VI Issues: Lessons Learned & Case Studies

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June 2012

"Top Ten" List of VI Issues Encountered

- Regulator/Agency Common Issues:

  - Requiring all soil gas samples to be collected in Summa canisters and analyzed by TO-15 when 8260 or 8021 ok.
  - Regulators using guidance for petroleum hydrocarbon issue that was written for chlorinated hydrocarbons.
  - Not understanding or usurping their own State guidance (i.e., making up their own rules)

- Example Contractor Issues:

  - Using RBSLs for soil gas for sub-slab or vice-versa.
  - Using screening levels as clean-up criteria
  - Calculating wrong screening levels
  - Using non-cancer screening levels for carcinogens
  - Using wrong exposure times

"Top Ten" List of VI Issues Encountered

- Soil Gas Probe Installation Issues:
  - Using wrong tubing type
  - Pinching off of tubes due to incorrect surface completion
  - Not collecting an equipment blank
  - Using air knife to clear borehole

- Consultant Field Sampling Issues:
  - Not opening Summa canisters or Tedlar bags
  - No experience with swagelok connectors
  - Applying too much liquid tracer

"Top Ten" List of VI Issues Encountered

- Unit Confusion:
  - Assuming ug/L equivalent to ppbv
  - Assuming ug/m3 equivalent to ppbv
  - Not knowing how to go from ug/m3 to ug/L
  - Vacuum units: inches Hg to inches H20

- Workplan Issues:
  - Workplans submitted for VI work not needed
  - Too many samples recommended by consultant than what is needed
  - Not collecting samples in upper part of vadose zone (e.g., 5' bgs) to demonstrate bioattenuation
  - Analyzing compounds that were never used at the site.

Case Study on How Not to Do PVI Investigation!

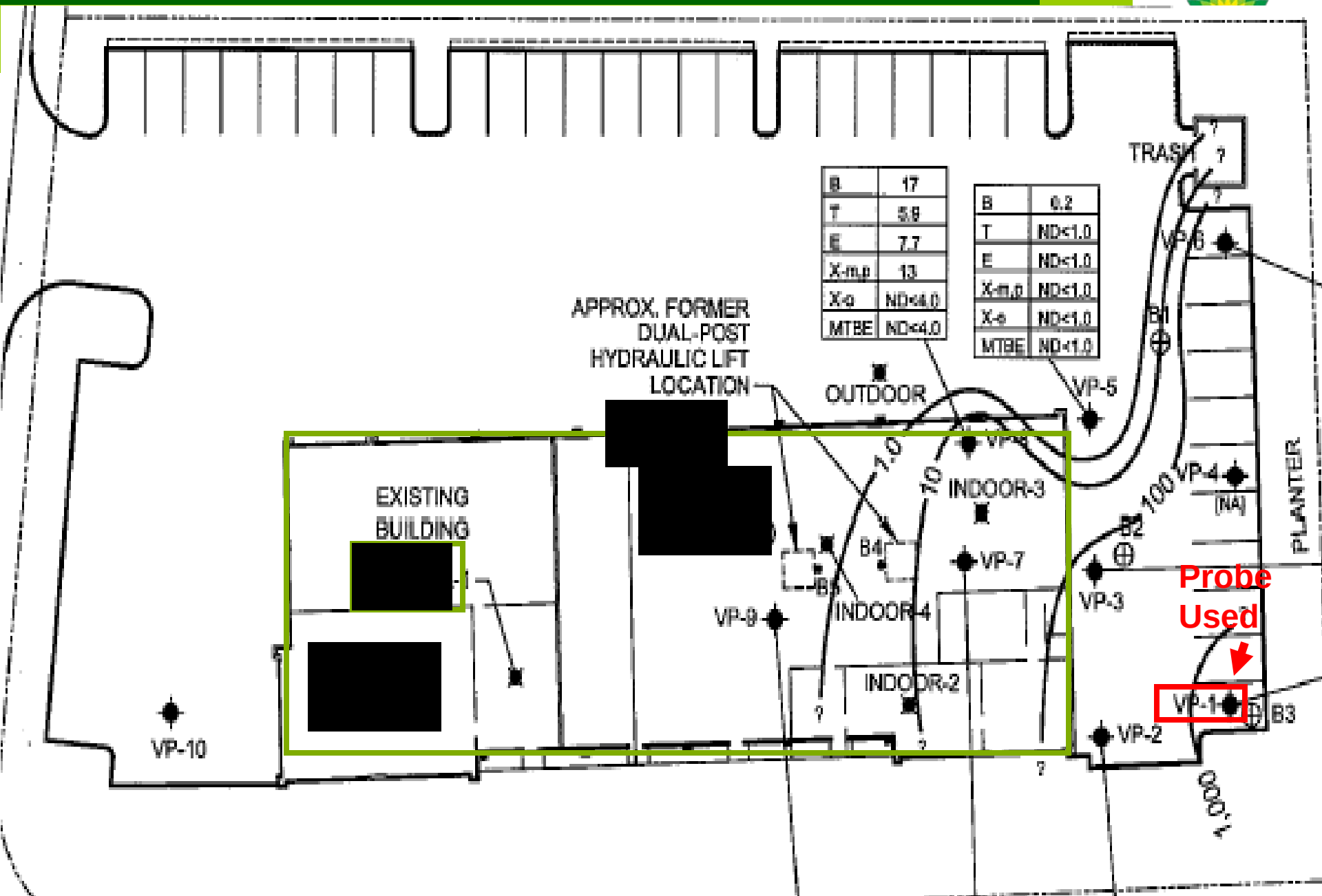


TABLE 1

SOIL GAS SURVEY VAPOR SAMPLE ANALYTICAL RESU

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

STEP 5: PRELIMINARY SCREENING EVALUATION

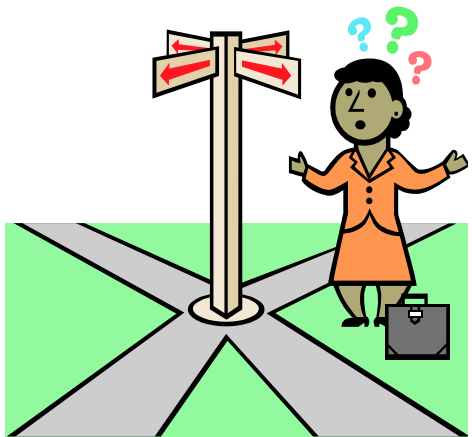
A preliminary screening evaluation was conducted using the default attenuation factors presented in Table 2 of the DTSC/Cal-EPA guidance document. Since the existing building on the site property is for commercial use, the default attenuation factor for the commercial building scenario with a slab-on-grade foundation configuration (0.001) was used along with the maximum detected soil gas BTEX and MTBE concentrations to determine an indoor air concentration. Maximum BTEX and MTBE concentrations were detected in VP-1. The results of the preliminary screening evaluations indicates that indoor air concentrations do not exceed the Office of Environmental Health Hazard Assessment (OEHHA) indoor air screening criteria for chronic inhalation reference exposure levels (RELs) for BTEX and MTBE. The results of the preliminary screening evaluations and the OEHHA chronic

Table 5 PRELIMINARY SCREENING EVALUATIONS

Preliminary Screening Evaluations for Soil Gas					
Analyte	Sample Name (sample with the maximum concentration)	Concentration (µg/m³)	Default Attenuation Factor	Indoor Air Concentration (µg/m³)	OEHHA Chronic Inhalation RELs (µg/m³)
Benzene	VP-1-25	1,200	0.001	1.20	60
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, [illegible] 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, repectively. 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	*0.29*	2.0	*0.29*	0.94	ND<1.0	ND<1.0	ND<1.0	N
Indoor-2	12-Sep-07	ND<2,000	*0.29*	1.6	*0.22*	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)
TBA 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 greateer 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, repectively. 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 Assestment Needed-Case 1: Former Refinery, Free Product, Odors in Building

1. Odors reported in new bldg

2. Free product on site

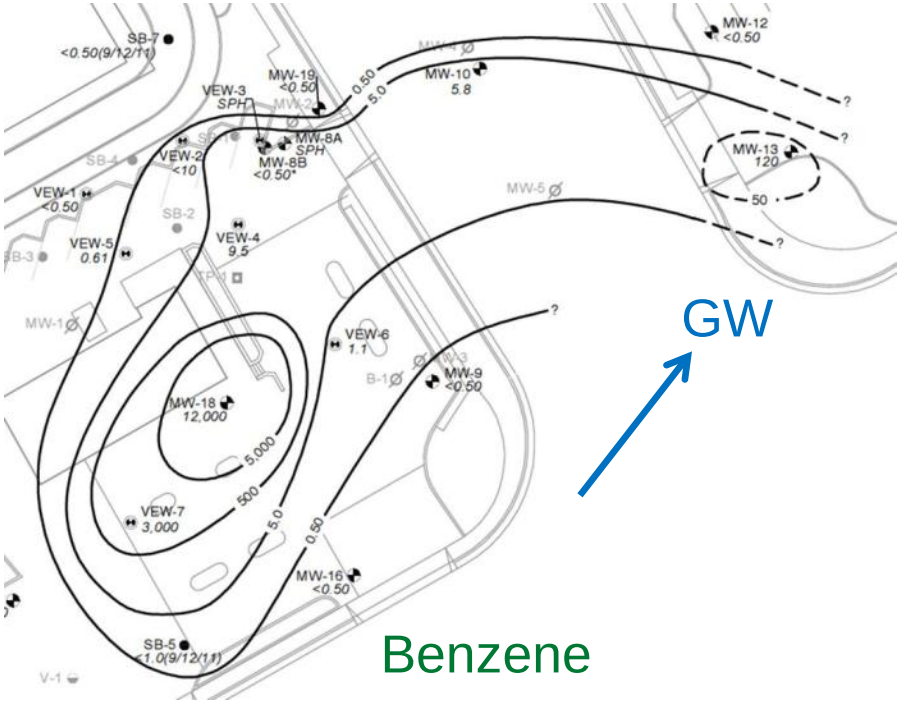
3. Sheening present

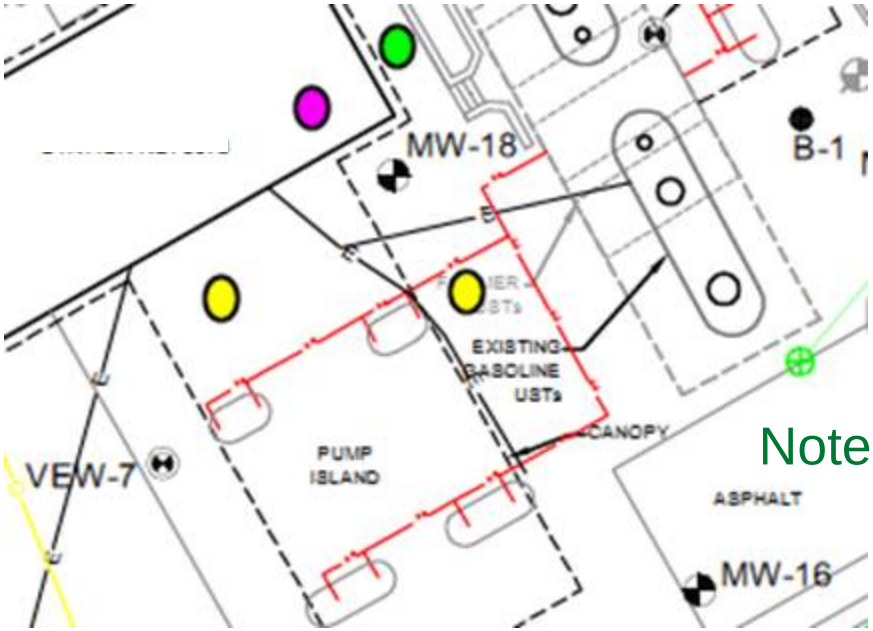
4. Sampling VI pathways

5. Sampling room with odors

6. Hartman incarerated

Case 2: Depth to GW=9 ft, Dirty soils @ 4 ft, Free Product in MW-18





Note Preferential Pathways

Case 3: Gasoline Pipeline Spill in Neighborhood

Emergency Response Clean Up

Field Lab: Basement: 1165; 1st Floor: 122 Cannister: 1st Floor: 470

Other homes: at or below ambient (6.4 measured)

All units ppbv

Dune sand in vadose zone

Gasoline Spill in Neighborhood: Emergency Response

1. TAGA bus

2. Taga lab

3. Gas input into GC

4. Output data quickly

Case 4: Gasoline Spill in Neighborhood with Fractured Rock and Free Product

1. Former Station site

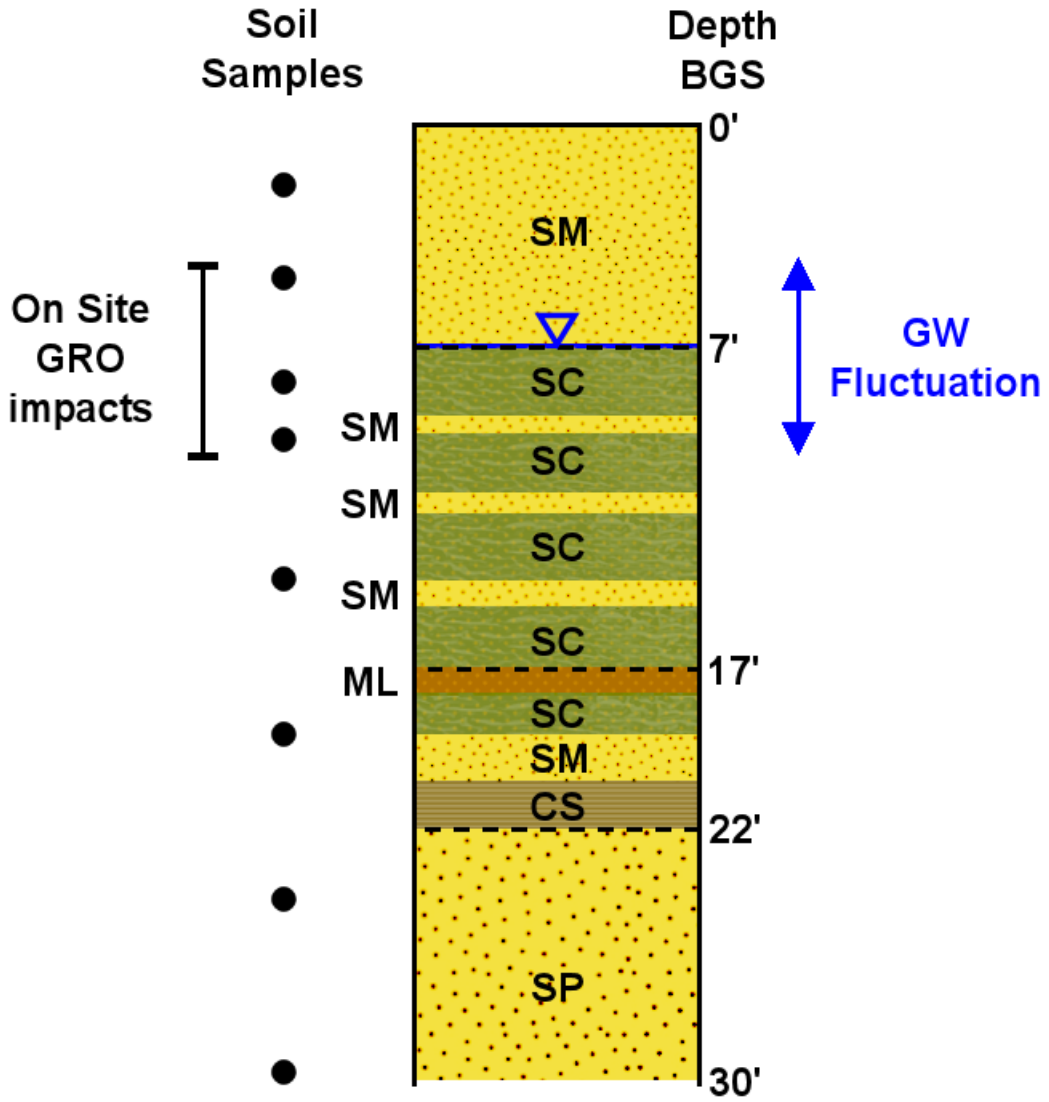
2. Station w/apparmentsadjacent

3. Sampling MW

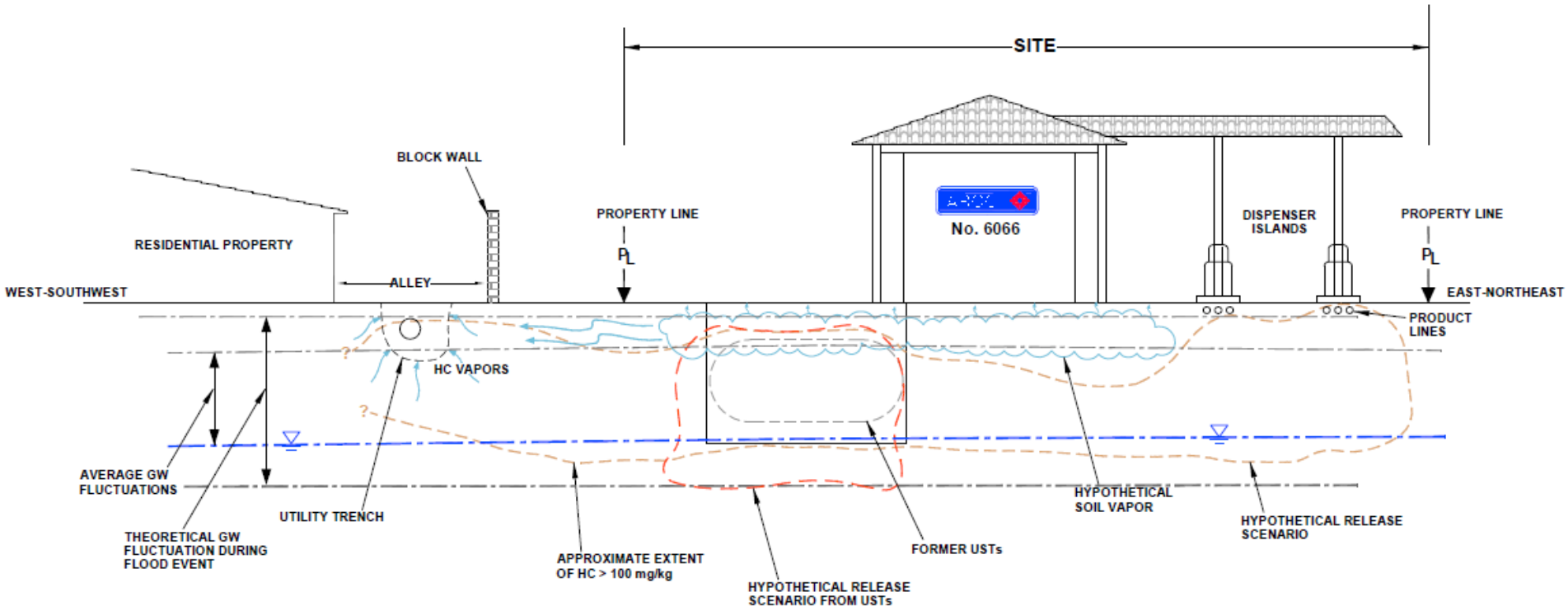
4. Free Product

5. Adjacent Home

Case 4: Gasoline spill at retail site with adjacent residential



Site Conceptual Model



Shallow Soil Gas Sample in the Alley

Soil Gas (18 inch depth) assessment data

360 **Benzene ug/m3**

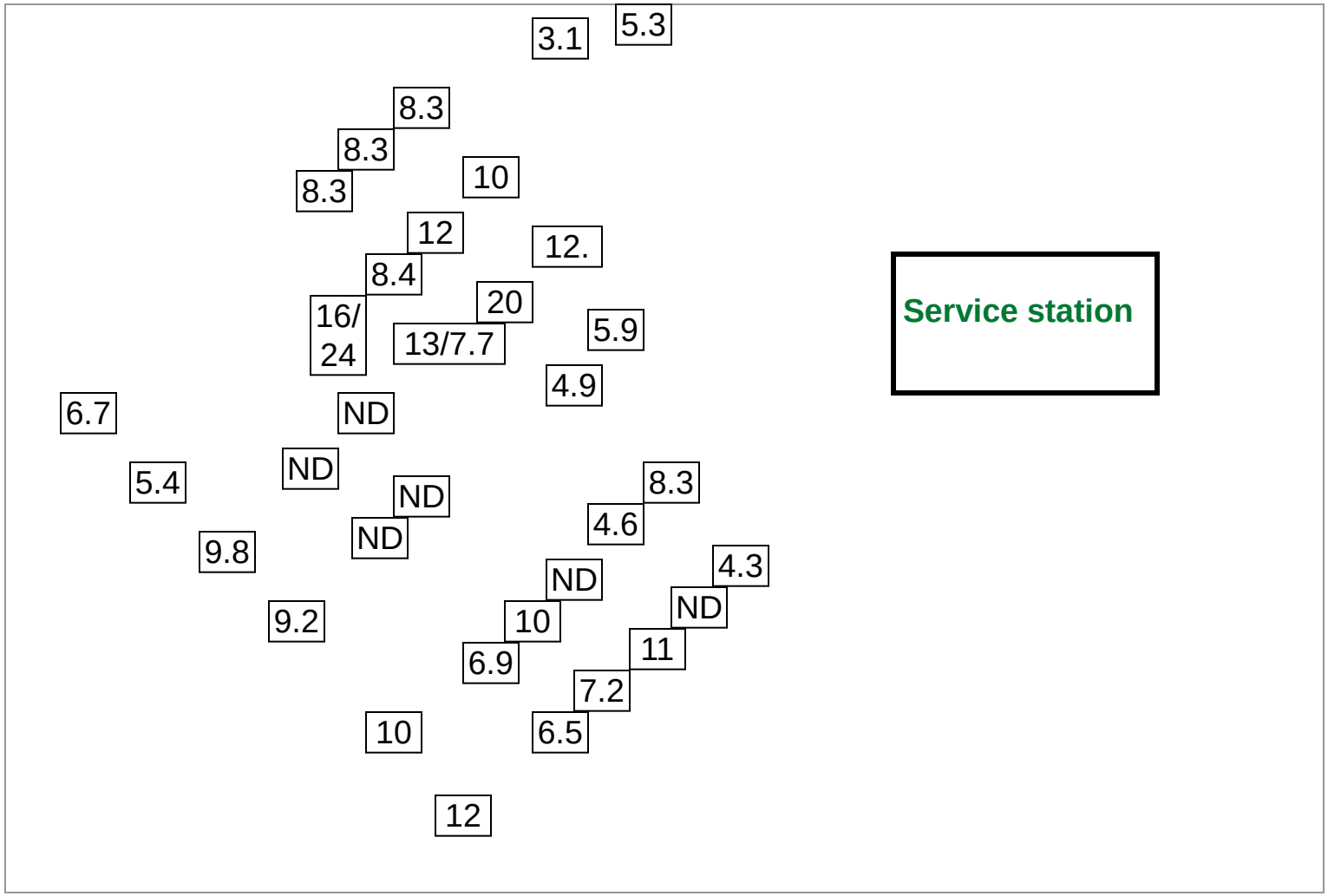
- 18 inch soil gas sample

Soil Gas Sample Locations (2 ft and 4 ft)

Dirty Soil (>100 ppm TPH) at Site Prior to SVE

Dirty Groundwater (>100 ug/l GRO) at Site

Subslab Soil Gas Data (ug/m3 benzene)



Conclusions: Subslab Soil Gas Sampling

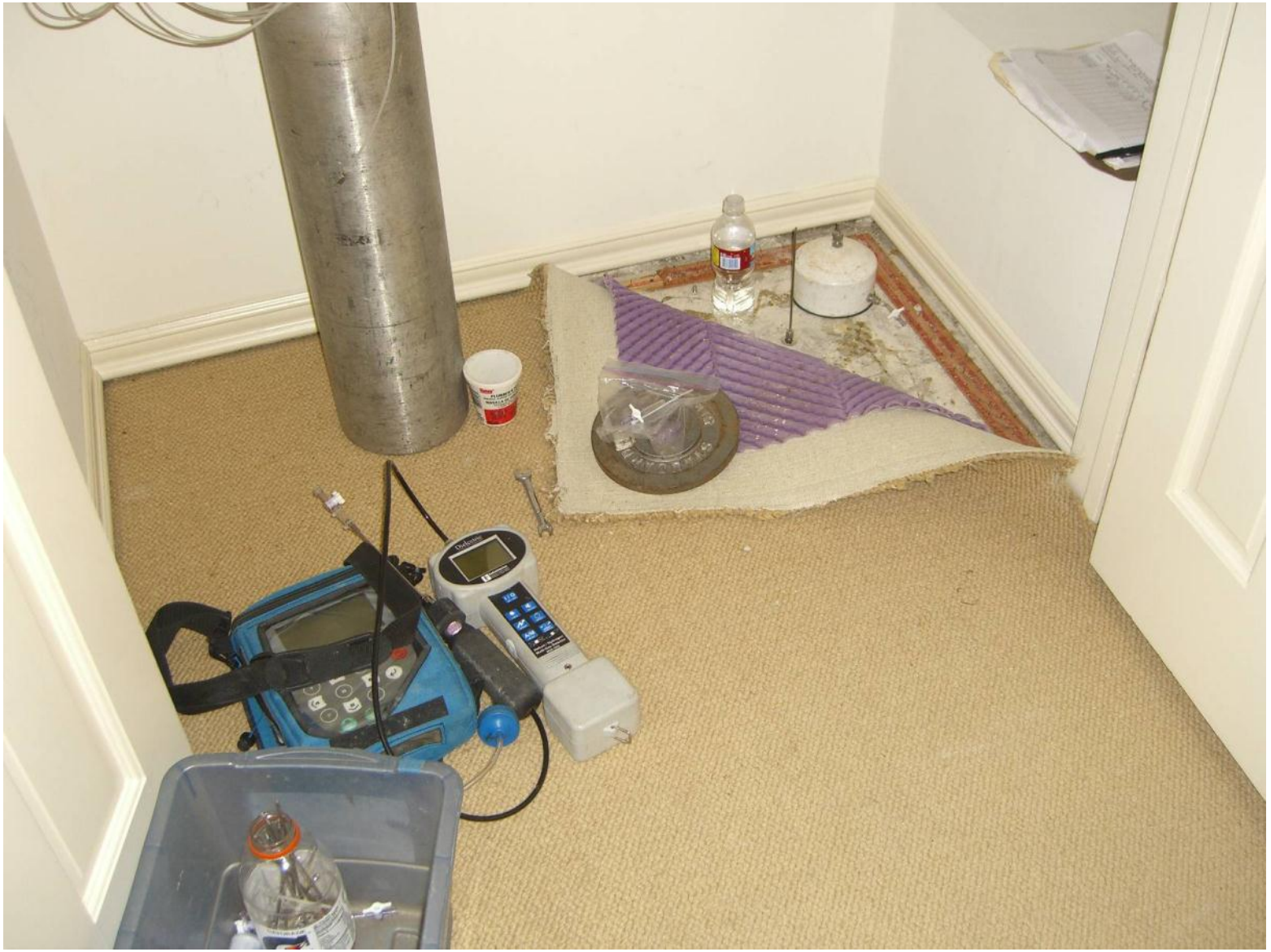
- The results provided statistical evidence that benzene concentrations inside the study area and outside the study area are not significantly different, and that benzene concentrations found in garage samples are higher than those in non-garage samples (primarily collected from living spaces)
- The resulting benzene ***background threshold values*** range from 12 $\mu g/m^3$ (for non-garage samples outside the study area) to 15 $\mu g/m^3$ (for all benzene data). These benzene concentrations correspond to cancer risk estimates ranging from $1x10^{-6}$ to $2x10^{-6}$, respectively, thus providing statistical evidence that background benzene levels in sub-slab are at or above the OCHCA risk management range level of $1x10^{-6}$

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	270	340	1900	6.5	7.9
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