Petroleum Hydrocarbon Vapor Intrusion (PVI)

PBW
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THE VAPOR INTRUSION PROBLEM

Long term, non-voluntary "constant" inhalation exposure to toxic compounds

Non-voluntarily inhale 20,000 liters per day
Vs
Voluntarily drink 2 liters of water per day

Risk is toxicity multiplied by exposure

Vapor Intrusion is the migration of volatile organic chemicals from the subsurface into overlying or adjacent buildings

US EPA Vapor Intrusion Guidance

2002 OSWER Draft Guidance – overly conservative, particularly for petroleum hydrocarbons

2012 Petroleum Hydrocarbons and Chlorinated Hydrocarbons Differ in Their Potential for Vapor Intrusion (EPA, 2012)

2013 Evaluation of Empirical Data To Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds (EPA, 2013)

General Vapor Intrusion (VI)

Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor air. (EPA OSWER, 2015)

Petroleum Vapor Intrusion (PVI)

Technical Guide for Addressing Petroleum Vapor intrusion at Leaking Underground Storage Tank Sites. (EPA OUST, 2015)

2012 - Petroleum Hydrocarbons and Chlorinated Hydrocarbons Differ in Their Potential for Vapor Intrusion

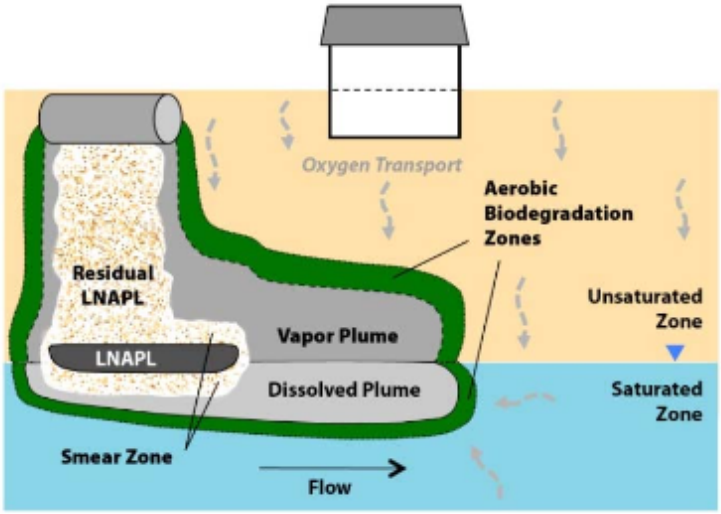


Figure 1. Typical petroleum hydrocarbon transport conceptual scenario

Aerobic biodegradation of PHCs along the perimeter of the vapor and dissolved plumes limits subsurface contaminant spreading. Effective oxygen transport (dashed arrows) maintains aerobic conditions in the biodegradation zone. Petroleum LNAPL (light nonaqueous phase liquid) collects at the capillary fringe between the saturated and unsaturated zones.

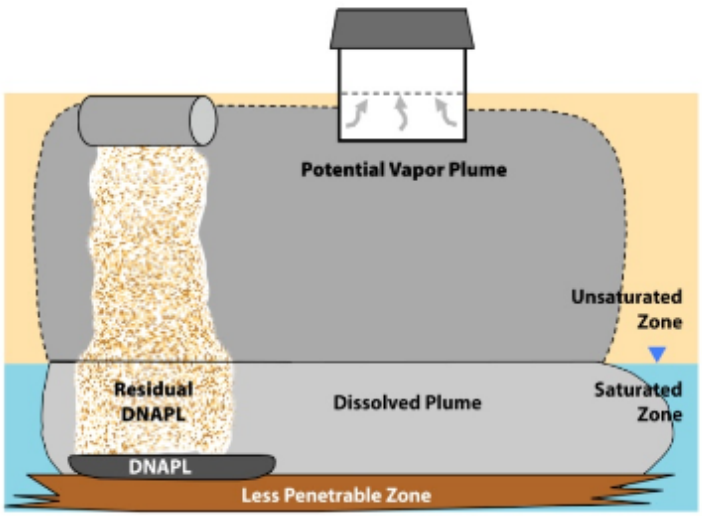
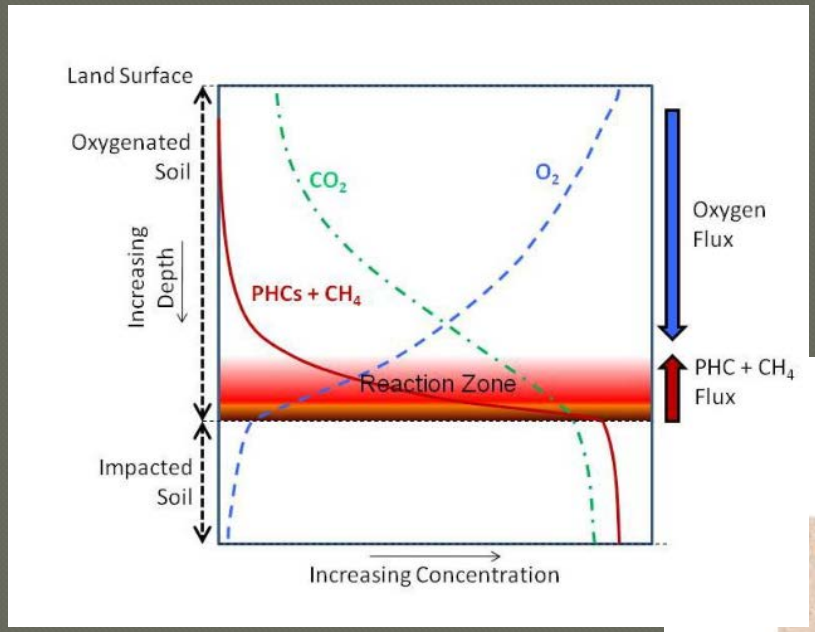


Figure 2. Typical chlorinated solvent transport conceptual scenario

Biodegradation of chlorinated solvents is anaerobic and usually slower than PHC biodegradation, so that the vapor and dissolved plumes often migrate farther than PHC plumes. Chlorinated solvents may migrate as a plume of DNAPL (dense nonaqueous-phase liquid). DNAPL can sink below the water table, collecting in this case on a less penetrable layer.

Source: EPA OUST 2012

2013 - Evaluation of Empirical Data To Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds



Source: EPA OUST March 2013

Source: EPA OUST 2015

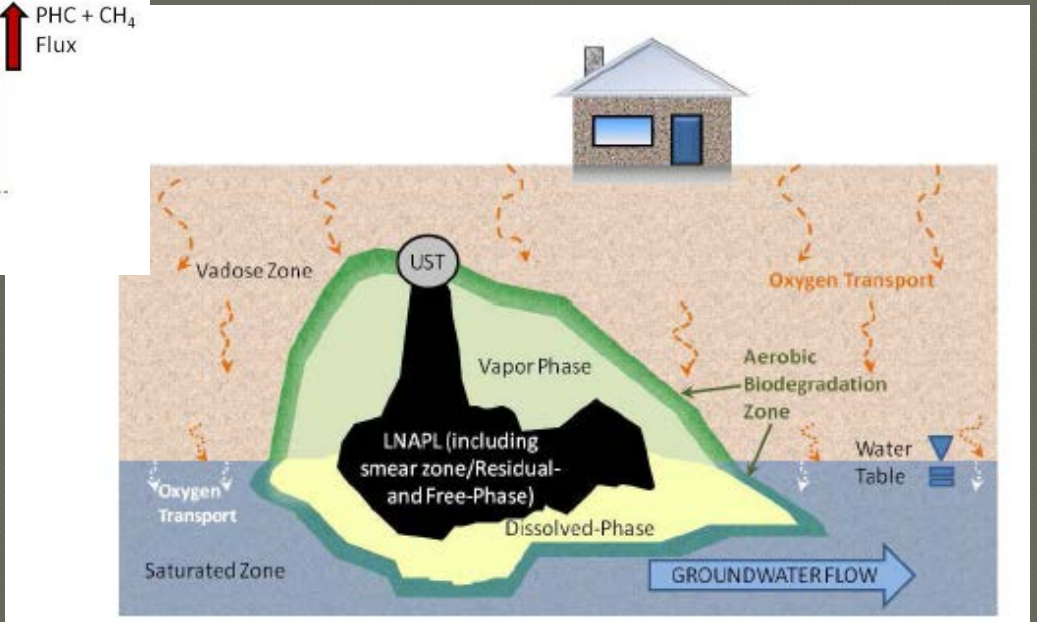


Figure 2. Conceptual Model Of Typical Petroleum Hydrocarbon Release

2013 - Evaluation of Empirical Data To Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds

For groundwater –

- Separation Distance Method - 97% of benzene soil vapor concentrations are less than 100 ug/m^3 for source-to-building separation distances as small as 0 ft.
- Clean Soil Method - The 95th percentile vertical clean soil thickness for benzene attenuation to 100 ug/m^3 is approximately 5.4 ft.

For free product –

- Separation Distance Method - 95% of benzene soil vapor concentrations are less than 100 ug/m^3 for source-to-building separation distances of ~ 15 ft.
- Clean Soil Method - Insufficient data for vertical clean soil thickness but estimated at 20 ft.

Source: EPA OUST March 2013

2013 - Evaluation of Empirical Data To Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds

For large sources such as fuel terminal, refinery and petrochem facilities –

- 90% of benzene soil vapor concentrations are less than screening thresholds for a source-to-building separation distances of ~ 18 ft.

Other findings –

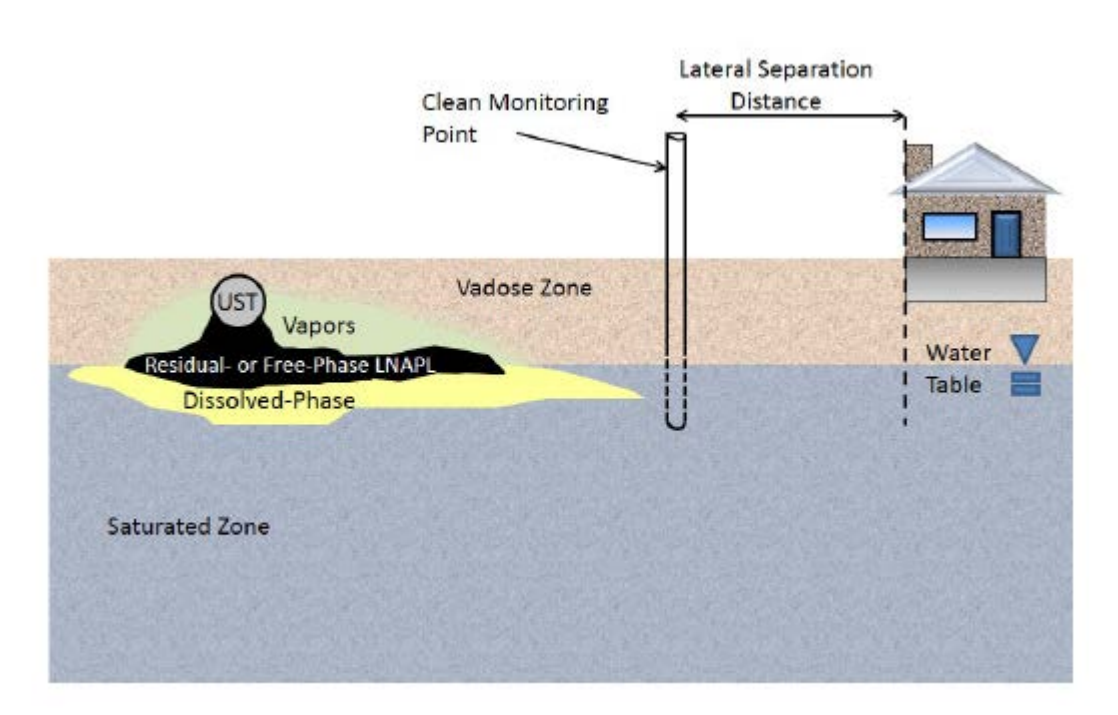
- Benzene is the risk driver, and requires greatest separation distance.
- Poor correlation between benzene concentration in groundwater and deep soil gas above groundwater, groundwater concentration not appropriate for screening at PVI sites.
- Ground cover matters – oxygen exchange.

Source: EPA OUST March 2013

PVI Guidance – Lateral Separation Distance

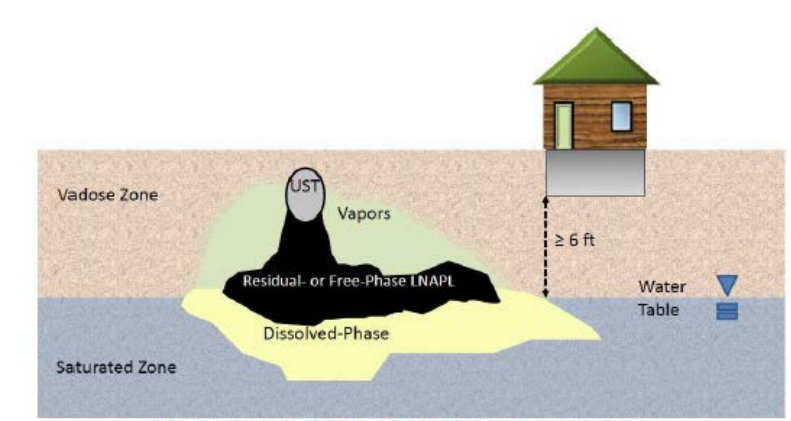
Determines if a structure is at risk from PVI based on proximity of structure to the contamination.

May combine lateral and vertical separation through use of site characterization data.

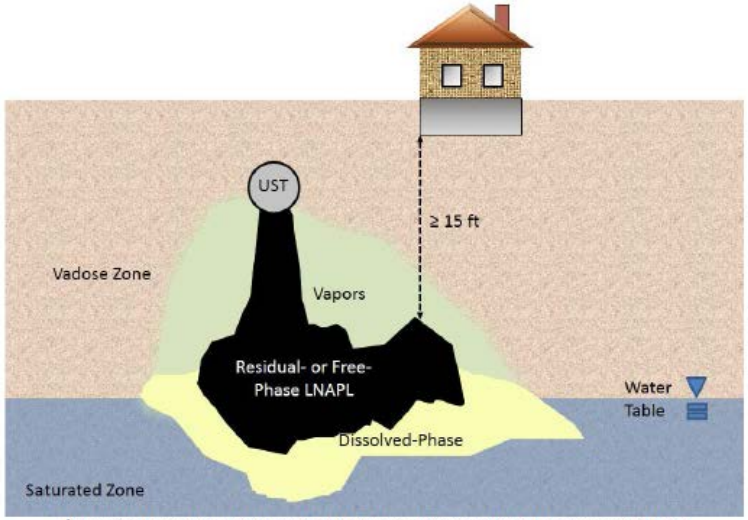


Source: EPA OUST 2015

PVI Guidance – Vertical Separation Distance



(a) Vertical separation distance for dissolved-phase source of PHCs.



(b) Vertical separation distance for LNAPL (residual or mobile phase) source of PHCs.

Determines if a structure is at risk from PVI based on proximity of structure to the contamination.

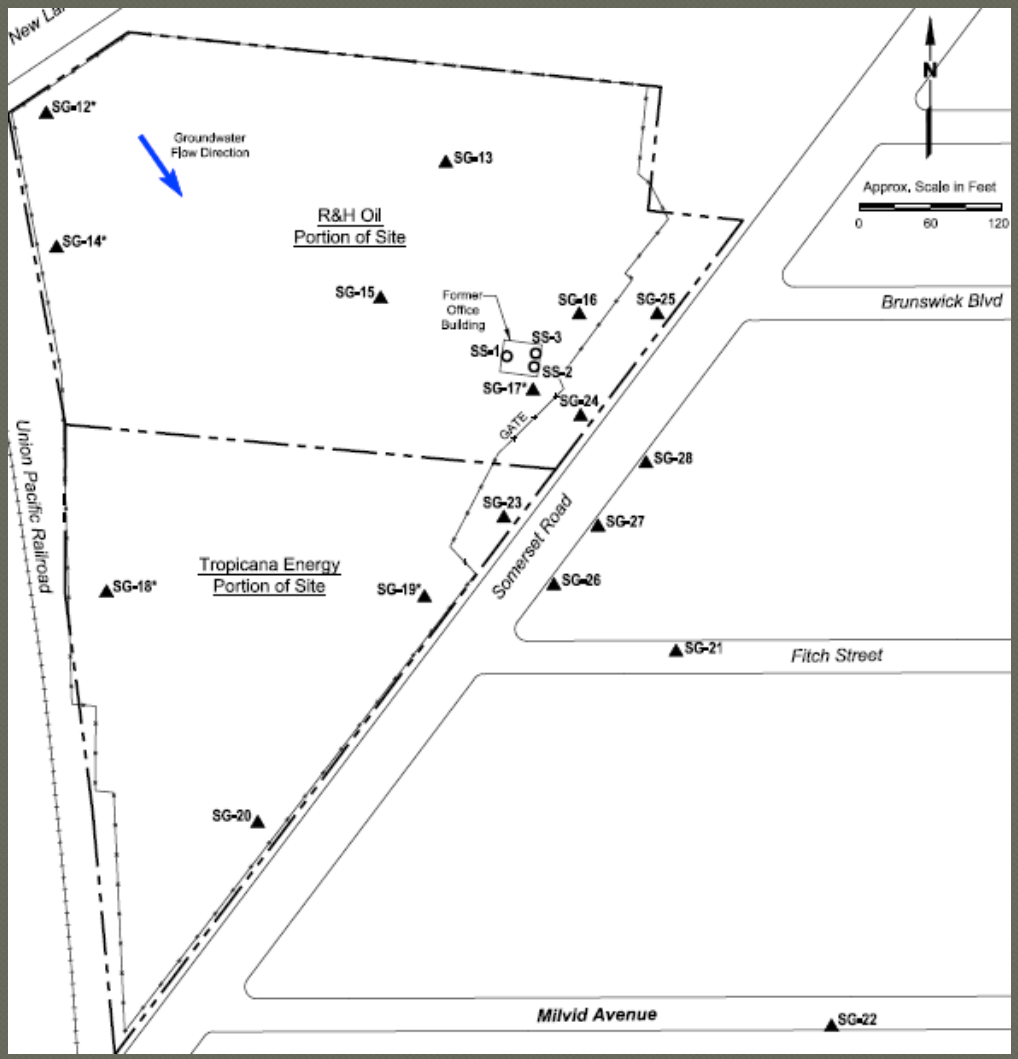
Greater distance required for a stronger source.

Source: EPA OUST 2015

Case Study

Remedial Investigation for Superfund Site

Conceptual Site Model for VI



Origin of primary BTEX plume in NW corner (historical gasoline loading)

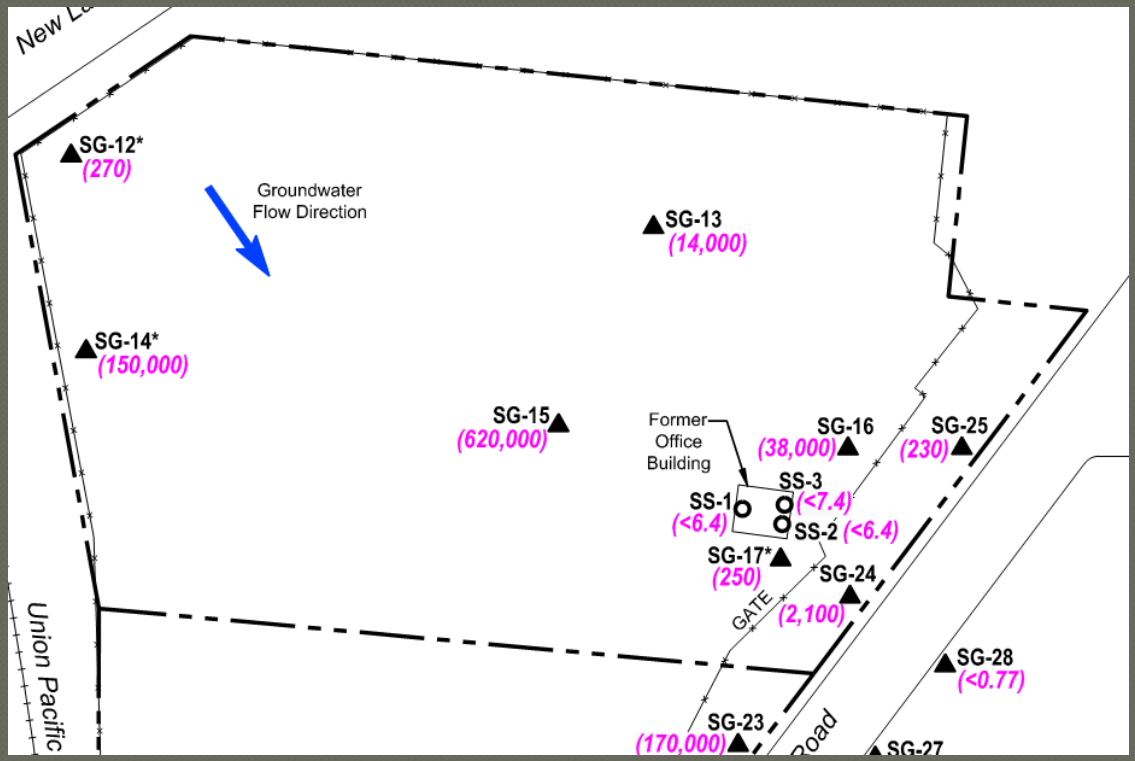
North side of Site location of former refinery and more recent oil recycling facility (tank battery)

South side of Site location of former refinery and gasoline blending

LNAPL present throughout northern portion of Site, benzene plume extends slightly beyond boundary of Site (downgradient)

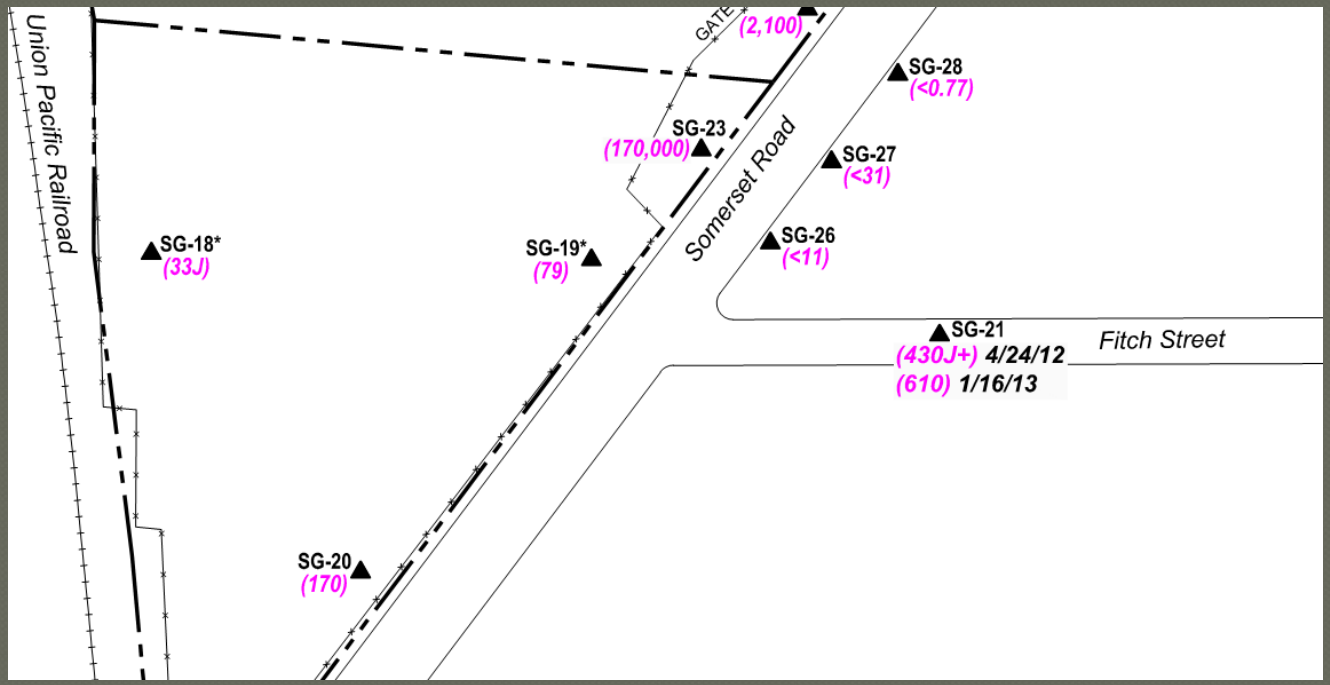
PVI Data Collected For RI - North Area

Sample Area:	North					
Sample Location:	SG-12*	SG-13	SG-14*	SG-15*	SG-16	SG-17*
Sample Depth (ft):	5-6	3.5-4.5	5-6	5-6	5-6	5-6
Units:	ug/m^3	ug/m^3	ug/m^3	ug/m^3	ug/m^3	ug/m^3
Benzene	**270**	**14,000**	**150,000**	**620,000**	**38,000**	**250**
Ethylbenzene	<80	<85	**290 J**	**8,500**	<490	**23 J**
Toluene	**690**	**7,700**	**2,100**	**16,000**	**650 J**	**640**
Xylenes, total	<80	**12,000**	**600**	**24,000**	<490	**53**



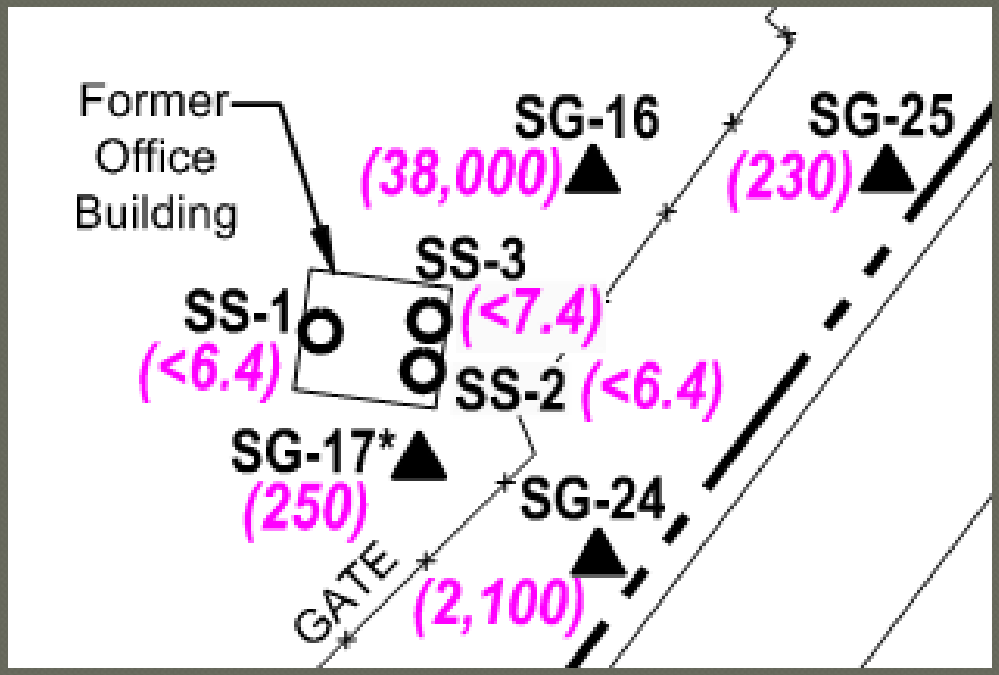
PVI Data Collected For RI - South Area

Sample Area:	South		
Sample Location:	SG-18*	SG-19*	SG-20
Sample Depth (ft):	3-4	5-6	5-6
Units:	ug/m^3	ug/m^3	ug/m^3
Benzene	**33 J**	**79**	**170**
Ethylbenzene	<41	**23**	<19
Toluene	**50 J**	**360**	**510**
Xylenes, total	**88**	**95**	**40**



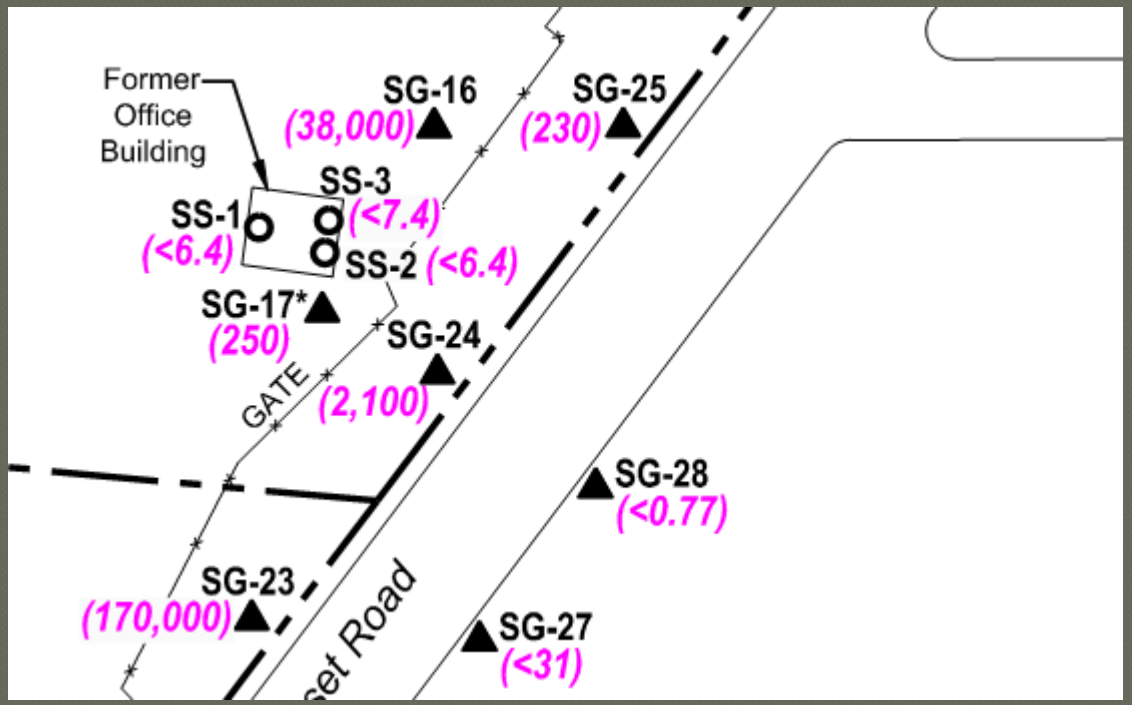
PVI Data Collected For RI - Subslab Data

Sample Area:	Building Sub-Slab			
Sample Location:	SS-1	SS-2	SS-2	SS-3
Sample Depth (ft):	1	1	1	1
Units:	ug/m^3	ug/m^3	ug/m^3	ug/m^3
Benzene	<6.4	<6.4	<6.4	<7.4
Ethylbenzene	<8.7	<8.7	<8.7	<10
Toluene	<7.5	<7.5	<7.5	<8.7
Xylenes, total	<8.7	<8.7	**19**	<10



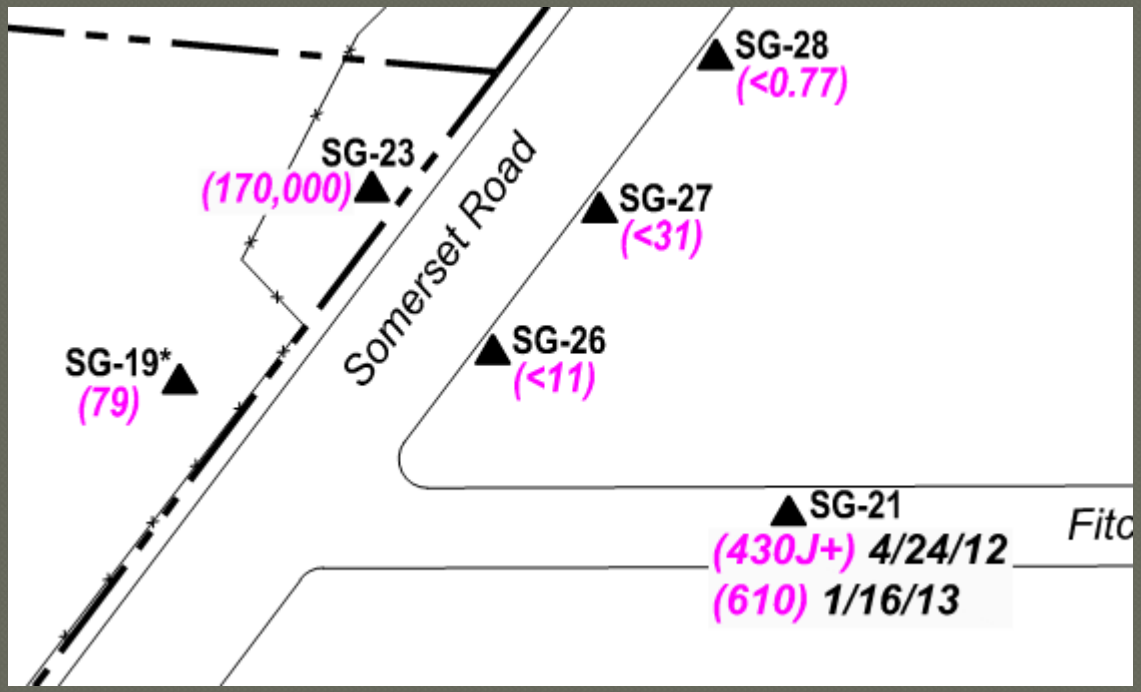
PVI Data Collected For RI - Downgradient Site Boundary

Sample Area:	Downgradient Site Boundary		
Sample Location:	SG-23	SG-24	SG-25
Sample Depth (ft):	4-5	4-5	4-5
Units:	ug/m^3	ug/m^3	ug/m^3
Benzene	**170,000**	**2,100**	**230**
Ethylbenzene	**7,900**	**460**	**92**
Toluene	**2,200**	**58**	**67**



PVI Data Collected For RI - Off-Site Data

Sample Area:	Off-Site			Off-Site Subslab (Sidewalk)		
Sample Location:	SG-21	SG-21	SG-22	SG-26	SG-27	SG-28
Sample Depth (ft):	5-6	5-6	5-6	1.5	1.5	1.5
Units:	ug/m^3	ug/m^3	ug/m^3	ug/m^3	ug/m^3	ug/m^3
Benzene	**430 J+**	**610**	<6.4	<11	<31	<0.77
Ethylbenzene	**2,300**	**520**	<8.7	<12 J	**46**	**10**
Toluene	<15	**100J**	<7.5	**100**	**210**	**4.1**
Xylenes, total	**570 J+**	**180J**	<8.7	**67**	**95**	**21.4**



Issues With Regulators and Risk Assessors

May not use or mention biodegradation in risk assessment.

Subslab data not relevant/representative because most homes in area are pier & beam.

How do we know soil vapor isn't migrating off site?

ON SITE - Shallow vapor sources were present at the Site, no inhabitable buildings on Site – Institutional Control requiring PVI mitigation for future construction.

OFF SITE – Collect sufficient shallow data to support no risk, present research data and 2015 EPA guidance information that shows minimal chance of PVI risk given off site conditions.

Issues With Regulators and Risk Assessors

EPA eventually agreed that risk was addressed on site by controlling potential future exposures and that risk off site was minimal based on the nature of PVI.

Epilogue –

ATSDR/CDC issued a letter stating data was inconclusive, more data should be collected, and risk may be present.

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Questions?