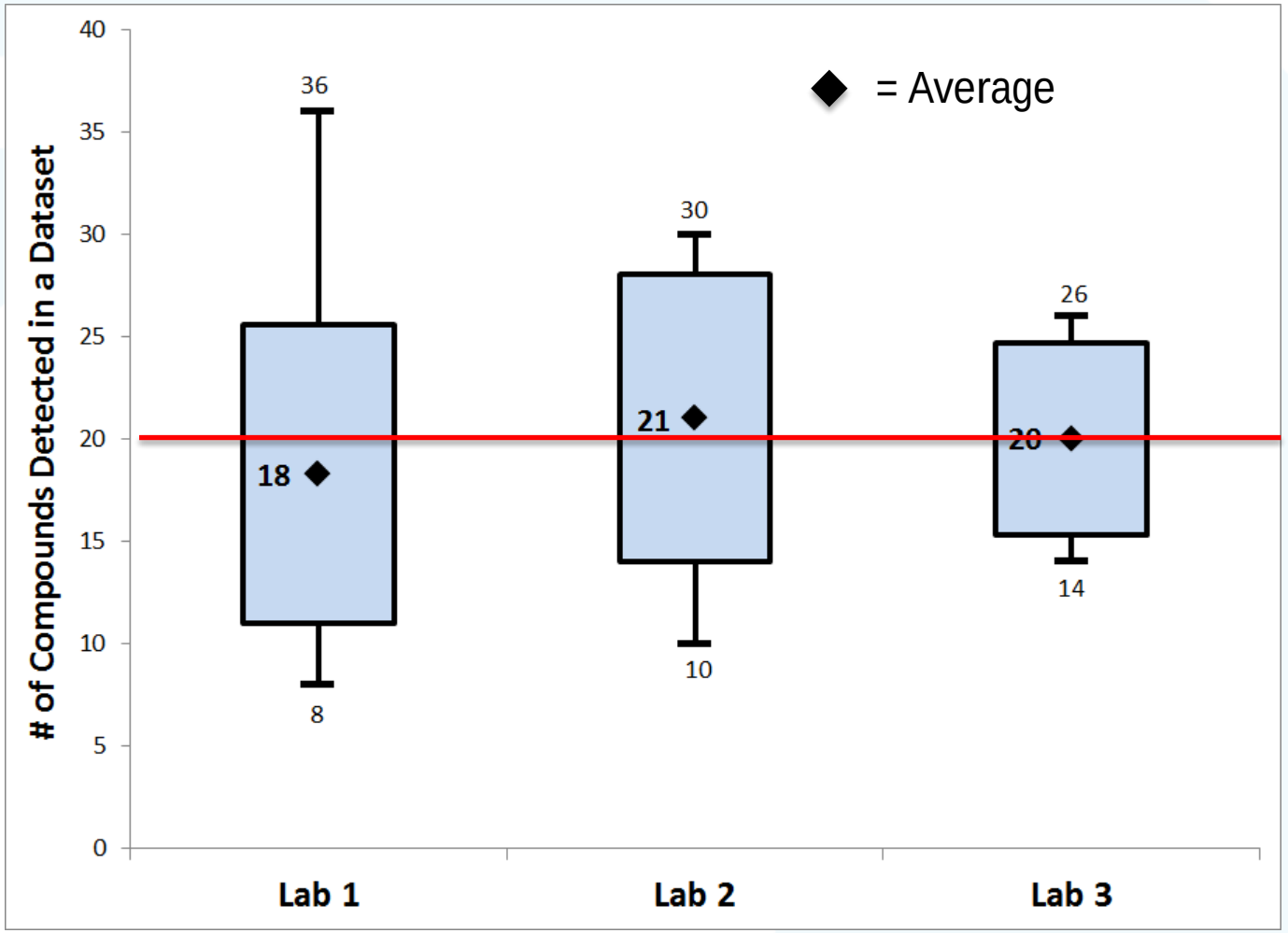
Soil gas detections

Compounds detected in the soil gas datasets:

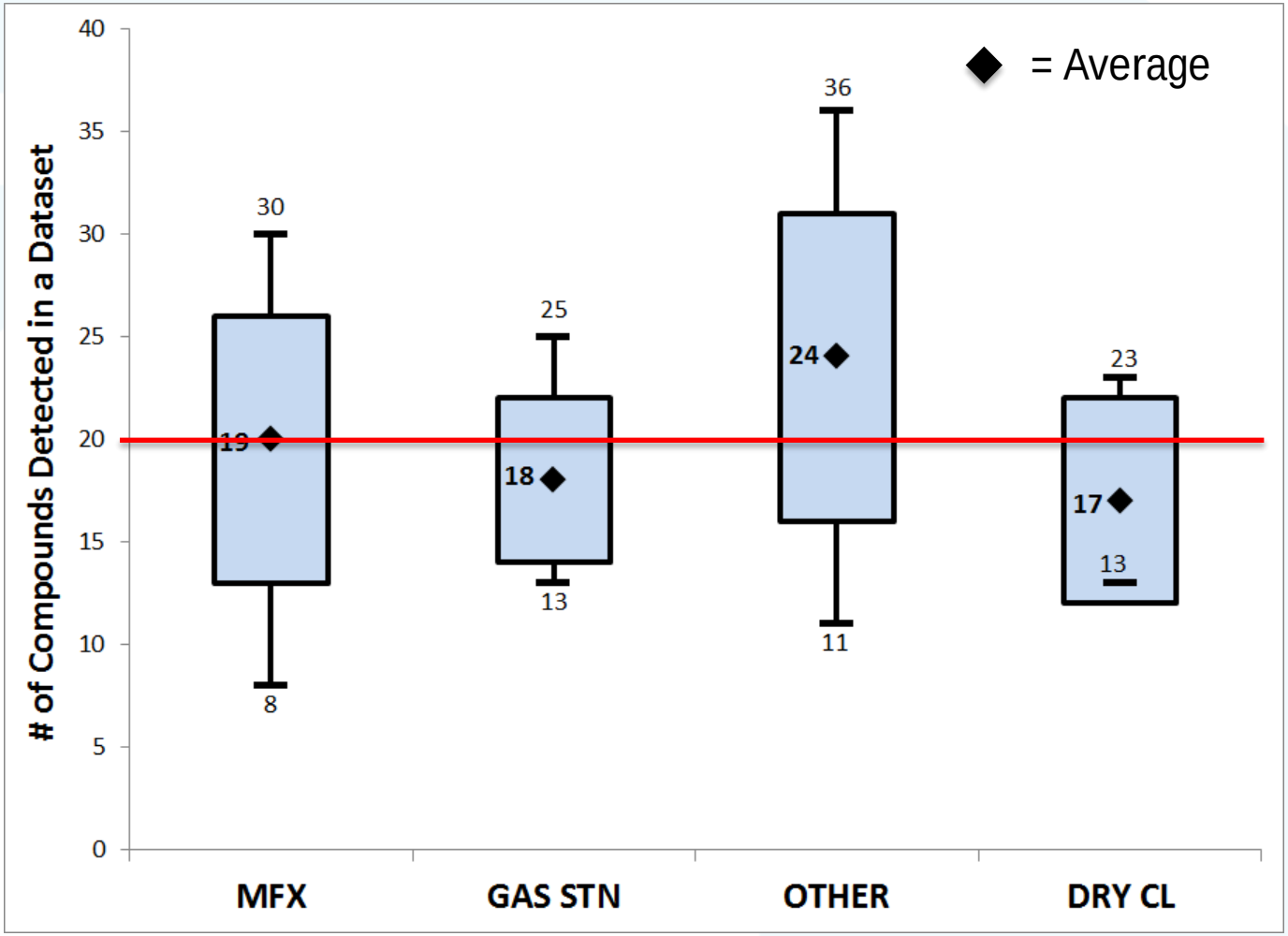
Ranged from 8 – 36 compounds (out of ~ 60 possible)

Avg. was 30% or 20 compounds

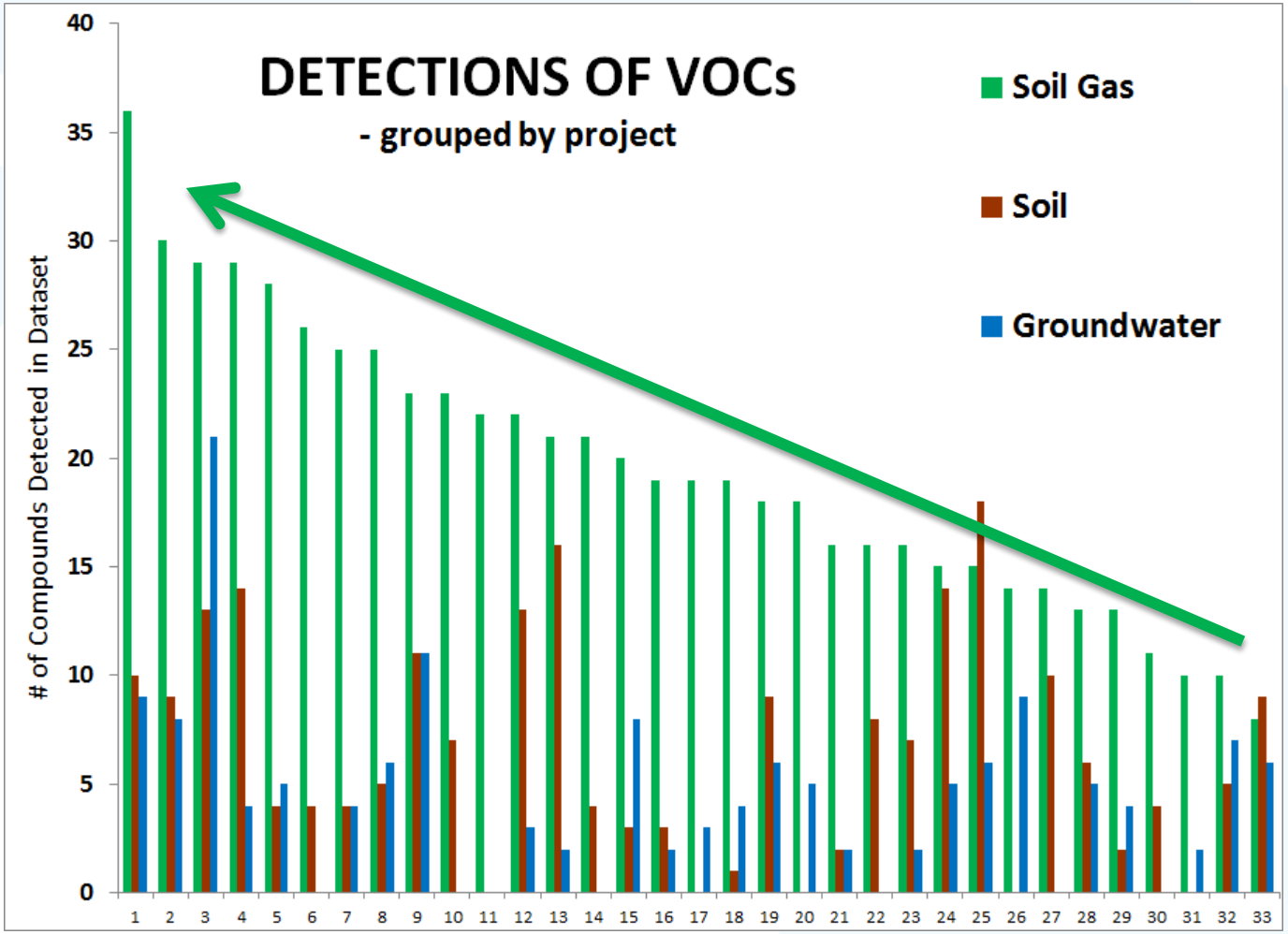
By lab: min, max, and average soil gas detections



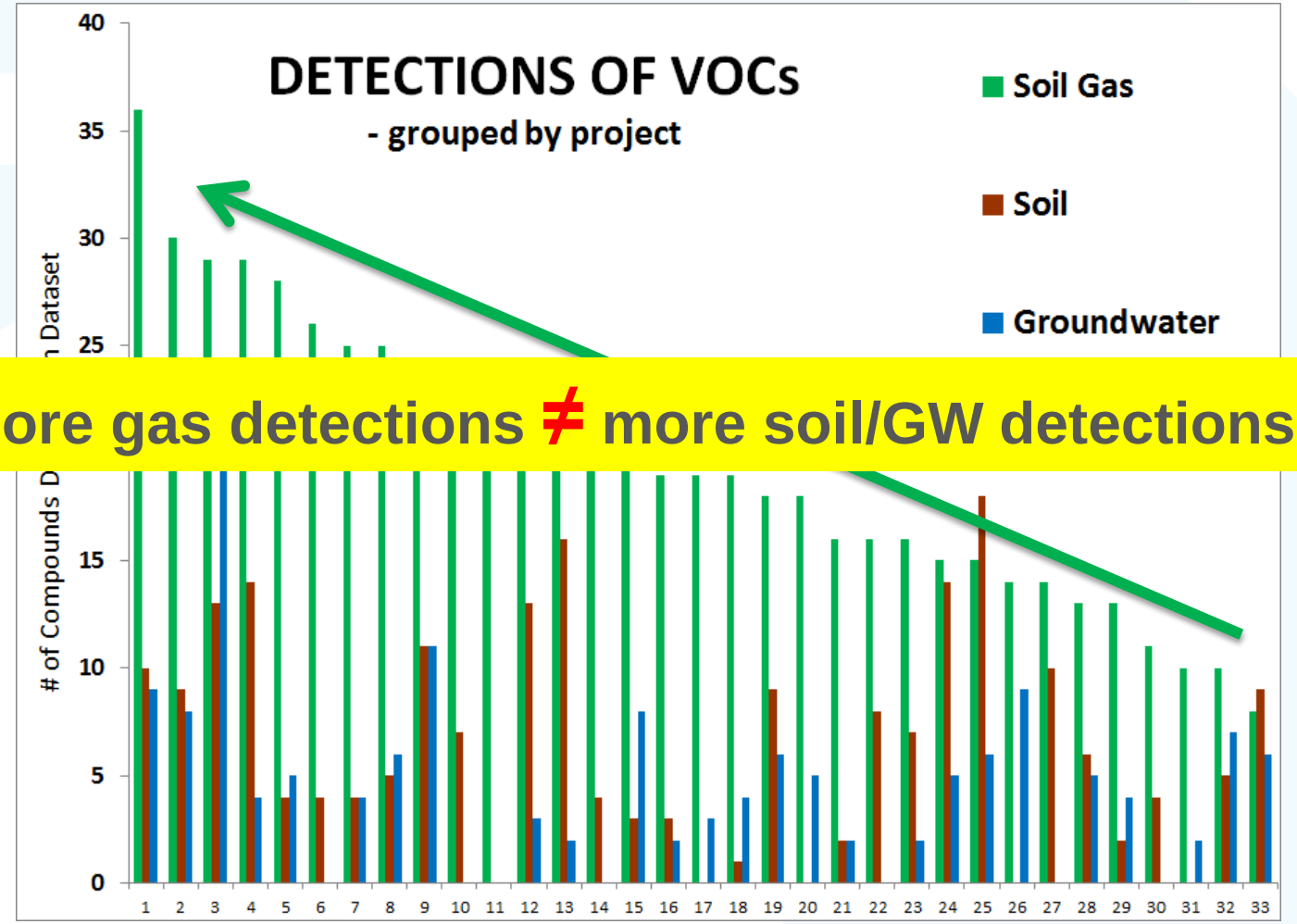
By type of site: min, max, and average soil gas detections



How do soil gas and soil/GW detections compare within a project dataset?



How do soil gas and soil/GW detections compare within a project dataset?



more gas detections ≠ more soil/GW detections

Detect, but exceed?

How many of these detections exceed VI screening levels?

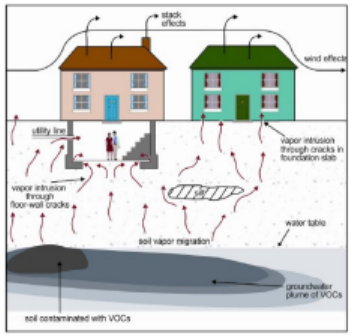
Data compared to Screening Levels

Compared soil gas, soil, and groundwater results to:

DEQ

Guidance Document
FOR THE VAPOR INTRUSION PATHWAY

MAY 2013
REMEDIATION AND REDEVELOPMENT DIVISION



APPENDIX D.1 - MDEQ Remediation and Redevelopment Division
INDOOR AIR, SOIL GAS, GROUNDWATER, AND SOIL SCREENING VALUES FOR THE VAPOR INTRUSION PATHWAY

RESIDENTIAL LAND USE

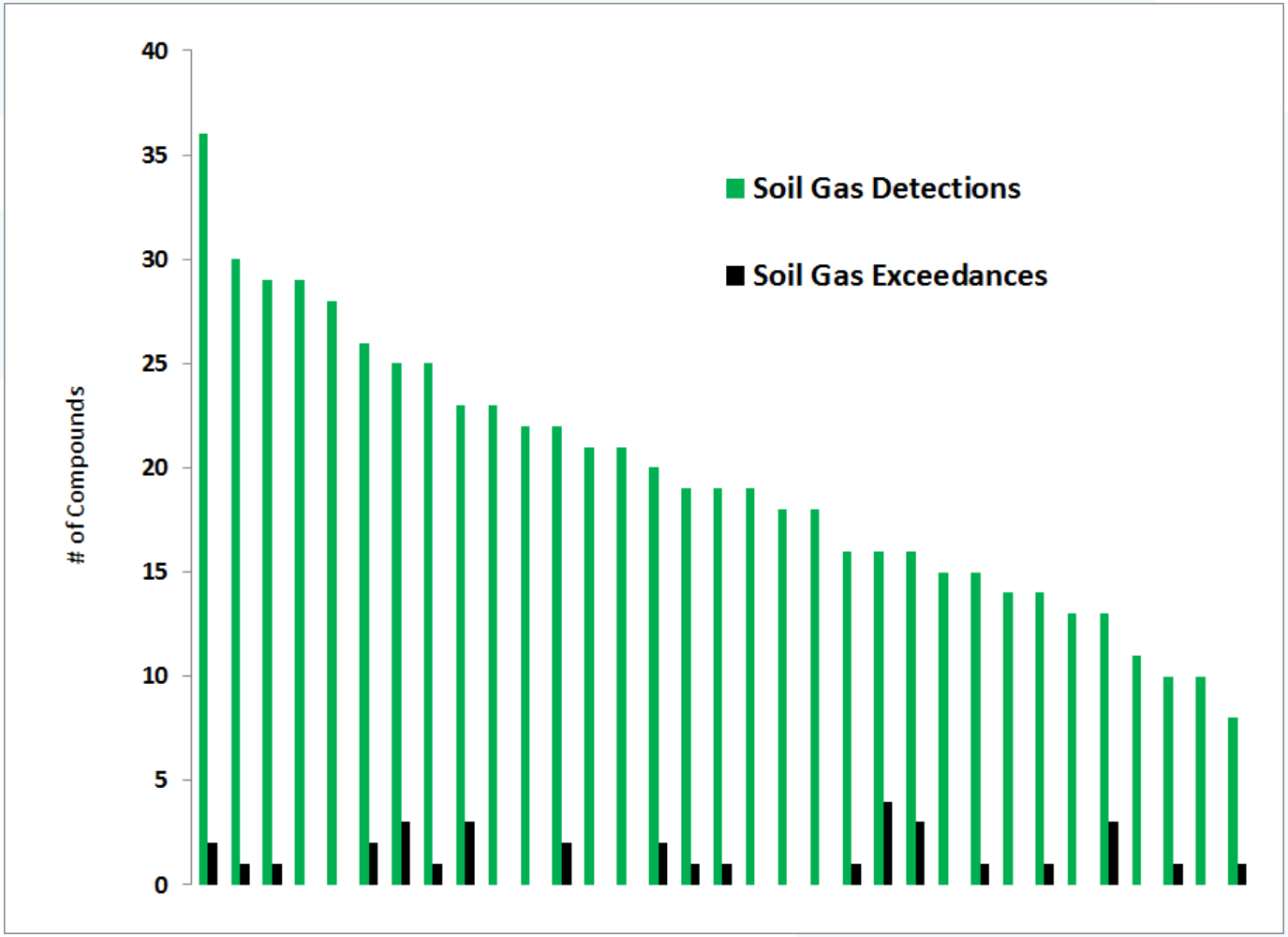
shallow **deep**

SOIL GAS			
Vapor Intrusion Shallow Soil Gas (sub-slab) Screening Levels[(b)] (Samples collected less than or equal to 1.5 meters bgs or building foundation)		Vapor Intrusion Deep Soil Gas Screening Levels[(b)]	
$SG_{VI\text{-}SS\text{-}res}$		$SG_{VI\text{-}res}$	
(ug/m^3)	$(ppbv)_{(c)}$	(ug/m^3)	$(ppbv)_{(c)}$

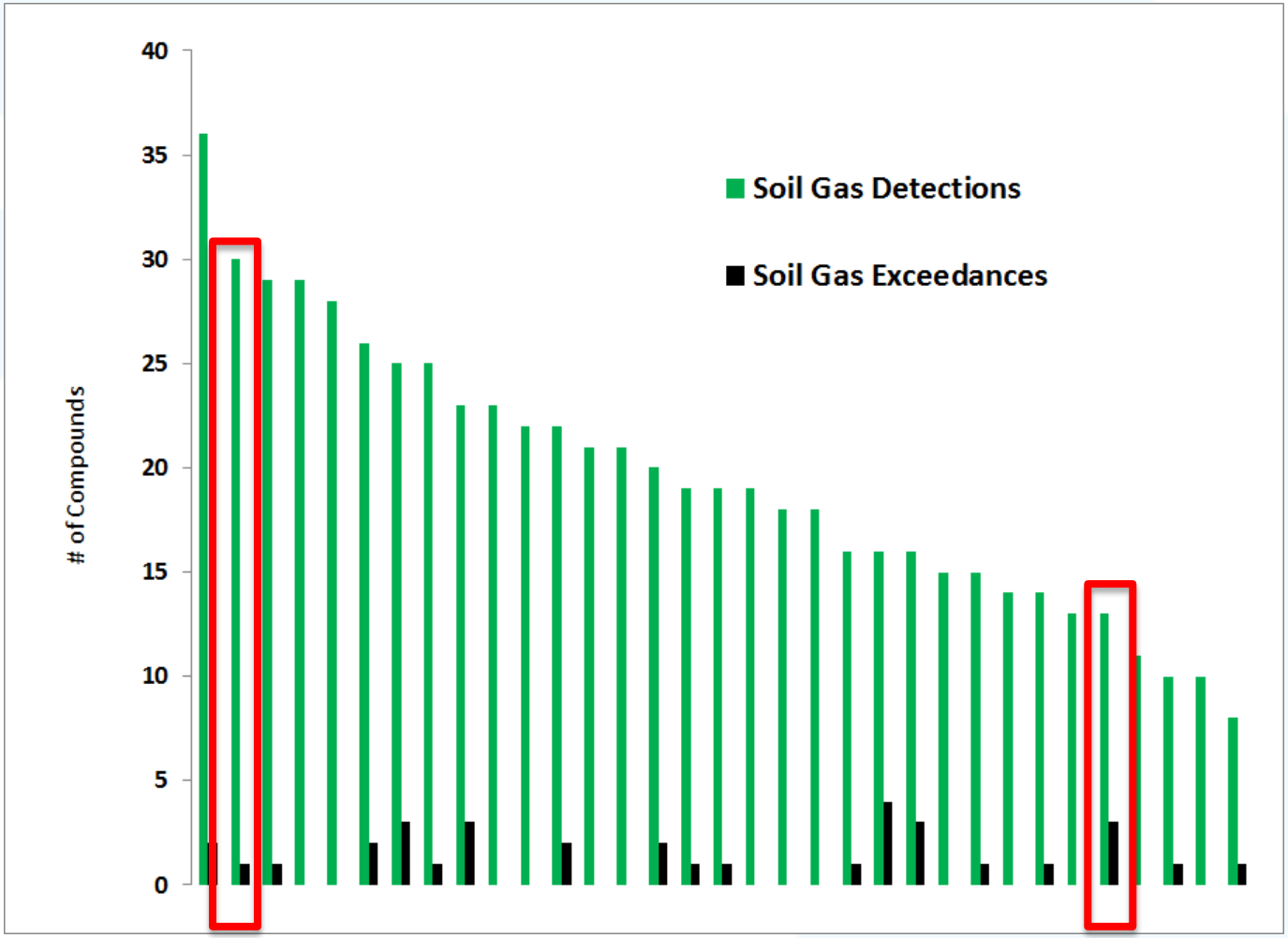
GROUNDWATER		SOIL
Vapor Intrusion Groundwater Screening Levels[(d,t)]	~~Vapor Intrusion Shallow Groundwater Screening Levels[(d,t)]~~	Vapor Intrusion Soil Screening Levels[(t)]
$GW_{VI\text{-}res}$	~~$GW_{VI\text{-}sump\text{-}res}$~~	$S_{VI\text{-}res}$
(ug/L)	~~(ug/L)~~	(ug/kg)

SME

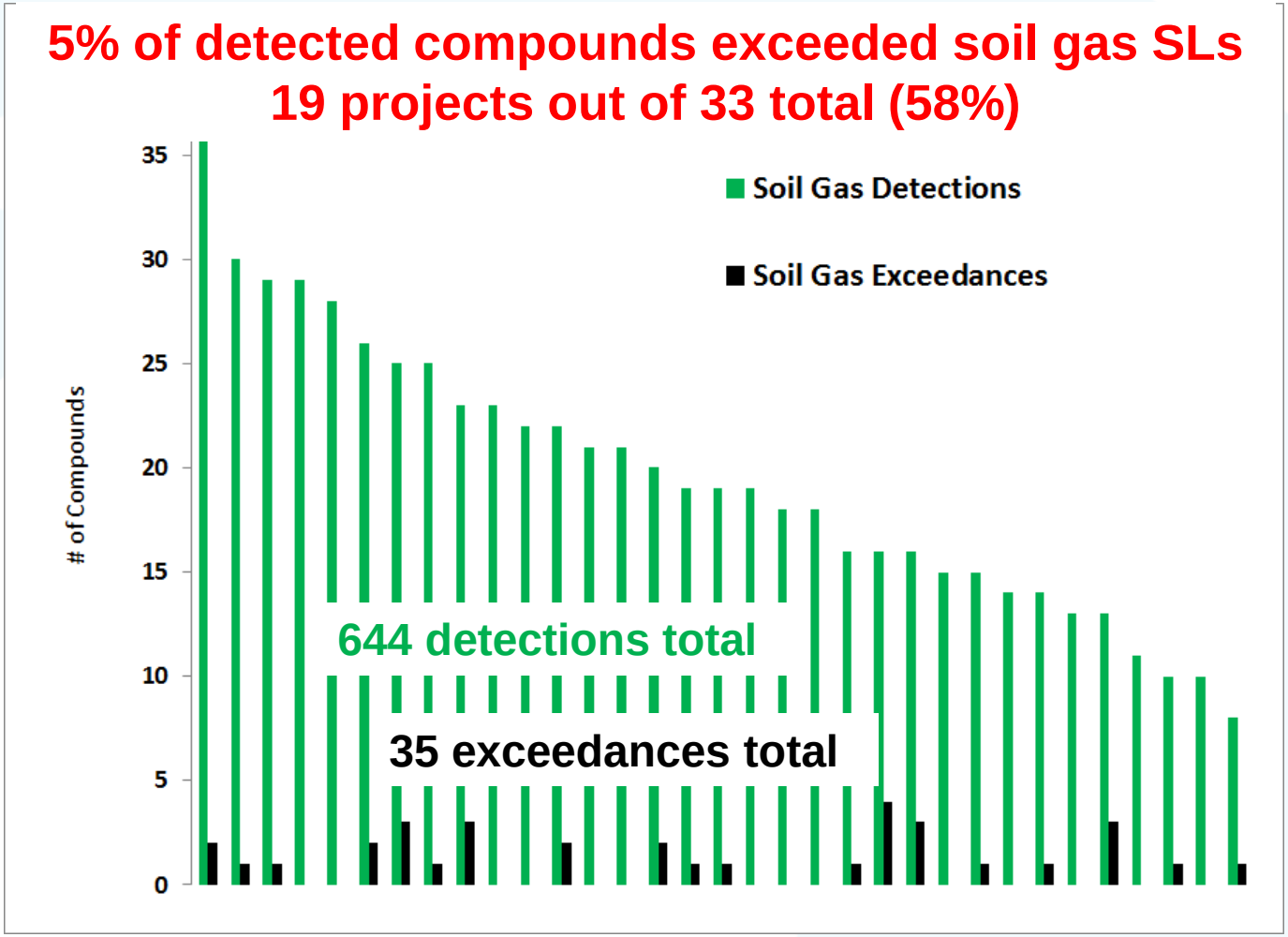
Soil gas detections vs. exceedances



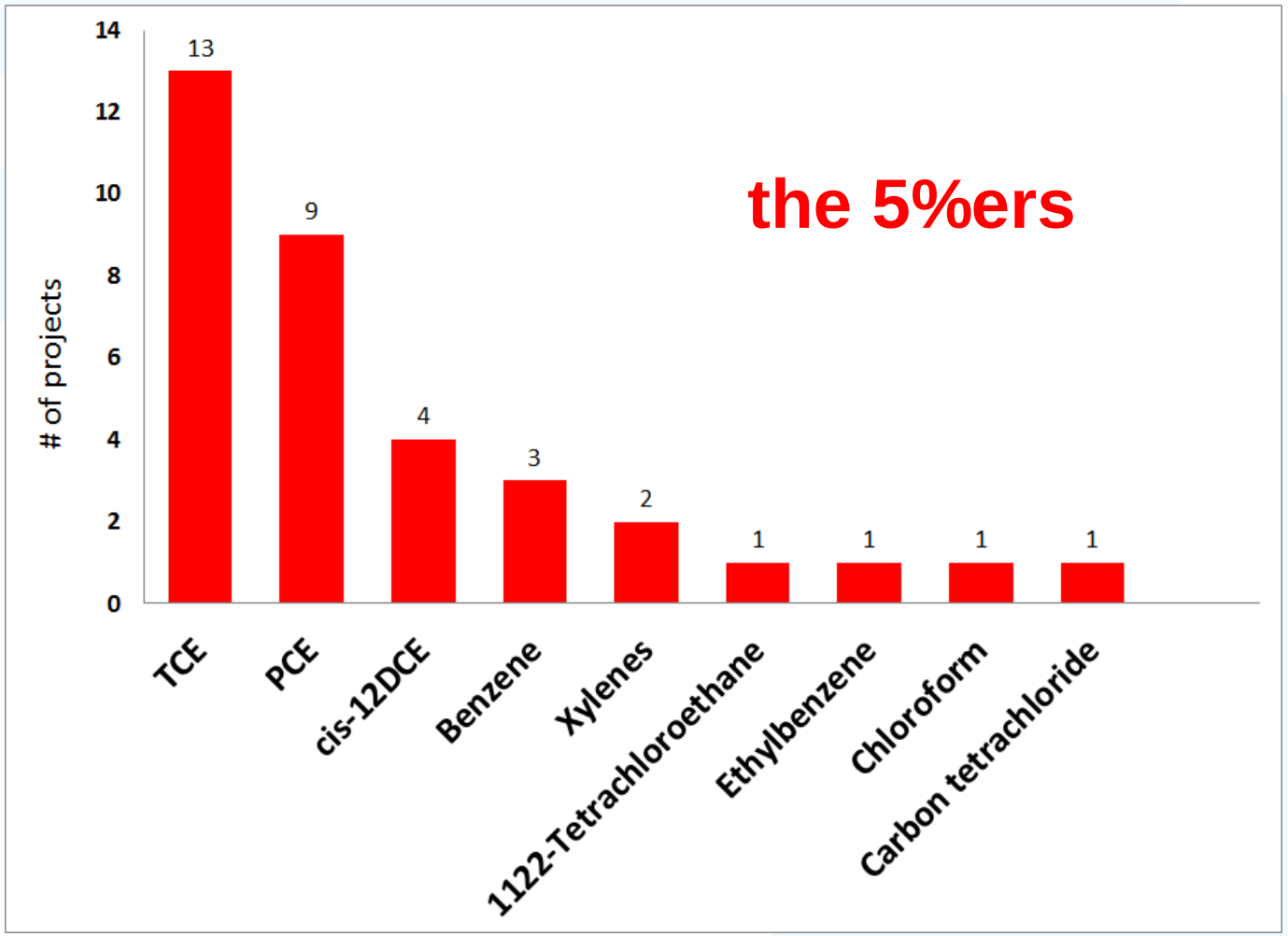
Soil gas detections vs. exceedances



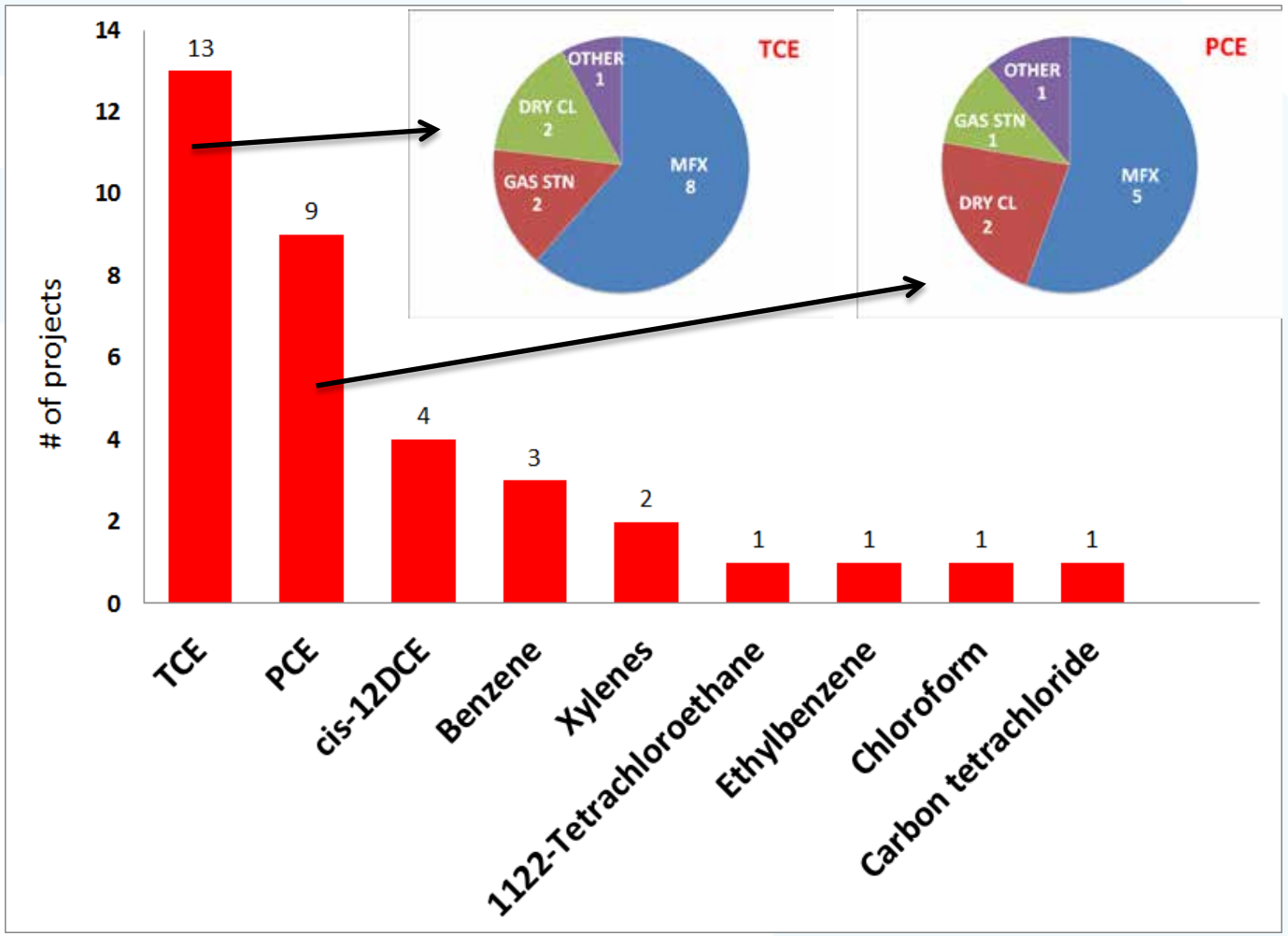
Soil gas detections vs. exceedances



Which compounds in soil gas exceeded VI?



TCE and PCE most prevalent

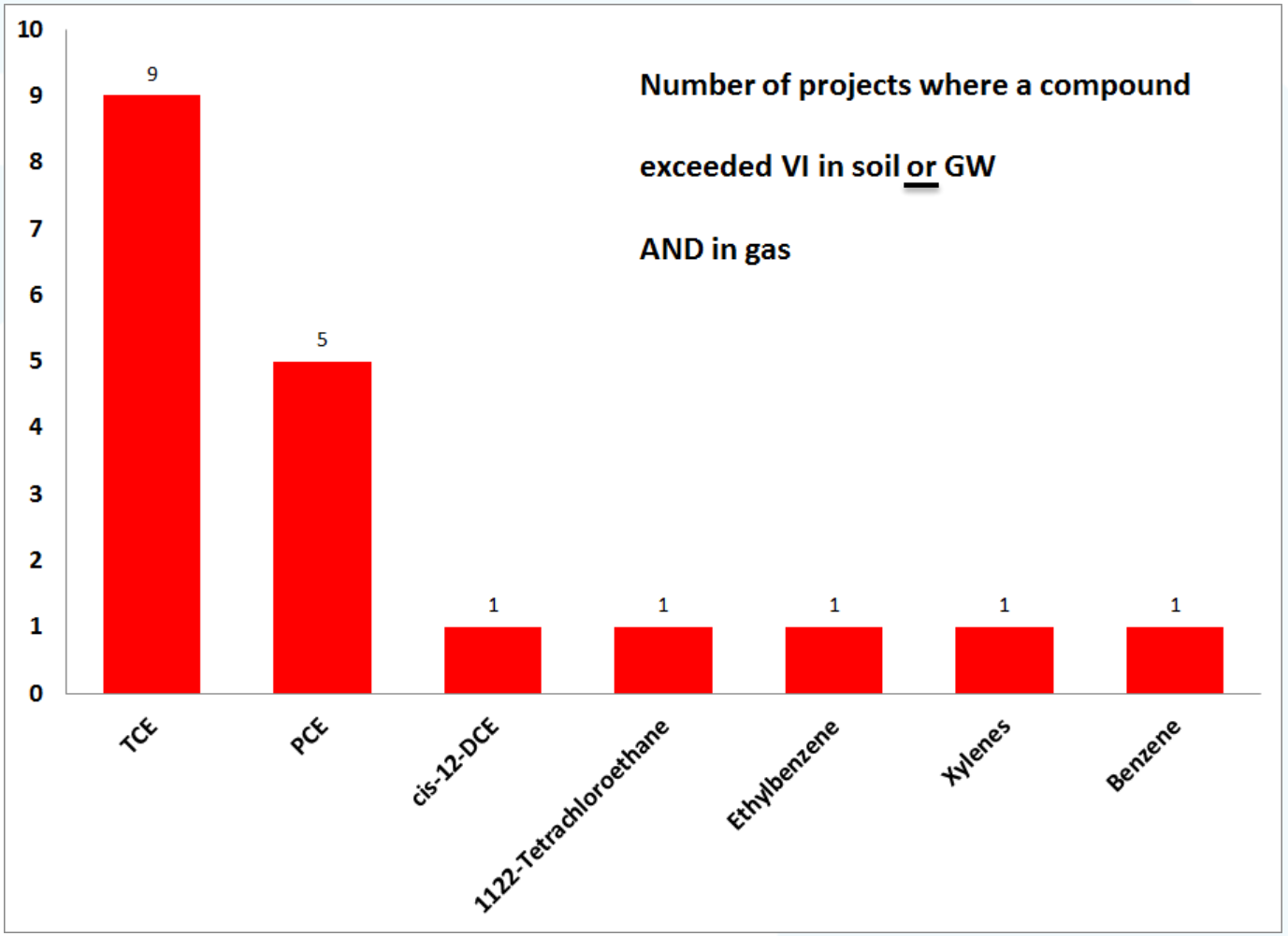


Soil/GW exceedances an indicator for gas exceedances?

First, we'll look at compounds in soil/GW

that <u>tracked well</u> with soil gas exceedances

Soil/GW exceedances an indicator for gas exceedances?

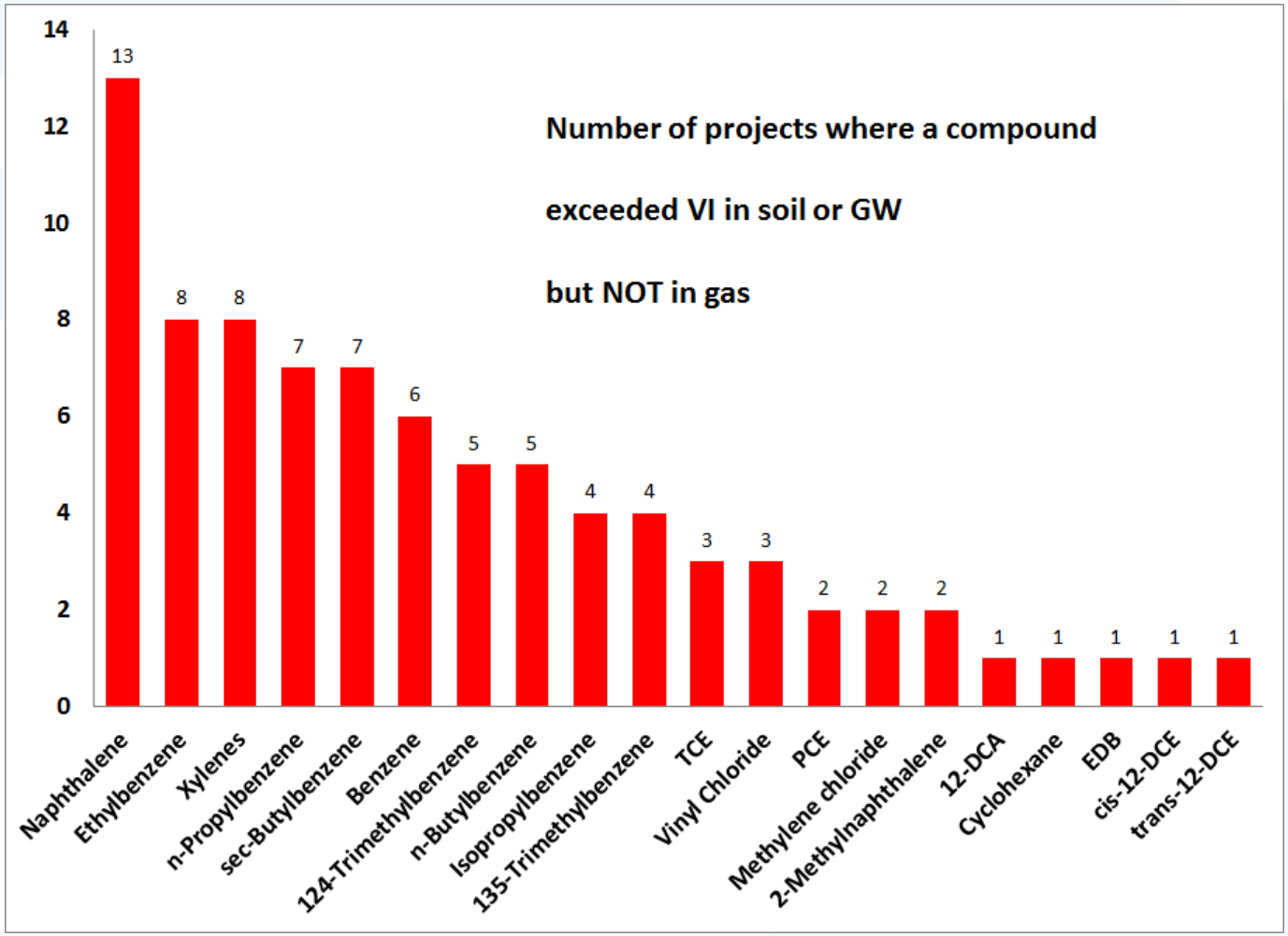


Soil/GW exceedances an indicator for gas exceedances?

Next, we'll look at compounds in soil/GW

that <u>did not track well</u> with soil gas exceedances

Soil/GW exceedances an indicator for gas exceedances?



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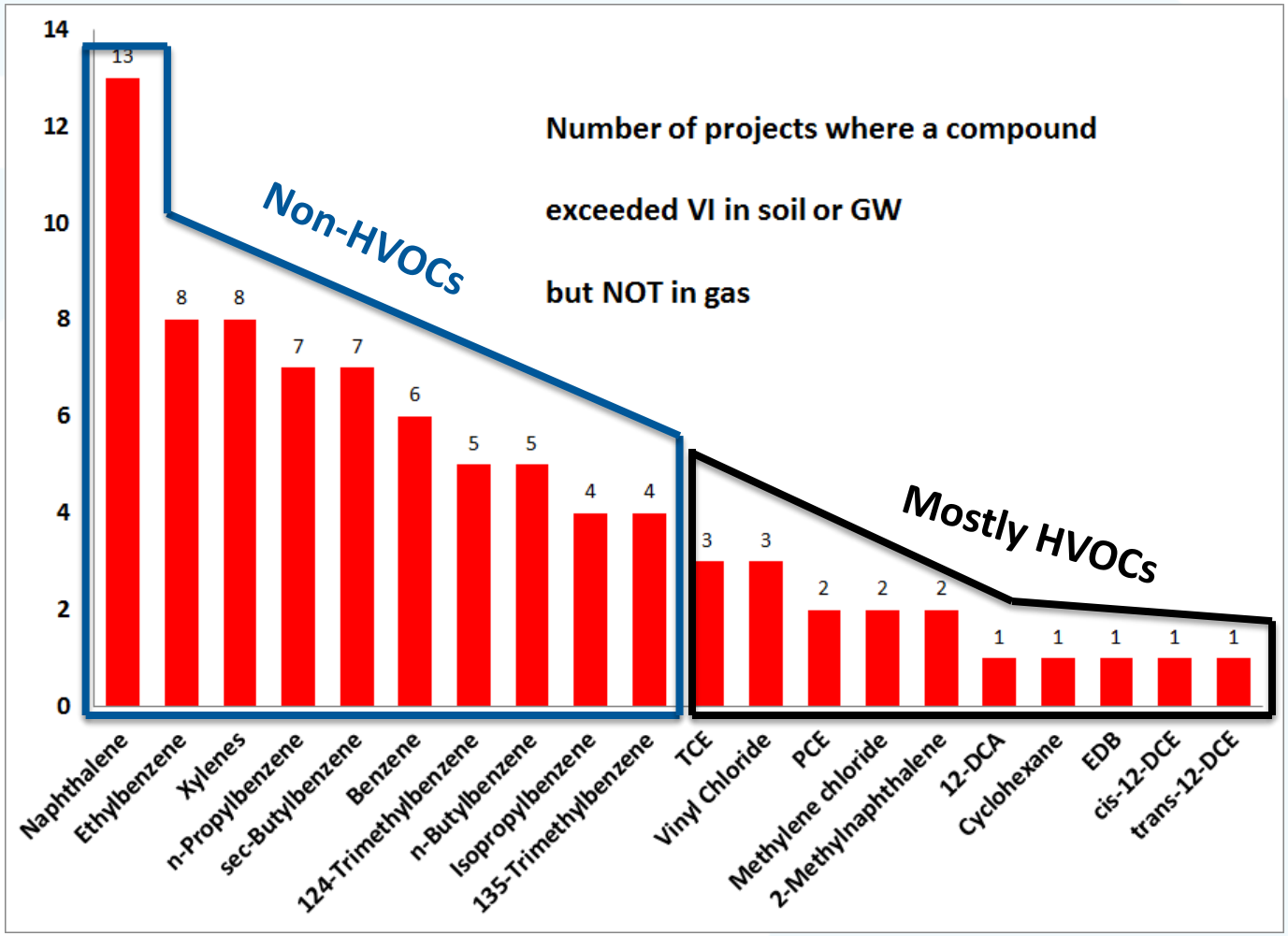
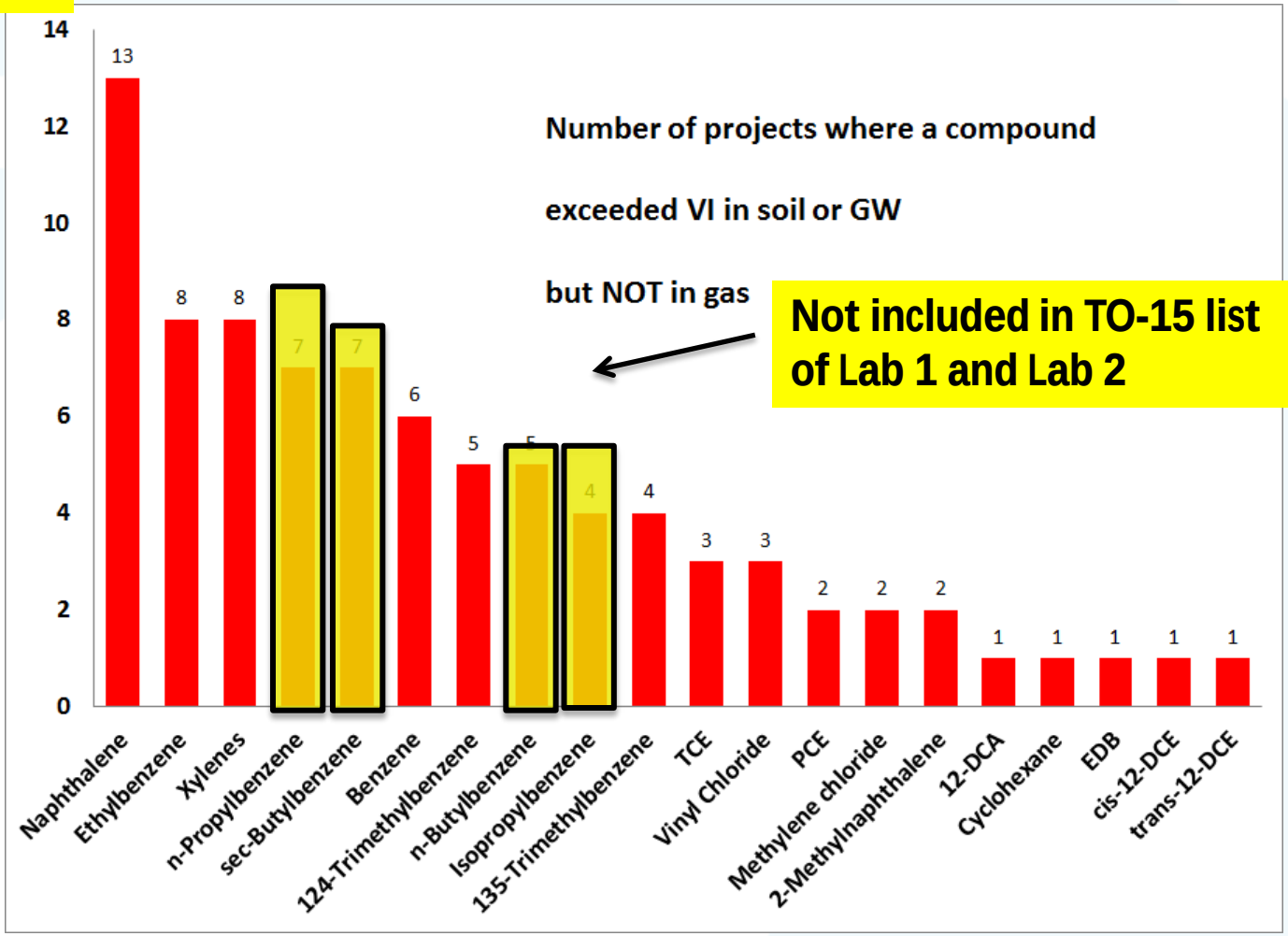
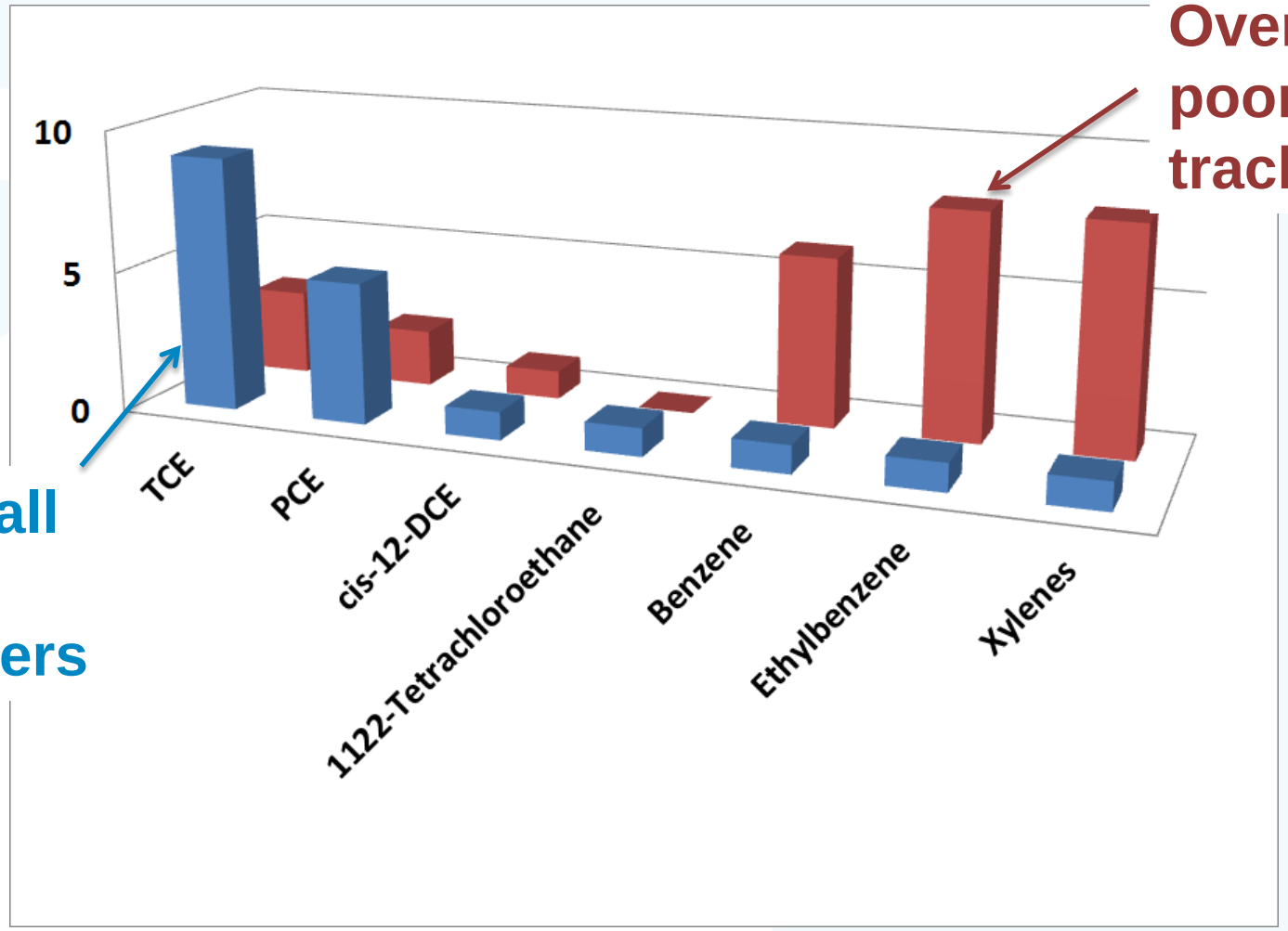


Soil/GW exceedances an indicator for gas exceedances?

Remember…



Good trackers can be poor trackers, and vice versa. But in general…



Overall poor trackers

Overall good trackers

Soil and GW screening levels as indicators of soil gas impacts

On a project basis, how often did soil and GW indicate soil gas exceedances?

Soil was an accurate indicator of gas concern **62%** of the time (15 out of the 24 projects with soil > VI)

GW was an accurate indicator of gas concern **77%** of the time (10 out of 13 projects with GW > VI)

VI screening levels for soil & GW…

Taking soil and GW together…

Soil+GW indicated a gas concern for 17 out of the 19 projects where gas exceeded VI screening levels

Furthermore, 16 of these 17 projects had soil+GW exceedances corresponding with one or more gas exceedances

So, Soil and GW together were indicators of gas concern 89% of the time

(and of this 89%, soil and GW together identified at least one of the constituents of concern in gas 94% of the time)

Low-level detections in gas

Some compounds were often detected in gas but did not exceed gas VI SLs.

e.g. acetone, n-heptane, n-hexane, 124-trichlorobenzene

Could there be significance to these detections?

Low-level detections in gas

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e.g. acetone, n-heptane, n-hexane, 124-trichlorobenzene

Could there be significance to these detections?

- Commercial chemical products are a mix of many compounds
- Lab cross contamination
- Contaminated sampling equipment
- Not in 8260 list?
- Do they matter?

Conclusions

Overall, 8 to 36 compounds were detected in soil gas on a project basis, avg was 20

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Only 5% of gas detections exceeded gas SLs, but this still translated to over half of our projects indicating soil gas concerns

NOTE: we looked at RES SLs, but most sites were NONRES

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VI SLs for soil and GW individually were fair indicators for gas impacts (62% and 77%); taken together they were even better (89%)

SME

Thank you

We will take questions now…