

# MEMORANDUM

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DIVISION OF LAND PROTECTION AND REVITALIZATION  
OFFICE OF SPILL RESPONSE AND REMEDIATION

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**SUBJECT:** Petroleum Vapor Intrusion at Home Heating Oil Tank Sites

**TO:** Betty Lamp, Director, Office of Spill Response and Remediation

**FROM:** James Barnett, State Lead Program Manager, Office of Spill Response and Remediation

**DATE:** February 8, 2019

The Virginia Department of Environmental Quality (DEQ) oversees the investigation and corrective action of petroleum releases including discharges from home heating oil tanks. DEQ has developed programmatic procedures to streamline the release response and corrective action process for most home heating oil tank discharges. DEQ contracted with Virginia Tech to evaluate risks from petroleum vapor intrusion at home heating oil tank discharge sites. This memo summarizes the findings of the study, discusses potential implications related to existing program guidance and procedures, and provides recommendations based upon the results of the study.

## Issue Statement

Discharges from home heating oil tanks are the most common type of oil discharge dealt with by DEQ staff. DEQ's policies and procedures must protect human health and the environment while, at the same time, not requiring those activities that provide minimal additional protection.

The DEQ contracted with Virginia Tech to evaluate risks posed by petroleum vapor intrusion at home heating oil tank sites. The primary objective of the study was a scientifically defensible answer to the question: To what degree do heating oil vapors from a home heating oil discharge pose unacceptable risks to residents? A secondary objective was to determine the site-specific variables that most strongly influence the potential risk for petroleum vapor intrusion.

## Discussion

DEQ's present home heating oil procedures were issued as guidance during the 2007 Fiscal Year. DEQ staff performed a database query and provided Virginia Tech with a list of all cases, starting in FY2008, where heating oil had been discharged from a residential heating oil UST. Virginia Tech randomly selected sites to include in the study and then requested that DEQ provide copies of the site characterization reports for the sites. Sites were grouped and then evaluated by:

- DEQ heating oil discharge category: NFA, Category 1, Category 2, Category 3.
- Physiographic region of state: Blue Ridge/Valley and Ridge, Piedmont, Coastal Plain

At sites where access was granted by the homeowner, Virginia Tech staff collected site data and subsurface soil vapor samples. Most samples were collected from within a couple of feet of the foundation of the house and from between the tank or former tank and the house. Soil vapor samples were analyzed for TPH, benzene, toluene, ethylbenzene, xylenes, naphthalene, and MTBE. TPH vapor concentrations represent a combined or total mass of hydrocarbon constituents ranging from C5 to C18.

Soil vapor survey sites were dependent on responses from current property owners. The lower the heating oil category, the fewer property owners responded for a variety of reasons. Category 3 sites represented the most responsive homeowners.

#### Report Findings:

- TPH and naphthalene appear to be the principal contaminants of concern (COC) with regards to petroleum vapor intrusion (PVI) risks. Moreover, the study data suggests a positive correlation between TPH and naphthalene in soil gas; especially when naphthalene is  $> 10 \text{ ug/m}^3$ . A study by Brewer uses  $72 \text{ ug/m}^3$  as the risk-based threshold for naphthalene and  $140,000 \text{ ug/m}^3$  as the screening level for TPH in soil gas.
- Fewer than 10% exceeded a risk-based threshold for either TPH soil gas or naphthalene soil gas. When a site did exhibit an exceedance of TPH or naphthalene soil vapor, a correlation between naphthalene and TPH concentrations was not consistent (see Appendix 1).
- The study indicated relatively poor correlation between measured TPH and BTEX concentrations in soil gas.
- Physiographic region within the state had some influence on higher vapor concentrations as it related to shallow groundwater. Sites with a combination of shallow water table (within 6' of ground surface) and free product were associated with higher TPH and naphthalene concentrations in soil vapor.
- Cases where there were documented impacts of oil in crawl spaces or in basements generally had higher observed TPH and/or naphthalene concentrations in soil vapor outside the residence.
- Time between tank removal or the collection of the initial soil sample (essentially the assumed release date) and the time that the soil gas samples were taken did not indicate any significant relationship between time of the release and observed soil gas concentrations.
- There is poor correlation between soil vapor concentrations and the maximum reported TPH concentration in soil documented in Site Characterization Reports.
- Soil vapor concentrations by DEQ Category
  - Samples were collected at ten (10) NFA cases. TPH concentrations in soil vapor exceeded the screening level of  $140,000 \text{ ug/m}^3$  at two of these sites.  
**Note:** Upon further file review by DEQ, soil samples for each site were not obtained in traditional fashion (hand auger at the end of the tank). One site was assigned NFA as a result of low TPH after a tank removal. The sample was taken at the bottom of the tank pit. The other site was assigned NFA as a result of a single sample collected during a tank closure in place under a deck where the sample was taken through the bottom of the tank. Both residences have crawl spaces which should induce air flow that would dissipate soil vapor before it would enter the home.
  - Samples were collected at ten (10) category 1 cases. One category 1 site had a naphthalene soil gas concentration that exceeded the screening level of  $72 \text{ ug/m}^3$ . None of the category 1 sites had TPH concentrations that exceeding the screening level.  
**Note:** Upon further file review, the one site with elevated naphthalene soil vapor had a sump in the basement of the residence and no evidence of an impact was detected in the sump.
  - Samples were collected at twenty (20) category 2 cases. Two of the cases had vapor concentrations that exceeded screening levels. One of these sites exceeded the screening

levels for both TPH and naphthalene while the other exceeded the screening level for naphthalene.

**Note:** Upon further file review, at the site with elevated TPH and naphthalene soil gas vapors, free product was observed in the tank pit following tank removal. Soils were excavated and the case closed. The other site (naphthalene only) had a sheen on water in the basement sump and technically should have been elevated to a Category 3 due to the impact; proper remediation measures were taken to abate the impact. The sump discharge water had been redirected from the storm drain to a reinfiltration pit; the location of the soil vapor gas result may be elevated as a result of the proximity to the reinfiltration point.

- Samples were collected at sixteen (16) category 3 sites. Four of the sites had TPH vapor concentrations that exceeded the screening concentration of 140,000 ug/m<sup>3</sup> while three of these same sites also had naphthalene concentrations that exceeded screening levels for that constituent. Three of these cases have free product on shallow groundwater. The fourth case had free product that entered a basement. All four of these cases are still open.
- Summary:
  - Soil vapor samples were collected at 56 sites.
  - 7 cases exceeded the naphthalene screening threshold of 72 ug/m<sup>3</sup> (13%)
  - 7 cases exceeded the TPH screening threshold of 140,000 ug/m<sup>3</sup>
  - 4 of these cases had documented free product present and 3 of them are still open cases
  - Of the cases without documented free product present, 3 exceeded the naphthalene screening threshold (5%) and 2 exceeded the TPH screening threshold (4%). One of these 3 cases having elevated naphthalene had documented impacts to a basement sump (sheen and dissolved constituents).

## Summary and Recommendations

### *Indoor Air Quality and Storage Tank Program Risk Thresholds*

Many petroleum constituents found in residences are the result of various sources. Naphthalene is widely found in indoor air due to emissions from wood burning, gasoline and oil combustion, tobacco smoking, cooking, the use of mothballs, fumigants, and deodorizers, and many other sources (Chunrong and Batterman, 2010)<sup>1</sup>. This same source noted that maximum “background” indoor air concentrations of naphthalene range from 1.4 to 144 ug/m<sup>3</sup> with medians ranging from .3 to 4 ug/m<sup>3</sup>.

### *Petroleum Soil Vapor Data and Free Product*

The PVI study shows that most of the cases having elevated soil vapor concentrations are associated with free product and, often, shallow groundwater. In accordance with the program’s procedures, these sites are managed as either Category 2 or Category 3 home heating oil cases. The results of the study suggest that vapor abatement via a vapor removal system or other type of vapor barrier in the vicinity of the heating oil UST may be appropriate at many sites where free product has been encountered.

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<sup>1</sup> Chunrong, Jia and Stuart Batterman. 2010. **International Journal of Environmental Research and Public Health**. July 7(7): 2903 - 2939

### *Petroleum Soil Vapor Data and PVI Risk Uncertainty*

The PVI study only collected soil gas samples in the immediate vicinity of the UST and usually between the tank and the residence. Screening concentrations for petroleum in subsurface are based on an assumption of equal vapor concentrations under the entire building. This type of subsurface vapor concentration profile may not fit the typical home heating oil UST discharge situation where most contamination is likely present on one side of the structure and, perhaps, under one portion of the structure rather than under all of it. The researchers suggested that a follow-up study where soil gas data is collected from multiple points around the structure may be useful in order to better evaluate the potential for PVI at home heating oil discharge cases. DEQ believes that based on the now-established relationship between the presence of free product and shallow groundwater as a source of the majority of the TPH and naphthalene soil vapor gas results above the risk threshold, implementing an abatement strategy is more productive and proactive than additional studies.

The Storage Tank Program has utilized an excess lifetime cancer risk of  $1 \times 10^{-6}$  for carcinogenic constituents and a hazard quotient of unity (1) for establishing numeric risk thresholds for various petroleum constituents. The EPA Region III risk based concentration table lists an indoor air screening level of .083 ug/m<sup>3</sup> for naphthalene. This corresponds with an estimated excess lifetime cancer risk of  $1 \times 10^{-6}$ . Chunrong and Batterman noted that typical or background concentrations of naphthalene in most residences would correspond with risks in the range of  $10^{-4}$ . The Storage Tank Program may consider utilizing “background” concentrations of petroleum constituents in indoor air when establishing remedial endpoints related to PVI and petroleum vapors in indoor air.

DEQ recognizes that the sources of the contaminants in question (TPH and naphthalene) are abundant in a typical household, therefore trying to isolate the origin of specific COCs in indoor air would be extremely difficult. Therefore indoor air sampling may not be a reliable tool to evaluate the impact on indoor air from an outdoor release of petroleum.

Based on the Virginia Tech heating oil vapor intrusion study results, DEQ believes that the current categorization system for heating oil tank releases adequately protects individuals from vapor intrusion. Of the sites selected by the study for the vapor gas assessment, sites with exceedances above the risk threshold are mostly open cases and have free product associated with them. At sites where free product is present either in the tank pit or at shallow groundwater sites, DEQ might consider authorizing additional protective actions such as the installation of a passive vapor removal (radon-type) system along the structure in the vicinity of the free product if the structure is on a slab or has a basement. A crawl space with adequate ventilation and air circulation should provide adequate protection from any soil vapor TPH and/or naphthalene contaminants in the area due to free product.

DEQ's current practice has been to proactively address potential vapor impacts from heating oil releases. It's generally more cost effective to implement a solution than quantify the degree of risk to the receptor. This approach eliminates the need to collect soil gas vapor samples. DEQ's technical guidance will be evaluated for modification based on the new information provided by this study.

**Appendix 1: DEQ Summation of Vapor Intrusion Data**

<b>Category</b>	<b>TPH Vapor Level</b>	<b>Naphthalene vapor level</b>	<b>DEQ Comments</b>
NFA	1100	0.83	
NFA	234000	113	tank was already removed
NFA	6400	13.8	
NFA	2000	5.42	
NFA	1500	0.77	
NFA	5500	0.56	
NFA	4400	2.36	
NFA	205000	0.4	tank had to be closed in place, sampled through bottom of tank
NFA	15000	6.66	
NFA	9500	1.43	
<b>Separator</b>			
1	490	0.12	
1	12,000	3.3	
1	7300	1.29	
1	18000	1.78	
1	36000	104	site had basement w. sump, no evidence of impact
1	29000	10.8	tank could not be removed due to utilities
1	3200	0.79	
1	4100	2.08	
1	986	2.39	
1	1100	3.64	
<b>Separator</b>			
2	311000	475	had FP in pit
2	57000	1.4	
2	4800	6.74	
2	3,900	0.89	
2	1,600	0.96	
2	1,100	1.2	
2	32,000	2.47	
2	29,000	10	
2	17,000	9	
2	2200	1.28	
2	252	0.32	
2	1.9	1.17	
2	3900	1.12	
2	23000	14.1	
2	77,000	82.2	Petroleum sheen on water in basement sump
2	4,000	2.19	
2	341	2.76	
2	4,800	1.36	
2	7,900	2.38	
2	6,200	1.86	

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Category	TPH Vapor Level	Naphthalene vapor level	DEQ Comments
3	5900	4.97	
3	123000	10.8	FP to basement
3	22000	4.08	
3	31000	8.04	
3	19000	17	1500 gal ust
3	8900	2.54	
3	281000	0	FP in basement, case open
3	293000	24.8	FP in monitoring wells, shallow gw, case open
3	427000	77.6	FP in monitoring wells, shallow gw, case open
3	6700	14.1	FP in monitoring wells
3	90000	54.5	case initiated due to vapors in residence
3	1200	9.37	
3	115,000	54.8	oil in excavation and MWs. Shallow GW
3	688,000	1,094	FP in monitoring wells, oil in excavation, shallow Gw, case open
3	431,000	752	FP in monitoring wells, shallow gw, case open
3	1,600	9.54	
3	895	4.57	
3	1,400	7.47	