



PVI Case Studies: Including Methane



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What Homeowners and Companies Do NOT Want



Front Yard Sampling for CH₄

Soil Gas Results-Evacuated Home



Site 1

Sample depth	Methane (ppmv)
1. Subslab 0.5 ft	12
2. Subslab 3 ft	8,300
3. Outside 1ft	1,700
4. Outside 3ft	180,000

Site 2

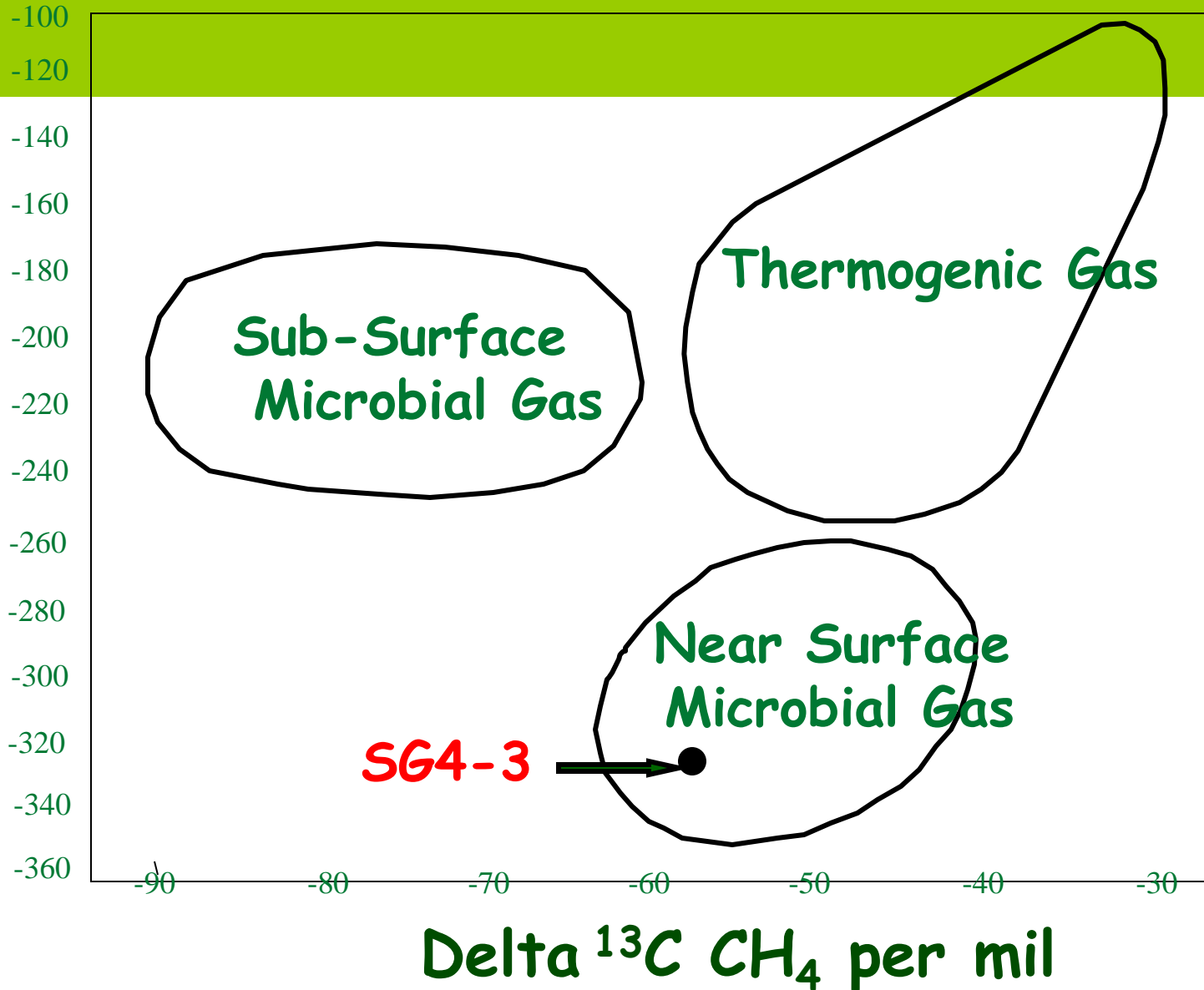
Sample depth	Methane (ppmv)
1. Subslab 0.5 ft	<10
2. Subslab 3 ft	11,000
3. Outside 1ft	45
4. Outside 5ft	120,000

Isotech Gas Data: High CH₄ Sample



- O₂ = 2.54%
- CO₂ = 35.19%
- N₂ = 38.9%
- C1 = 22.9%
- C2 through C6+ = 0%
- Delta ¹³C1 = -57.18 per mil
- Delta DC1 = -328.4 per mil
- ¹⁴C pMC = 109%

Delta D CH₄ per mil



Sources of gases as defined in Coleman (1994)

PVI Case Studies



Analyzing soil gas samples in late 1980's for oil and gas exploration

Case Study: How NOT to Do a PVI Investigation!

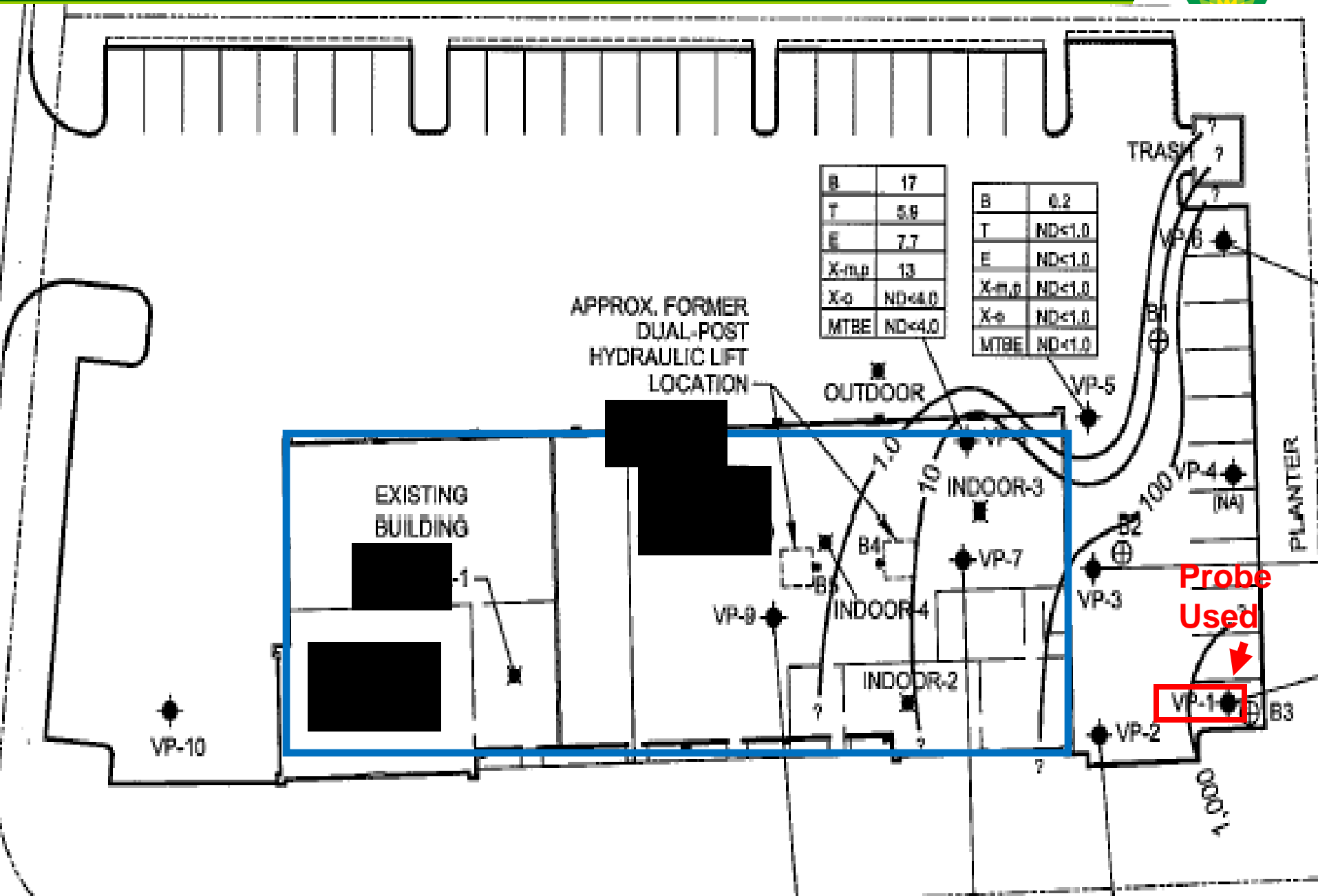


TABLE 1
SOIL GAS SURVEY VAPOR SAMPLE ANALYTICAL RESULTS

Sample Name	Sample Date	VFH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	m,p-Xylenes (ug/L)	o-Xylenes (ug/L)
VP-1-5	30-Aug-07	ND<200	0.4	ND<1.0	ND<1.0	ND<1.0	ND<1.0
VP-1-15	30-Aug-07	620	4.1	ND<4.0	ND<4.0	ND<4.0	ND<4.0
VP-1-25, 1PV	30-Aug-07	40,000	1200	ND<100	ND<100	110	ND<100
VP-1-25, 3PV	30-Aug-07	13,000	400	ND<100	ND<100	110	ND<100
VP-1-25, 7PV	30-Aug-07	7,800	200	ND<100	ND<100	ND<100	ND<100

Table 5

PRELIMINARY SCREENING EVALUATIONS



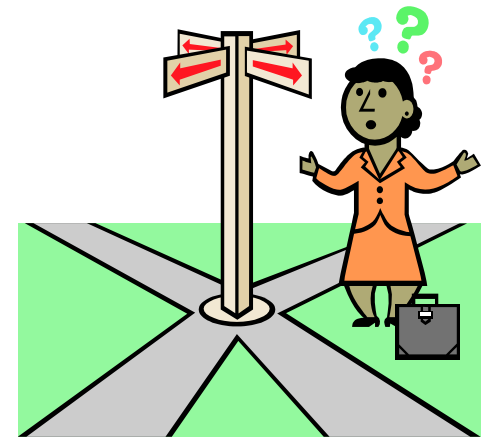
Preliminary Screening Evaluations for Soil Gas					
Analyte	Sample Name (sample with the maximum concentration)	Concentration ($\mu\text{g}/\text{m}^3$)	Default Attenuation Factor	Indoor Air Concentration ($\mu\text{g}/\text{m}^3$)	OEHHA Chronic Inhalation RELs ($\mu\text{g}/\text{m}^3$)

Benzene	VP-1-25	1,200	0.001	1.20	60
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Toluene	VP-2-25	420	0.001	0.42	300
Ethylbenzene	VP-6-25	30	0.001	0.03	2,000
Xylenes	VP-1-25	110	0.001	0.1	700
MTBE	VP-1-25	170	0.001	0.2	8,000

1200 ug/L = 1,200,000 ug/m³

CA-EPA 1 e-5 allowable benzene value: 4.2 ug/m³

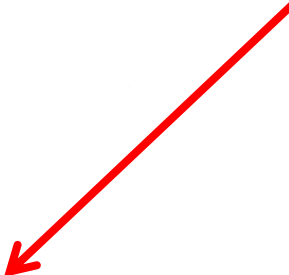


Laboratory analytical results for the vapor samples collected during the soil gas survey indicate that petroleum hydrocarbon vapors are present in the subsurface. The preliminary data was modeled using the advanced version of the Johnson and Ettinger Model (J&E Model). The J&E Model is a fate and transport model that simulates the transport of soil vapors from the subsurface into indoor air. Although the measured vapor concentrations decreased with increasing distance from the vapor source (impacted groundwater), and results for the vapor samples collected from five feet below ground surface (bgs) in each of the vapor probes revealed little to no hydrocarbon vapor concentrations (Table 1), the results of the J&E Model indicated that there was a potential risk of benzene vapor intrusion into indoor air from the concentrations detected at 25 feet bgs in the vapor probes. Therefore, in order to evaluate the potential risk of benzene vapor intrusion into the indoor air of the vacant building at the site, the collection of indoor air samples was proposed. On September 12 and 13, 2007, _____ collected indoor

TABLE 7
J&E MODEL RESULTS

Advanced Soil Gas Screening Model				
Analyte	Sample Name (sample with the maximum concentration)	Concentration (ppmv)	Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
Benzene	VP-1-25	1,200	0.0019	19.0

Benzene is a carcinogen!



Benzene was detected in vapor samples Indoor-1, Indoor-2, and Indoor-3 at concentrations of 0.29, 0.29, and 0.32 ppmv, respectively. Toluene and xylenes were detected in all indoor and outdoor vapor samples. Toluene concentrations ranged from 1.4 to 2.0 ppmv, detected in Indoor-1. Xylenes concentrations ranged from 0.62 to 0.94 ppmv, detected in Indoor-1. Ethylbenzene was detected in Indoor-1 and Indoor-2 at concentrations of 0.29 and 0.22 ppmv, respectively. Indoor air sample analytical results are presented in Table 9.

TABLE 9
INDOOR AIR SAMPLE ANALYTICAL RESULTS

Sample Name	Sample Date	VFH	Benzene	Toluene	Ethylbenzene	Xylenes	MTBE	DIPE	ETBE	T
Indoor-1	12-Sep-07	ND<1,700	<i>0.29</i>	2.0	<i>0.29</i>	0.94	ND<1.0	ND<1.0	ND<1.0	N
Indoor-2	12-Sep-07	ND<2,000	<i>0.29</i>	1.6	<i>0.22</i>	0.83	ND<1.0	ND<1.0	ND<1.0	N
Indoor-3	12-Sep-07	ND<1,900	0.32	1.7	ND<0.30	0.84	ND<1.0	ND<1.0	ND<1.0	N
Indoor-4	12-Sep-07	ND<2,100	ND<0.30	1.5	ND<0.30	0.62	ND<1.0	ND<1.0	ND<1.0	N
Outdoor-1	12-Sep-07	ND<1,800	ND<0.30	1.4	ND<0.30	0.63	ND<1.0	ND<1.0	ND<1.0	N

NOTES:

VFH = Volatile Fuel Hydrocarbons (C4 - C12)

MTBE = Methyl Tertiary Butyl Ether

DIPE = Di-Isopropyl Ether

ETBE = Ethyl Tertiary Butyl Ether

TAME = Tertiary Amyl Methyl Ether

TBA = Tertiary butanol

ND< = Analyte not detected at or above stated laboratory reporting limit, or method detection limit (MDL), if MDL is specified

All concentrations are in parts per billion by volume (ppbv)

TPH analysis by method EPA-2 TO-3, volatiles analysis by method EPA-2 TO-15

Italics indicates that concentrations are estimated values detected at a level less than the reporting limit and greater than or equal to the MDL

CA allowed
Level for
Benzene:
~1 ppbv

Benzene was detected in vapor samples Indoor-1, Indoor-2, and Indoor-3 at concentrations of 0.29, 0.29, and 0.32 ppmv, respectively. Toluene and xylenes were detected in all indoor and outdoor vapor samples. Toluene concentrations ranged from 1.4 to 2.0 ppmv, detected in Indoor-1. Xylenes concentrations ranged from 0.62 to 0.94 ppmv, detected in Indoor-1. Ethylbenzene was detected in Indoor-1 and Indoor-2 at concentrations of 0.29 and 0.22 ppmv, respectively. Indoor air sample analytical results are presented in Table 9.

Based on the results for the ambient air sample (outdoor sample), there are outside influences on indoor air quality of the investigation building. However, the DTSC recommends a minimum of two indoor air sampling events before making a final risk determination for a site. One indoor air sampling event cannot be reasonably representative of continuous long-term exposure within a building. Multiple sampling events should be conducted to characterize exposure over the long term (DTSC, 2004). In addition,

PVI Assesment Needed-: Former Refinery, Free Product, Odors in Building



1. Odors reported in new bldg **2. Free product on site**

3. Sheening present



4. Sampling VI pathways **5. Sampling room with odors**

6. Avoided This!

Gasoline Pipeline Spill in Neighborhood



Emergency Response Clean Up



**Field Lab: Basement: 1165; 1st Floor: 122 ppbv/ Cannister: 1st Floor: 470 ppbv
Other homes: at or below ambient (6.4 ppbv measured)**



Dune sands



**Look
Who showed
up!**

Retail Site in Residential Area



Soil Gas (18 inch depth) assessment data



Service Station

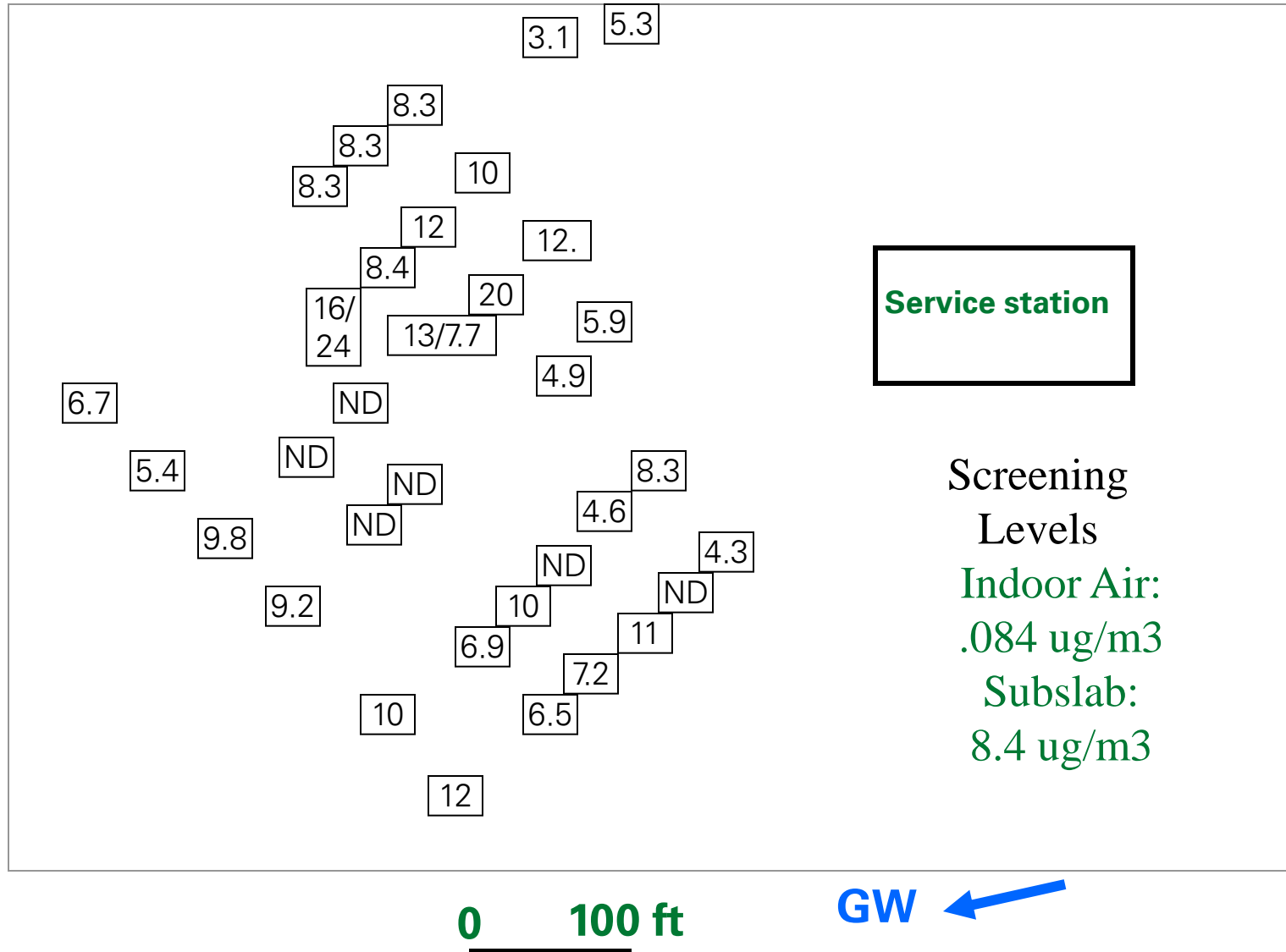
360 Benzene ug/m3

◆ 18 inch soil gas sample

Soil Gas Sample Locations (2 ft and 4 ft)



Subslab Soil Gas Data (ug/m3 benzene)





Conclusions: Subslab Soil Gas Sampling

- The results provided statistical evidence that benzene concentrations inside the study area and outside the study area are not significantly different, and that benzene concentrations found in garage samples are higher than those in non-garage samples (primarily collected from living spaces)
- The resulting benzene *background threshold values* range from $12 \mu\text{g}/\text{m}^3$ (for non-garage samples outside the study area) to $15 \mu\text{g}/\text{m}^3$ (for all benzene data). These benzene concentrations correspond to cancer risk estimates ranging from 1×10^{-6} to 2×10^{-6} , respectively, thus providing statistical evidence that background benzene levels in sub-slab are at or above the OCHCA risk management range level of 1×10^{-6}

Typical House Subslab Investigation



Subslab Sample- Garage



**Note bentonite seal
and syringe sample**

Subslab Sample- Interior of Home



BBQ Grill With Natural Gas Connection



Subslab Sample Results: Home with Leaking Natural Gas Pipeline



Analyte	BBQ	Garage	Patio	Garage #2	Closet
methane	40%	90%	100%	nd (0.1%)	nd (0.1%)
	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
n-hexane	1700	2000	10000	nd (15)	nd (15)
cy-hexane	750	5500	12000	nd (20)	21
n-heptane	460	710	3100	nd (50)	nd (50)
benzene	<u>270</u>	<u>340</u>	<u>1900</u>	<u>6.5</u>	<u>7.9</u>
toluene	150	110	120	44	62
xylenes	40	105	177	113	33
tri-methyl benzene	3	85	25	110	nd (10)
tri-methyl pentane	nd (200)	300	nd (200)	nd (20)	nd (20)

The Final Solution?



Excavation within cell



Clean backfill

SVE Prior to Dig



**SVE Still Running
(1999 to Present)**