Petroleum Vapor Intrusion: Sampling & Analytical Issues

PVI Webinar

June 26, 2012

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Most Common VI Bloopers

- Unit Confusion
  - Assuming ug/L equivalent to ppbv
  - Assuming ug/m3 equivalent to ppbv
  - Vacuum units: inches Hg to inches water
- Screening Levels
  - Comparing to generic screening Levels
  - Not calculating correct levels
- Sampling & Analysis Errors
  - Using wrong hardware
  - Using wrong analysis

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Sample ID	Date Sampled	TPH Gas mg/L	Benzene mg/L	Toluene mg/L	Ethylbenzene mg/L	Xylenes mg/L	MTBE mg/L
Residential Land Use ESL ((Shallow Soil Gas)	NA	10.0	0.084	63.0	0.98	21.0	9.4
SG1	11/10/2009	<0.25	<0.05	<0.05	<0.05	<0.05	NT
	10/1/2010	NT	<0.005	<0.005	<0.005	<0.005	<0.005
SG2	11/10/2009	<0.25	<0.05	<0.05	<0.05	<0.05	NT
	10/1/2010	NT	<0.005	<0.005	<0.005	<0.005	<0.005
SS1	11/10/2009	<0.25	<0.05	<0.05	<0.05	<0.05	NT
	10/1/2010	NT	<0.005	<0.005	<0.005	<0.005	<0.005

Notes

<###	Below Laboratory Method Detection Limit
mg/L	Milligram per liter
MTBE	Methyl *tertiary* butyl ether
NA	Not applicable
NT	Analyte not tested
TPHg	Total Petroleum Hydrocarbons as gasoline

CHEMICAL & ENVIRONMENTAL LABORATORIES, INC.

ANALYTICAL REPORT

--- VOLATILE ORGANICS BY EPA TO-15 (GC/MS) ---

Client Name :
Project Name :
Matrix : Air
Unit: ppm v

Date Sampled :
Date Received :
Date Analyzed :
Date Reported :

SAMPLE ID	SS Closet	SG1	SG		MDL	PQL
C&E LAB ID						
DILUTION FACTOR	1	1	1			
1,2,4-Trimethylbenzene	ND	ND	ND		0.005	0.01
1,3-Dichlorobenzene	ND	ND	ND		0.005	0.01
1,4-Dichlorobenzene	ND	ND	ND		0.005	0.01
	ND	ND	ND		0.005	0.01

IA & SG Screening Levels

- Indoor Air:
  - Benzene Res: 0.084 ug/m3 (1e-6)
  - Benzene Com: 4.2 ug/m3 (1e-5) 50x higher
- Sub-slab Soil Gas
  - Benzene Res: 8.4 ug/m3 (1e-6), a=.01
  - Benzene Com: 840 ug/m3 (1e-5), a=.005 100x higher
- External Soil Gas (5’ bgs)
  - Benzene Res: 42 ug/m3 (1e-6), a=.002
  - Benzene Com: 4200 ug/m3 (1e-5), a=.001 100x higher

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Allowable Soil Gas Levels
(Benzene 1e-6 Risk, residential)

State	Alpha	1/Alpha	Risk Based Level (ug/m^3)
EPA Now	0.002	500	155
EPA 2012?	0.1	10	3.1 (gulp!)
CA	0.002	500	42
NJ	0.05	20	16
MO			118,000
TN	0.0013	780	2,414
CT	0.1	10	192

Allowable Benzene in GW
1e-6 risk

- New OSWER Guidance:

0.31 ug/m3/0.001 = 0.31 ug/L/0.2 = 1.5 ug/L

- Proposed Exclusion Value: 1000 ug/L

~700 times lower than database suggests!!

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Methods to Assess VI

- Indoor Air Sampling
- Groundwater Sampling
- Soil Phase Sampling
- Predictive Modeling
- Measure Flux Directly
- Soil Gas Sampling
- Supplemental Tools/Data

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The Most Important Ingredient

- Experience:
  - Consultant
  - Collector – done soil gas before?
  - Lab – certified for methods?
  - Regulator
  - Public
  - YOU!

What level person is going in the houses?

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Approach Generalizations

- Indoor Air
  - Always find something
  - Multiple sampling rounds: extra time & $
- Groundwater Data
  - Typically over-predicts risk
- Soil Phase Data
  - Typically not allowed; over-predicts risk
- Soil Gas Data
  - Transfer rate unknown
  - Sub-slab intrusive

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Indoor Air Measurement

- Pros:
  - Actual Indoor Concentration
- Cons:
  - Where From?
    - Inside sources (everything!)
    - Outside sources (exhaust)
    - People activities – NO CONTROL!
  - Time-intensive protocols
  - Snapshot, limited data points
  - Expensive!!

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Indoor Air Sampling Lessons

- Always Collect Ambient Air Sample
- Hardware Issues
  - Blanks
  - Performance – Fill at Proper Rate?
  - Fittings Tight? Cross-threaded?
  - Pen/marker Type – Don’t use Sharpies
  - Gauges on cans, not on flow chokes

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But We Don't Use "CHLORINATED" Chemicals Anymore……

Gun Cleaner: TCE

Pepper Spray: TCE

Brake Cleaner: TCE/PCE

Hobby Glue: PCE

Plastics: 1,2-DCA

Why is Long-Term IA Sampling Such a Terrible Idea for Petroleum HCs?

Bloonie Analysis Results

12)	Isopropyl alcohol	3.317	45	94670	3850.82 ng	#	1
13)	Methylene Chloride	3.680	84	6533	7.84 ng	#	1
16)	Diisopropyl ether*	4.264	45	1756282	817.99 ng	#	1
17)	1,1-Dichloroethane	4.091	63	52909	25.95 ng	#	1
18)	Ethyl-t-butyl ether*	4.710	59	501954	253.12 ng		67
19)	2-Butanone	4.871	72	36815	861.58 ng	#	1
22)	Chloroform	4.859	83	22151	9.38 ng	#	35
23)	Bromochloromethane	4.728	128	217	0.58 ng	#	36
26)	1,1-Dichloropropene	5.109	75	2475	1.63 ng	#	1
29)	1,2-Dichloroethane	5.151	62	1445	1.00 ng		56
30)	TAME* (2-methoxy-2-met...	5.347	73	5913	3.94 ng	#	54
31)	Benzene*	5.264	78	2724469	750.89 ng		100
32)	Trichloroethene	5.705	95	1454	1.23 ng	#	12
33)	1,2-Dichloropropane	5.847	63	109116	143.17 ng	#	1
34)	Bromodichloromethane	6.008	83	127010	88.94 ng	#	47
35)	Dibromomethane	5.961	93	794	1.84 ng	#	28
36)	cis-1,3-Dichloropropene	6.336	75	3448	2.82 ng	#	1
38)	Methyl Isobutyl Ketone	6.520	43	737901	1989.35 ng	#	49
39)	Toluene*	6.592	92	7153783	2744.00 ng	#	57
40)	trans-1,3-Dichloropropene	6.651	75	14157	12.87 ng	#	1
41)	1,1,2-Trichloroethane	6.860	83	219678	553.89 ng	#	1
42)	1,2-Dibromoethane	7.139	107	424	0.84 ng		96
46)	2-Hexanone	7.127	43	490027	809.97 ng	#	33
47)	Dibromochloromethane	7.312	129	11484	6.08 ng		94
48)	Chlorobenzene	7.717	112	60252	10.78 ng	#	26
49)	Ethylbenzene*	7.669	106	2499510m	715.67 ng		

Bloonie Analysis Results (continued)

60)	n-Propylbenzene	8.616	91	8054470	1288.03 ng	#	26
62)	1,3,5-Trimethylbenzene	8.741	105	6061679m	1318.01 ng		
63)	2-Chlorotoluene	8.681	91	6809750	1789.21 ng		49
64)	4-Chlorotoluene	8.741	91	1265341	322.07 ng		50
65)	tert-Butylbenzene	9.027	119	1891115	435.53 ng		75
66)	1,2,4-Trimethylbenzene	9.027	105	8143013m	1879.66 ng		
67)	sec-Butylbenzene	9.027	105	8143968	1416.03 ng		60
68)	p-Isopropyltoluene	9.253	119	54681	11.06 ng		92
71)	n-Butylbenzene	9.562	91	27682	5.95 ng		99
76)	Naphthalene	11.033	128	869	0.69 ng		100
79)	Ethanol	2.978	45	983528	207445.35 ng		100
80)	t-Butanol *	3.317	59	432657	9715.81 ng	#	1

Cleaning Your Dishes?
(or Polluting Your House)

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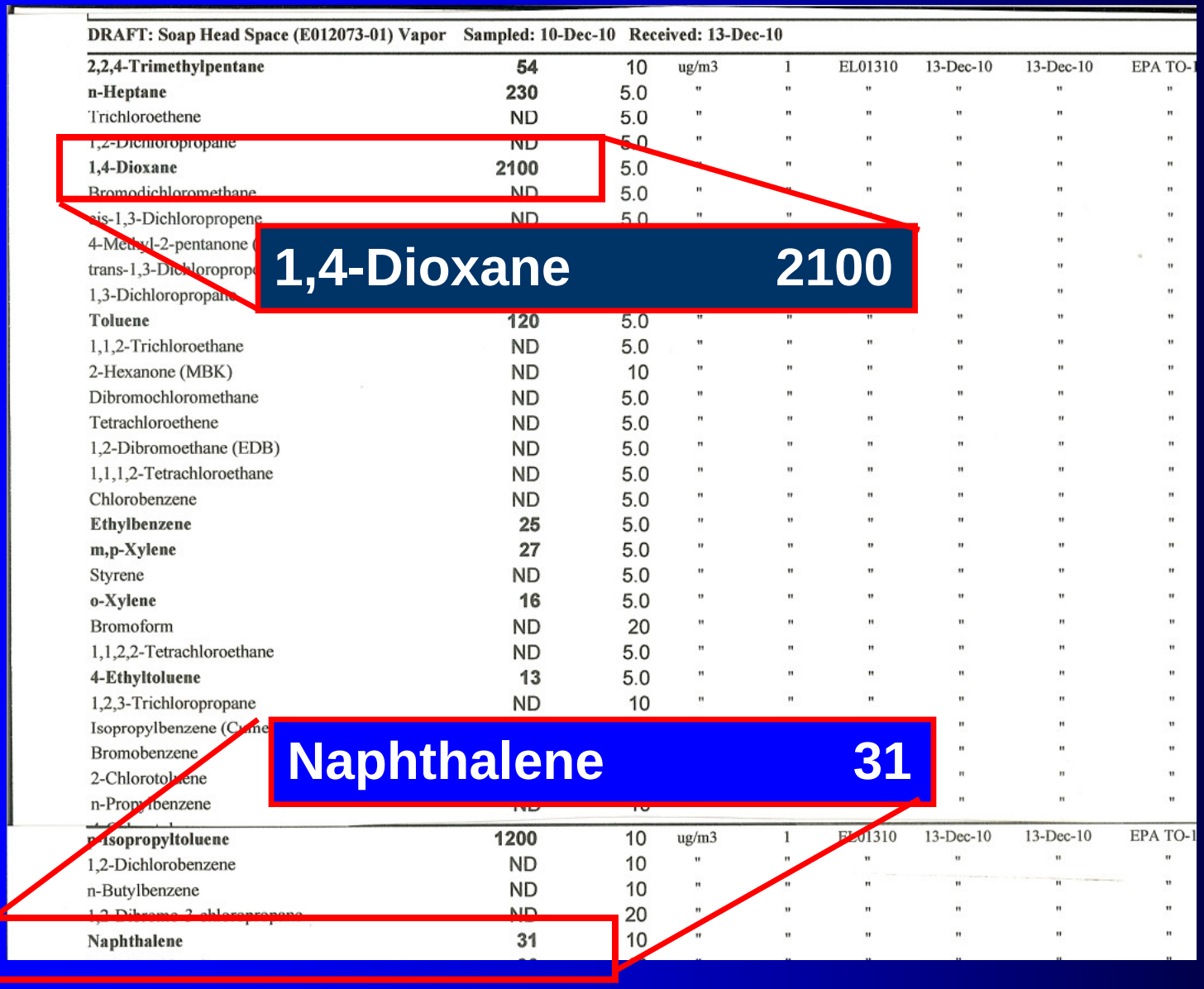
Dawn VOC Analysis Results



DRAFT: Soap Head Space (E012073-01) Vapor	Sampled: 10-Dec-10	Received: 13-Dec-10						
2,2,4-Trimethylpentane	**54**	10	ug/m3	1	EL01310	13-Dec-10	13-Dec-10	EPA TO-1
n-Heptane	**230**	5.0	"	"	"	"	"	"
Trichloroethene	ND	5.0	"	"	"	"	"	"
1,2-Dichloropropane	ND	5.0	"	"	"	"	"	"
1,4-Dioxane	**2100**	5.0	"	"	"	"	"	"
Bromodichloromethane	ND	5.0	"	"	"	"	"	"
cis-1,3-Dichloropropene	ND	5.0	"	"	"	"	"	"
4-Methyl-2-pentanone								
trans-1,3-Dichloroprop								
1,3-Dichloropropane								
Toluene	**120**	5.0	"	"	"	"	"	"
1,1,2-Trichloroethane	ND	5.0	"	"	"	"	"	"
2-Hexanone (MBK)	ND	10	"	"	"	"	"	"
Dibromochloromethane	ND	5.0	"	"	"	"	"	"
Tetrachloroethene	ND	5.0	"	"	"	"	"	"
1,2-Dibromoethane (EDB)	ND	5.0	"	"	"	"	"	"
1,1,1,2-Tetrachloroethane	ND	5.0	"	"	"	"	"	"
Chlorobenzene	ND	5.0	"	"	"	"	"	"
Ethylbenzene	**25**	5.0	"	"	"	"	"	"
m,p-Xylene	**27**	5.0	"	"	"	"	"	"
Styrene	ND	5.0	"	"	"	"	"	"
o-Xylene	**16**	5.0	"	"	"	"	"	"
Bromoform	ND	20	"	"	"	"	"	"
1,1,2,2-Tetrachloroethane	ND	5.0	"	"	"	"	"	"
4-Ethyltoluene	**13**	5.0	"	"	"	"	"	"
1,2,3-Trichloropropane	ND	10	"	"	"	"	"	"
Isopropylbenzene (Cume								
Bromobenzene								
2-Chlorotoluene								
n-Propylbenzene								
p-Isopropyltoluene	**1200**	10	ug/m3	1	EL01310	13-Dec-10	13-Dec-10	EPA TO-1
1,2-Dichlorobenzene	ND	10	"	"	"	"	"	"
n-Butylbenzene	ND	10	"	"	"	"	"	"
1,2-Dibromo-3-chloropropane	ND	20	"	"	"	"	"	"
Naphthalene	**31**	10	"	"	"	"	"	"

1,4-Dioxane 2100

Naphthalene 31

No Wonder She's Smiling

DRAFT: Soap Head Space (E012073-01) Vapor	Sampled: 10-Dec-10	Received: 13-Dec-10						
Propene	**190**	10	ug/m3	1	EL01310	13-Dec-10	13-Dec-10	EPA TO-15
Dichlorodifluoromethane (F12)	ND	10	"	"	"	"	"	"
Chloromethane	**190**	5.0	"	"	"	"	"	"
Dichlorotetrafluoroethane (F114)	ND	10	"	"	"	"	"	"
Vinyl chloride	ND	5.0	"	"	"	"	"	"
1,3-Butadiene	**7.2**							
Bromomethane	ND							
Chloroethane	ND							
Ethanol	**6000000**							E
Trichlorofluoromethane (F11)	ND	5.0	"	"	"	"	"	"
Acetone	ND	20	"	"	"	"	"	"
Isopropyl alcohol	ND	10	"	"	"	"	"	"
1,1-Dichloroethene	ND	5.0	"	"	"	"	"	"
Tertiary-butyl alcohol (TBA)	ND	20	"	"	"	"	"	"
1,1,2-Trichlorotrifluoroethane (F113)	ND	10	"	"	"	"	"	"
Methylene chloride (Dichloromethane)	ND	10	"	"	"	"	"	"
Carbon disulfide	ND	5.0	"	"	"	"	"	"
trans-1,2-Dichloroethene	ND	5.0	"	"	"	"	"	"
Methyl tertiary-butyl ether (MTBE)	ND	5.0	"	"	"	"	"	"
Vinyl acetate	ND	10	"	"	"	"	"	"
1,1-Dichloroethane	ND	5.0	"	"	"	"	"	"
2-Butanone (MEK)	**100**	5.0	"	"	"	"	"	"
n-Hexane	**110**	5.0	"	"	"	"	"	"
cis-1,2-Dichloroethene	ND	5.0	"	"	"	"	"	"
Diisopropyl ether (DIPE)	ND	5.0	"	"	"	"	"	"
Ethyl acetate	ND	5.0	"	"	"	"	"	"
Chloroform	**130**	5.0	"	"	"	"	"	"
2,2-Dichloropropane	ND	10	"	"	"	"	"	"
Tetrahydrofuran	ND	5.0	"	"	"	"	"	"
Ethyl tert-butyl ether (ETBE)	ND	5.0	"	"	"	"	"	"
1,1,1-Trichloroethane	ND	5.0	"	"	"	"	"	"
1,2-Dichloroethane (EDC)	ND	5.0	"	"	"	"	"	"
1,1-Dichloropropene	ND	10	"	"	"	"	"	"
Benzene	**19**	5.0	"	"	"	"	"	"
Carbon tetrachloride	ND	5.0	"	"	"	"	"	"
Dibromomethane	ND	10	"	"	"	"	"	"
Cyclohexane	ND	10	"	"	"	"	"	"
Tertiary-amyl methyl ether (TAME)	ND	5.0	"	"	"	"	"	"

Ethanol 600,000!!

Barbasol ... AHHHHH!!!

Ahhh or Aaaah?

DRAFT: Volatile Organic Compounds by EPA TO-15

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Analyte	Result	Reporting Limit	Units	Dilution Factor	Batch	Prepared	Analyzed	Method	Notes
DRAFT: Shaving Cream (E103030-01) Vapor	**Sampled: 03-Mar-11**	**Received: 04-Mar-11**							
Carbon disulfide	**136**	31.5	"	"	"	"	"	"	
trans-1,2-Dichloroethene	ND	40.2	"	"	"	"	"	"	
Methyl tertiary-butyl ether (MTBE)	ND	18.3	"	"	"	"	"	"	
Vinyl acetate	ND	17.8	"	"	"	"	"	"	
1,1-Dichloroethane	ND	20.5	"	"	"	"	"	"	
2-Butanone (MEK)	ND	149	"	"	"	"	"	"	
n-Hexane	**2590**	17.8	"	"					
cis-1,2-Dichloroethene	ND	20.1	"	"					
Diisopropyl ether (DIPE)	ND	21.2	"	"					
Ethyl acetate	ND	91.2	"	"					
Chloroform	ND	24.8	"	"					
2,2-Dichloropropane	ND	23.4	"	"					
Tetrahydrofuran	ND	149	"	"					
Ethyl tert-butyl ether (ETBE)	ND	21.2	"	"					
1,1,1-Trichloroethane	ND	27.6	"	"	"	"	"	"	
1,2-Dichloroethane (EDC)	ND	20.5	"	"	"	"	"	"	
1,1-Dichloropropene	ND	23.0	"	"	"	"	"	"	
Benzene	**389**	16.2	"	"	"	"	"	"	
Carbon tetrachloride	ND	31.9	"	"	"	"	"	"	
Cyclohexane	**469**	87.1	"	"	"	"	"	"	
p-Isopropyltoluene	**37100**	27.8	ug/m3	5	EC10305	04-Mar-11	04-Mar-11	EPA TO-15	E
1,2-Dichlorobenzene	ND	61.0	"	"	"	"	"	"	
n-Butylbenzene	**3000**	27.8	"	"	"	"	"	"	
1,2-Dibromo-3-chloropropane	ND	49.0	"	"	"	"	"	"	
Naphthalene	**104**	26.6	"	"	"	"	"	"	
1,2,4-Trichlorobenzene	**160**	37.6	"	"	"	"	"	"	
1,2,3-Trichlorobenzene	**134**	37.6	"	"	"	"	"	"	
Hexachlorobutadiene	**89.2**	54.1	"	"	"	"	"	"	
Xylenes (total)	ND	22.0	"	"	"	"	"	"	
TPHv (C5 - C11)	**680000**	500	ug/m3	5	EC10305	04-Mar-11	04-Mar-11	EPA TO-15	E

CS2 = 140 ug/m3

H&P Mobile Geochemistry Inc.

Benzene = 389 ug/m3

TPH=680,000 ug/m3

Got Gas?
(natural that is)

Active Soil Gas

- Pros:
  - Representative of Subsurface Processes
  - Higher Screening Levels
  - Relatively Inexpensive
  - Can Give Real-time Results
- Cons:
  - Mass Transfer Coefficient Unknown
  - Large Spatial Variability
  - Protocols Still Debated

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Which Soil Gas Method?

- Active?
- Passive? (limited use)
- Flux Chambers? (limited use)

Active method most often employed for VI

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Passive Soil Gas Samplers

Adsorbent inside tube open on one end

Adsorbent inside badge

Adsorbent inside vapor permeable, waterproof membrane

Site #2 – High GW Site

- Trailer Park Adjacent to former Gas Station
- Gasoline Contamination Underlying
  - GW contamination ~6’ bgs
  - Very high soil gas at 1.5’ to 3’

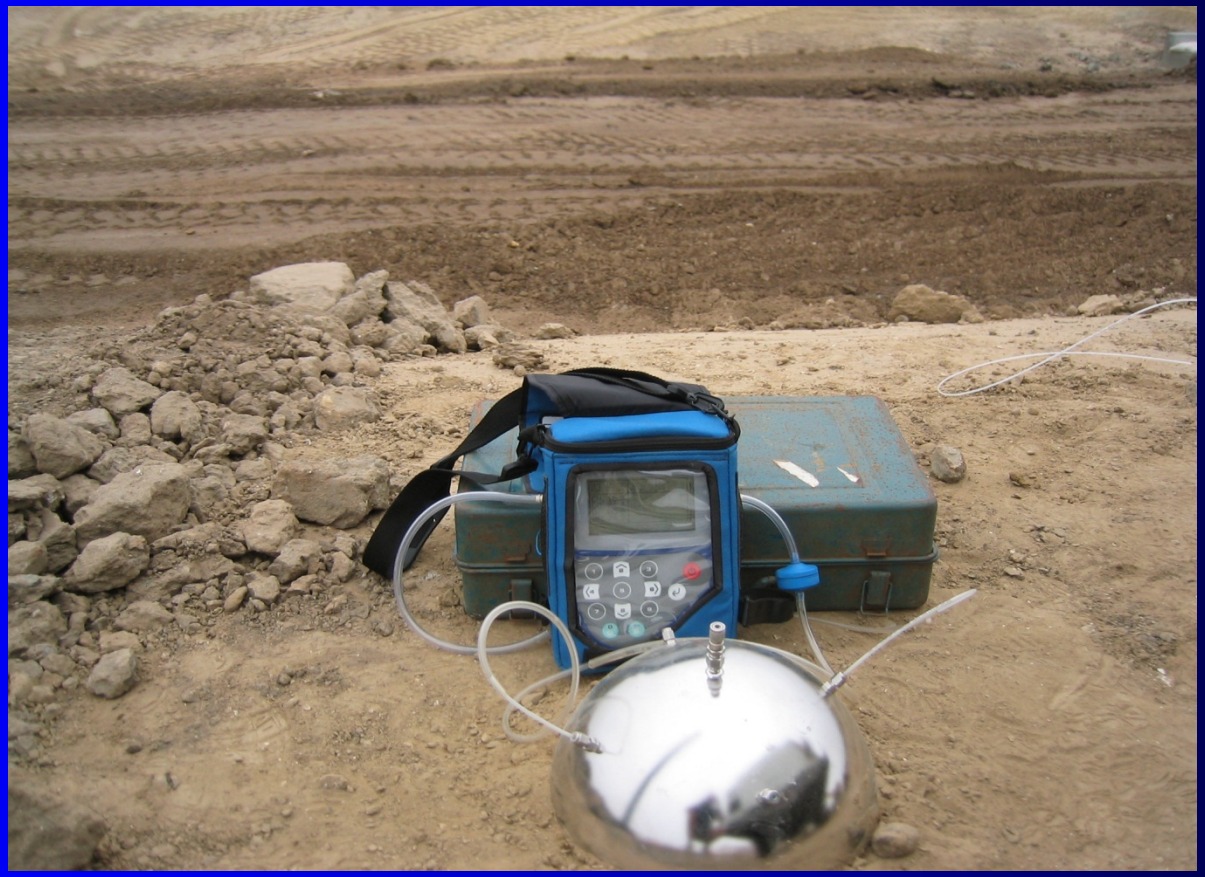
No slabs to sample

Chances for False Positives High with IA

What Alternative Approach to Use?

Site #2

Static Flux Chamber



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Probe Considerations

- Tubing Type
  - Rigid wall tubing ok (nylon, teflon, SS)
  - Flexible tubing not (tygon, hardware store)
- Probe Tip
  - Beware metal tips (may have cutting oils)
- Materials Used to Bury Probes
  - Sand, cement
- Equipment Blanks
  - Need to collect blank through collection system

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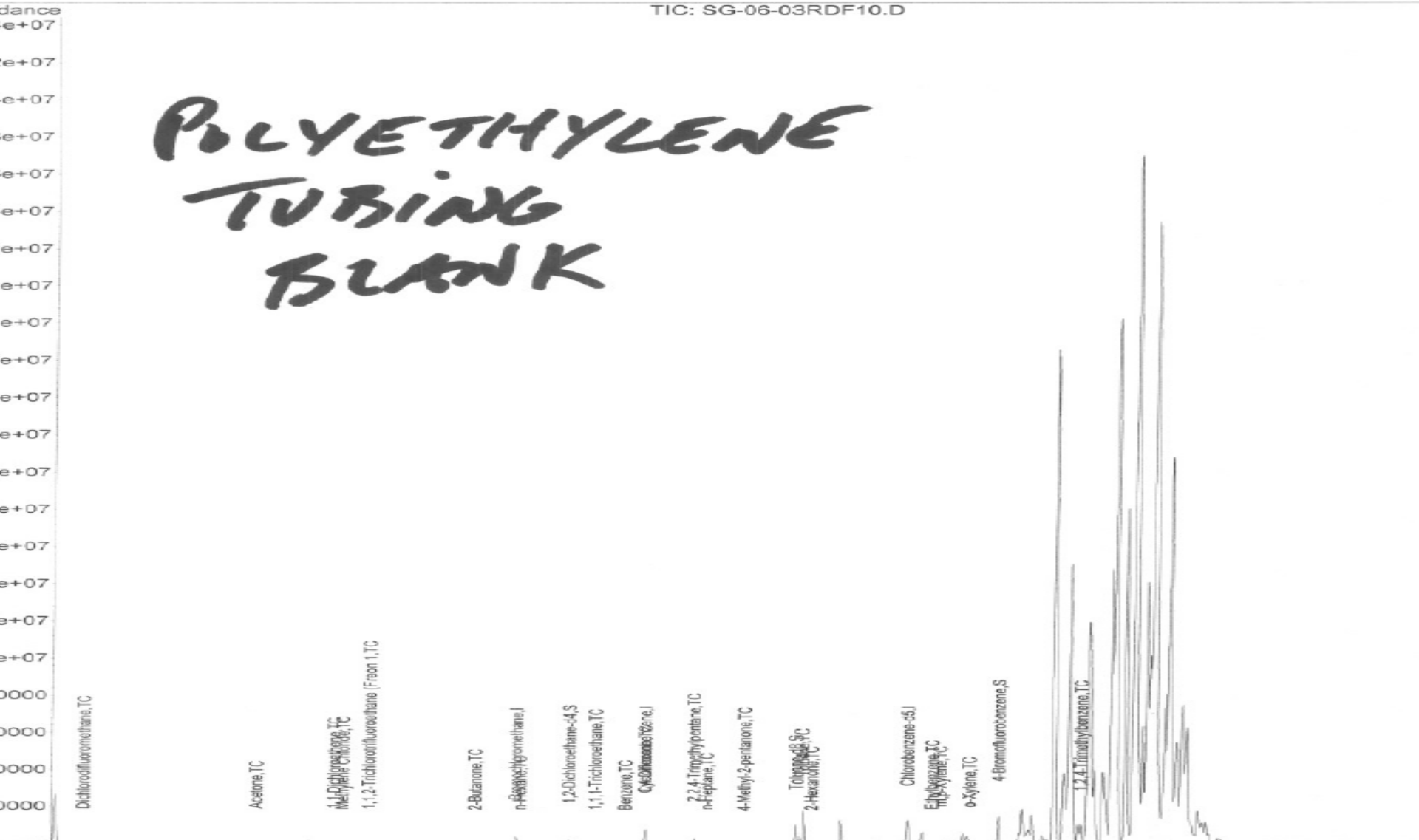
Path : D:\111406.12p\
File : SG-06-03RDF10.D
On : 14 Nov 2006 6:05 pm
erator : cb
ple : [redacted]
C : 10
Vial : 11 Sample Multiplier: 1

nt Time: Nov 15 08:59:47 2006
nt Method : C:\MSDCHEM\1\METHODS\102406TOUGM3.M
nt Title : TO-15 Full Scan Mode
st Update : Fri Oct 27 07:30:49 2006
sponse via : Initial Calibration



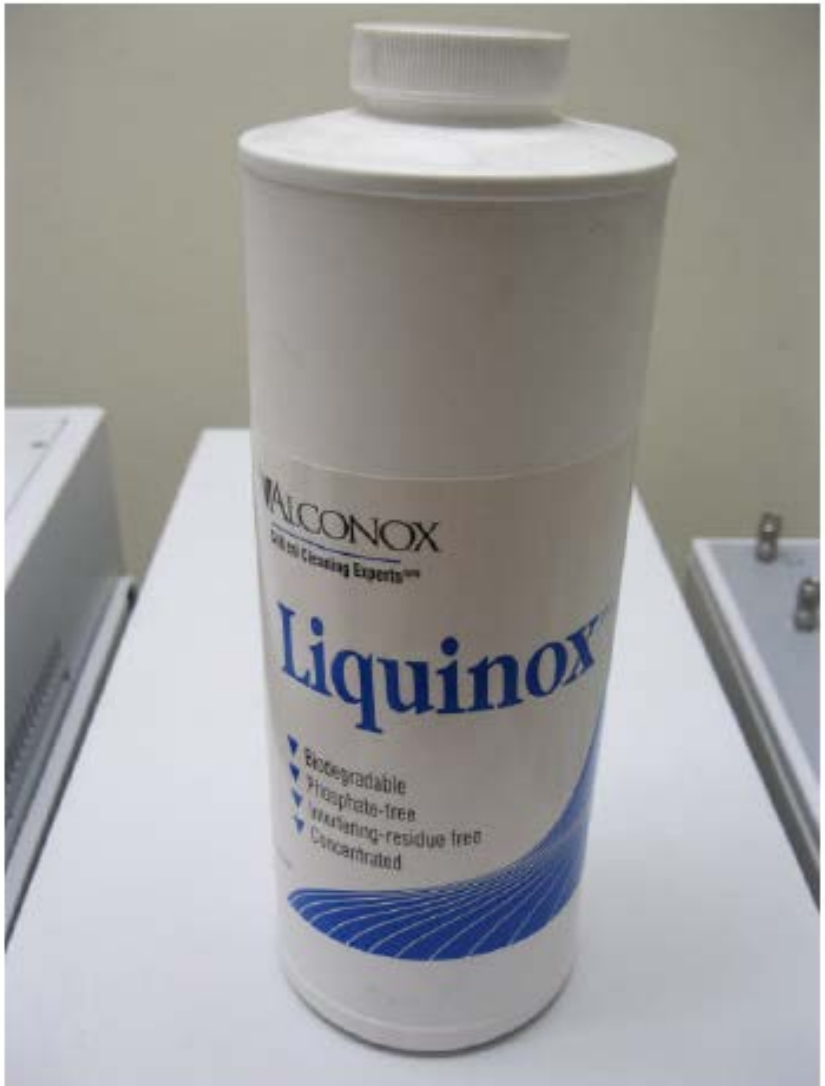
Some Lessons Learned

Watch what you use to seal holes

Loaded with TCE

Loaded with TBA

Deconning?


ALCONOX
Liquinox
Biodegradable
Phosphate-free
Concentrated

Better Be Sure to Triple Wash!

H&P Mobile Geochemistry, Inc.

Analyte	Result	Reporting Limit	Units	Dilution Factor	Batch	Prepared	Analyzed	Method	Notes
DRAFT: Liquinox (E102045-02) Vapor Sampled: 10-Feb-11 Received: 10-Feb-11									
Benzene	**1530**	16.2	ug/m3	5	EB11401	10-Feb-11	10-Feb-11	EPA TO-15	
Carbon tetrachloride	ND	31.9	"	"	"	"	"	"	
Trichloroethene	ND	27.3	"	"	"	"	"	"	
1,2-Dichloropropane	ND	46.9	"	"	"	"	"	"	
Bromodichloromethane	ND	34.0	"	"	"	"	"	"	
cis-1,3-Dichloropropene	ND	23.0	"	"	"	"	"	"	
4-Methyl-2-pentanone (MIBK)	ND	41.5	"	"	"	"	"	"	
trans-1,3-Dichloropropene	ND	23.0	"	"	"	"	"	"	
Toluene	**90.2**	19.1	"	"	"	"	"	"	
1,1,2-Trichloroethane	ND	27.6	"	"	"	"	"	"	
2-Hexanone (MBK)	ND	41.5	"	"	"	"	"	"	
Dibromochloromethane	ND	43.2	"	"	"	"	"	"	
Tetrachloroethene	ND	34.4	"	"	"	"	"	"	
1,2-Dibromoethane (EDB)	ND	39.0	"	"	"	"	"	"	
1,1,1,2-Tetrachloroethane	ND	34.8	"	"	"	"	"	"	
Chlorobenzene	ND	23.4	"	"	"	"	"	"	
Ethylbenzene	**671**	22.0	"	"	"	"	"	"	
m,p-Xylene	**1950**	44.0	"	"	"	"	"	"	
Styrene	ND	21.6	"	"	"	"	"	"	
o-Xylene	**612**	22.0	"	"	"	"	"	"	
Bromoform	ND	52.4	"	"	"	"	"	"	
1,1,2,2-Tetrachloroethane	ND	34.8	"	"	"	"	"	"	

Benzene =1530 ug/m3

TEX>3500 ug/m3

Soil Gas Sampling Issues

- Sample Size
  - Greater the volume, greater the uncertainty
  - Smaller volumes faster & easier to collect
- Containers
  - Canisters: More blank potential. Higher cost
  - Tedlars: Good for ~2 days. Easier to collect
- Flow Rate
  - Really not imp. But most agencies < 200 ml/min
- Tracer/Leak Compound
  - Crucial for sub-slab & larger sample volumes
  - Gases (He, SF6, Propane) & Liquids (IPA)

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Canisters vs. Tubes

SVOC Sampling

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Beware of the Hardware

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Soil Gas Sampling for PVI

- Might Need to Sample <5’ bgs
  - If samples >5’ bgs exceed allowable levels
  - How to know? On-site analysis best
  - If not, collect samples anyway
- Always Collect Oxygen Data (& CO2 & CH4)
- Might Need Soil Phase Data

Oxygen Profiling Only?

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NJDEP Gasoline Exclusion Criteria

VI Investigation is not required when:

- ≥10 ft between water table and foundation and benzene in GW is ≤1,000 µg/L; or
- ≥5 ft between seasonal high water table and benzene in shallow GW is ≤100 µg/L; or
- ≥5 ft between seasonal high water table and foundation, oxygen levels measured at ≥2% (v/v), and benzene in shallow GW is ≤1,000 µg/L.

CA Low Risk Closure Policy

A LUFT site is assumed to present no unacceptable risk from vapor intrusion if the following conditions are met:

- *Dissolved* groundwater concentrations <1000 (ug/L) for benzene and 5’ of clean soil to receptor.
- *Dissolved* groundwater concentrations >1000 (ug/L) for benzene for TPH and 10’ from receptor.
- Soil gas valuex 100x higher if 5’ of aerobic zone.
- Free product is 30’ or more from receptor

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Definition of Clean Soil (p.138)

- In the unsaturated zone, clean soil is defined as TPH concentrations less than 100 mg/kg or oxygen present concentrations >4%.

Under these conditions, it is assumed that natural attenuation is sufficient to mitigate Concentrations of volatile petroleum constituents

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O_2 Profiling - Approach

- 18 Locations Throughout Neighborhood
- Vertically Every Foot Down to 8’-10’ bgs
  - Used direct-push (not PRT)
  - Oxygen by portable meter (& CO2 & CH4)
- Soil Samples at 1’ & 5’ bgs – (backup)
- Did All Locations in 11 Hours!

O_2 Profiling - Results

- Oxygen > 10% from 1’-5’ at all Locations
- Oxygen > 4% from 5’-8’ at all Locations
- Soil Phase Data < 100 mg/kg
- Only Houses With Basements Proposed for IA/SS

Reduced # of Houses from ~50 to 10
~$40,000 Savings per event!!

Common Soil Gas Analyses

- VOCs
  - Soil and Water Methods: 8021, 8260
  - Air Methods: TO-14, TO-15, TO-17
- Hydrocarbons
  - 8260, TO-3, MA-APH
  - Must check lab to see if they can do
- Oxygen, carbon dioxide
  - ASTM 1945-96
  - Portable meters ok
- SVOCs
  - TO-4, TO-10, TO-13

Autosampler GC/MS for TO-17 Analysis

TO-17 gets PVOCs, TPHg, TPHd in same run!!

TPH Compounds

- Recommended
  - BTEX (BE only drivers)
  - Methane
  - 1-2 dichloroethane (EDC) & 1-2 dibromoethane (EDB)
  - Naphthalene
- Some States:
  - Aliphatics (C5-C8 & C9-C12)
  - Aromatics (C9-C10)

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Other Analytical Issues

- 1,3 Butadiene
  - False positive caused by i-butylene
  - Must have lab manually read ion chromatogram
  - Not on most agency soil gas target lists
- Naphthalene
  - 8260, TO-15, TO-17

TO-17 gets PVOCs, TPHg, TPHd in same run!!

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Supplemental Tools/Data

- Site Specific Alpha Using Radon
  - Factor of 10 to 100. $100/sample
- Indoor Air Ventilation Rate
  - Factor of 2 to 10. ~$500 per determination.
- Vadose Zone Permeability Testing
- Other
  - Flux Chambers – supportive LOE
  - Continuous real-time monitoring
  - Pressure measurements/fluctuation

Refer to ASTM E2600-08 Table X.1 for summary table

7-Eleven building before, during, and after the release of the carbon dioxide gas. The air change rate was calculated using a first-order exponential equation for the carbon dioxide decay rate.

The two air change measurements were made between 9:35 and 10:05 AM (low foot traffic volume) and between 12:10 and 12:35 PM (high foot traffic volume). The approximate volume of the retail portion of the 7-Eleven store is 11,400 cubic feet.

3.0 FINDINGS

The air change rates are summarized in the following table.

Description	*Approximate air changes per hour calculated by regression analysis from logged data*
Average during low foot traffic (mid morning)	2.75
Average during high foot traffic (lunch hour)	3.26
Minimum	2.64
Maximum	3.34
Overall average	3.11

The estimated potential error in these measurements is plus or minus 0.3 air changes per hour. Details of the air change measurements are presented in Appendix A.

Forthcoming VI Events

- AWMA VI Conference – Denver: Oct 3 & 4
- 2-day VI Course: 2013 Dates Being Scheduled

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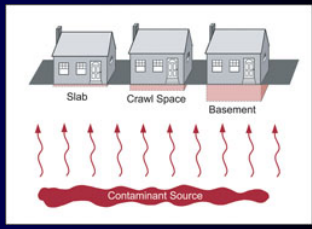
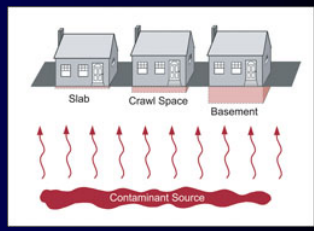
Previews of the VI Future



- VI Likely to be a Concern at Your Sites
- Variable Regulatory Guidance Makes Assessment Tricky & Slow
- New EPA OSWER Guidance to be Stricter
- ASTM Standard Increase # of Sites
- Hydrocarbons to be Less of a Concern

VI Articles



- Overview of SV Methods (www.handpmg.com)
  - LustLine Part 1 - Active Soil Gas Method, 2002
  - LustLine Part 2 - Flux Chamber Method, 2003
  - LustLine Part 3 - FAQs October, 2004
  - LustLine Part 4 – Soil Gas Updates, Sept 2006
  - LustLine – VI For Petroleum Hydrocarbons, Dec 2010
- Robin Davis' Articles on Bioattenuation:
  - Lustline #61 May 2009
  - LustLine #52 May 2006 (www.neiwpcc.org)

Forthcoming Sampling Guidance: ITRC PVI Toolkit

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For a copy of this presentation with lecture notes go to:

www.handpmg.com, Presentations