# Letter Health Consultation

## PASSYUNK SOIL GAS SITE
## PHILADELPHIA, PHILADELPHIA COUNTY, PENNSYLVANIA

### Evaluation of Residential Indoor Air and Sub-Slab Soil Gas Data

**January 09, 2018**

Prepared by

pennsylvania
DEPARTMENT OF HEALTH

**Pennsylvania Department of Health**
**Division of Environmental Health Epidemiology**

## A Disclaimer

“This report was supported in part by funds provided through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. The findings and conclusions in these reports are those of the author(s) and do not necessarily represent the views of the ATSDR or the U.S. Department of Health and Human Services. This document has not been revised or edited to conform to ATSDR standards.”

Pennsylvania Department of Health
Division of Environmental Health Epidemiology
Harrisburg, PA
717-787-3500

01/09/2018

Ruth Scharr
On Site Coordinator
U.S. EPA Region 3
Philadelphia, PA

Re: Review of EPA 2014/2016 indoor air and sub-slab soil gas data at the Passyunk Soil Gas Site

Dear Ms. Scharr,

At the request of the U.S. Environmental Protection Agency (EPA), the Pennsylvania Department of Health (DOH) has prepared this letter health consultation to evaluate potential public health issues and to provide relevant conclusions and recommendations based on data you shared with us in April 2017. DOH worked on this evaluation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

**SITE BACKGROUND AND STATEMENT OF ISSUES**

The Passyunk Soil Gas site ("the site") is located on the west side of South Philadelphia. It is an approximately 3.7-acre residential neighborhood bounded by the Schuylkill River and the Philadelphia Gas Works (PGW) Passyunk facility on the west, the Philadelphia Energy Solutions refining complex (formerly Sunoco, Inc. refinery) to the south, and the Schuylkill Expressway to the east/northeast. The neighborhood is predominately residential with a tavern, a playground, and a Philadelphia Mummers hall. There are no daycares or schools within the neighborhood. (See the Appendix A for a map of the site and surrounding area.)

In 2003, PGW began conducting independent environmental studies on their Passyunk Plant property adjacent to the site. Those studies showed elevated concentrations of benzene in the shallow groundwater aquifer beneath their property, confirmed the transport of benzene towards the adjacent residential neighborhood (the site), and confirmed that vapor intrusion was not a concern on PGW plant property (PGW, 2013). Additional investigations conducted after 2010 confirmed their previous conclusions. In 2012, it was determined that off-property vapor exposure should be investigated and evaluated because of the confirmed off-property transport of benzene (PGW, 2013). The Pennsylvania Department of Environmental Protection (DEP) oversaw PGW's 2012 soil vapor study where soil gas samples were collected along the exterior of residences. The results of the investigation identified chloroform at levels greater than standards established by DEP; however, there was no attributable source of chloroform on PGW property or in the groundwater originating from their property (PGW, 2013). No other compounds were detected in soil gas samples at or above their respective Medium Specific Concentrations – a DEP standard (PGW, 2013).

In 2013, DOH and ATSDR screened the 2012 PGW sampling data using more conservative health-based comparison values (CVs) – the ATSDR Cancer Risk Evaluation Guide (CREG) values. DOH concluded that maximum concentrations of chloroform and benzene in the soil gas data exceeded their CREG values and required further evaluation; however, it could not be determined if indoor air concentrations of the chemicals were of public health concern in the absence of sub-slab or indoor air samples from within the residences.

Because chloroform is unrelated to PGW's operations, DOH and ATSDR referred the site, which does not include PGW property, to the EPA removal program to conduct a follow-up residential vapor intrusion investigation. EPA collected 24-hour samples of sub-slab soil gas, indoor air, and outdoor ambient air. Sample collection took place once in January 2014, once in October 2014, and once in March 2016. The samples were collected using SUMMA® canisters at residential units at the site and were analyzed in accordance with EPA Toxic Organic Method TO-15 for the full target compound list. Lifestyle products were removed from residences 24 hours prior to sampling to reduce their potential interference (EPA, 2017). Not all sources of indoor air contamination can be eliminated, such as carpeting and building materials.

DOH prepared this letter to review the EPA sampling data and evaluate whether exposure to indoor air contaminants pose a public health threat to residents.

**THE VAPOR INSTRUSION EXPOSURE PATHWAY**

Vapor intrusion is the general term given to the migration of hazardous vapors from any subsurface contaminant source, such as contaminated soil or groundwater, into a building or structure above (EPA, 2015). (See Appendix B for additional information on vapor intrusion.)

Indoor air in many buildings contain detectable levels of vapor-forming chemicals from a variety of indoor and outdoor sources. If vapor intrusion is occurring, the measured concentration of a contaminant will lessen as it migrates from a subsurface source to sub-slab soil gas and then to indoor air (EPA, 2015), provided there are no other indoor sources of that contaminant.

Exposure to contaminants of concern is determined by examining human exposure pathways. An exposure pathway has five parts:

1. A source of contamination (e.g., industrial facilities utilizing hazardous materials);
2. An environmental medium that can hold or move the contamination (e.g. water, soil, or air);
3. An exposure point at which people could come into contact with a contaminated medium (e.g., private residential well water or a building into which vapors enter);
4. An exposure route (e.g., ingestion or inhalation); and
5. A population that could come in contact with the contaminants.

For a completed pathway, all five parts must exist and exposure to a contaminant must have occurred, is occurring, or will occur (ATSDR, 2005a). For this investigation, vapor intrusion is the

exposure pathway of concern. The five parts of the vapor intrusion exposure pathway are present or could be present at the site as follows:

1. Source: Although the specific source is unknown, the presence of contaminants above their screening levels in the subsurface was confirmed during the 2012 soil vapor study.
2. Environmental medium: Groundwater and sub-slab soil are mediums that can hold and transport the contaminants.
3. Exposure point: People could become exposed within their residences if the vapors enter their homes, contaminating the indoor air.
4. Exposure route: People could inhale the contaminants that may be present in the indoor air.
5. Population: The residents living within the site are the potentially exposed population of concern.

This investigation sought to determine if chemical contaminants (particularly benzene and chloroform, which were detected at concentrations above their CREG values in 2012) were present in the indoor air of residences at concentrations that could harm people's health.

**DATA EVALUATION**

DOH screened the air sampling data against appropriate ATSDR CVs, which are health-based guidelines. Table 1 presents the maximum contaminant concentrations and the corresponding CVs. ATSDR CVs are conservative estimates of contaminant levels below which no health effects would be expected. When an ATSDR CV is not available, DOH uses screening values from other environmental and health agencies such as the EPA or another state agency (ATSDR, 2005a). Concentrations found to be above a CV do not necessarily mean they are harmful but that they require further evaluation to determine if adverse health effects are likely. Contaminants that exceed a CV are further evaluated using other standards and/or scientific studies, where appropriate, to determine whether adverse health effects are likely.

To evaluate non-cancer health effects, the CVs used were ATSDR's chronic and acute Minimal Risk Level (MRL) values, which are estimates of human exposure to a hazardous substance that are unlikely to have an appreciable risk of adverse non-cancer health effects over a specified route and duration of exposure in most people, including sensitive populations. If an MRL was not available, the EPA Reference Concentration (RfC) was used, which is an estimate of a continuous inhalation exposure that is unlikely to have an appreciable risk of harmful health effects during a lifetime, including to members of sensitive populations (EPA, 2017).

To evaluate cancer risk, DOH screened the data using ATSDR's CREG values, which are media-specific CVs used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population. If the air concentration of a specific contaminant exceeded the ATSDR CREG, DOH reviewed the toxicological information for that chemical and calculated an estimated excess cancer risk for residents using the following equation, which uses default values for an adult's exposure years living at one residence in their lifetime (ATSDR, 2016):

Estimated cancer risk =

$$\frac{\text{Exposure Concentration x EPA Inhalation Unit Risk (IUR) x 33 Exposure Years}}{\text{78 Years.}}$$

To compare chemical concentrations in the sub-slab and indoor air across all units, average chemical concentrations were calculated using the results from all three sampling periods. Non-detect values were estimated and were not treated as zero. The assumption that undetected contaminants are absent from samples is often unduly optimistic as some carcinogens can pose potential health risks at levels below detection limits (EPA, 1991b). The non-detect values were estimated by dividing the Method Detection Limit (MDL) by two (EPA, 1991b). The laboratory also reported lab-estimated concentrations if a compound exceeded the MDL and was less than the reporting limit (Table 2, green-highlighted cells).

**PUBLIC HEALTH IMPLICATIONS**

*Non-cancer health effects*

With one exception—a single detection of benzene at 14.2 μg/m$^3$ (Table 1), to be discussed—all contaminants detected in the basement and first-floor indoor air were below their non-cancer health-based CVs; therefore, exposure to the contaminants at the levels detected is not expected to cause harmful non-cancer health effects.

*Cancer risk evaluation*

There were seven contaminants detected at the site that exceeded their CREG value at least once, requiring further evaluation for cancer risk: benzene; chloroform; 1,2-dicholoroethane; 1,3-butadiene; carbon tetrachloride; tetrachloroethylene; and trichloroethylene. Sub-slab, basement indoor air, and first-floor indoor air sample data for those seven contaminants are presented in Tables 2a–2g.

Benzene

Benzene was historically associated with the site, having been detected above its CVs in the groundwater aquifer below the nearby PGW facility with confirmed off-site transport towards the residential units.

During this investigation, benzene was detected at a maximum concentration of 14.2 μg/m$^3$ in the first floor of unit 175 during October 2014 (Table 2a). The benzene concentration in the basement indoor air was 2.24 μg/m$^3$ and was undetected in the sub-slab during the same sampling period – October 2014. The average benzene concentration in the sub-slab, basement indoor air, and first-floor indoor air across all units and sampling periods was 0.368 μg/m$^3$, 1.191 μg/m$^3$, and 1.878 μg/m$^3$, respectively. Benzene was undetected in nine of the 18 sub-slab samples. These values, where the average chemical concentrations are greater in the indoor air, do not indicate a subsurface source of contamination.

A National Human Exposure Assessment Survey (NHEXAS) study of six states in the Great Lakes region found benzene in 100% of indoor air samples with concentrations averaging 7.19

> μg/m$^3$ [Clayton et al., 1999]. People living in cities or industrial areas are generally exposed to higher levels of benzene in air than those living in rural areas. The major sources of benzene exposure are exhaust from motor vehicles, automobile service stations, industrial emissions, and tobacco smoke. Vapors from products that contain benzene, such as glues, paints, furniture wax, and detergents, can also be a source of exposure. People may be exposed to higher levels of benzene in air by living near hazardous waste sites, petroleum refining operations, petrochemical manufacturing sites, or gas stations. (ATSDR, 2007)

The U.S. Department of Health and Human Services (HHS) has classified benzene as a human carcinogen (NTP, 2016). The International Agency for Research on Cancer (IARC) has also classified benzene as a human carcinogen (IARC, 2017).

The estimated increased cancer risk using the maximum concentration of 14.2 μg/m$^3$ (detected in the first-floor indoor air of unit 175 during October 2014) was 4.69 x $10^{-5}$ (Table 2a), which falls within EPA's target cancer risk range of 1 x $10^{-4}$ to 1 x $10^{-6}$ (EPA, 1991). There is no apparent increased cancer risk from exposure to benzene at the levels detected. Additionally, the estimated increased cancer risk from exposure to the average background level of 7.19 μg/m$^3$ that the NHEXAS study identified is 2.37 x $10^{-5}$, which is greater than the risk estimated for exposure at the site.

Chloroform

Chloroform is the other chemical historically associated with the site, detected above its CVs, though the chemical is not associated with PGW facility operations.

During this investigation, the maximum *exposure* concentration of chloroform (from an indoor air detection to which residents could be exposed, as opposed to a sub-slab detection) was 9.26 μg/m$^3$ in the first-floor indoor air of unit 175 during October 2014 (Table 2b). Chloroform was detected at an overall maximum concentration of 67 μg/m$^3$ in the sub-slab of unit 175 during March 2016. The basement indoor air chloroform concentration in March 2016 was 0.78 μg/m$^3$. The average chloroform concentration in the sub-slab, basement indoor air, and first-floor indoor air all units and sampling periods was 5.610 μg/m$^3$, 0.652 μg/m$^3$, and 0.945 μg/m$^3$, respectively. Chloroform was undetected in six of the 18 sub-slab samples. The higher average concentration in the sub-slab indicates a potential subsurface source of contamination, though the first-floor average is higher than the basement, indicating an alternate source of contamination.

> Typical median indoor air concentrations of chloroform range from 0.98 to 19 μg/m$^3$. Chloroform has been found in the air from all areas of the United States and in nearly all public drinking water supplies; it is formed in small amounts when chlorine is added to water. Chloroform was once widely used as an anesthetic during surgery in humans. (ATSDR, 1997)

HHS has classified chloroform as *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP, 2016). IARC has classified chloroform as *possibly* carcinogenic to humans (IARC, 2017).

The estimated increased cancer risk using the maximum *exposure* concentration of 9.26 $\mu g/m^3$ (detected in the first-floor indoor air of unit 175 during October 2014) was $9.01 \times 10^{-5}$ (Table 2b), which falls within EPA's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. There is no apparent increased cancer risk from exposure to chloroform at the levels detected. Additionally, the estimated increased cancer risk using the higher background concentration of 19 $\mu g/m^3$ (ATSDR, 1997) is $1.85 \times 10^{-4}$, which is greater than the risk estimated for exposure at the site.

1,2-Dicholoroethane

During this investigation, 1,2-dicholoroethane was detected at a maximum concentration of 1.58 $\mu g/m^3$ in the basement indoor air of unit 70 during October 2014 (Table 2c). The average 1,2-dicholoroethane concentrations in the basement indoor air and first-floor indoor air across all units and sampling periods were 0.247 $\mu g/m^3$ and 0.342 $\mu g/m^3$, respectively. 1,2-Dicholoroethane was undetected in all sub-slab samples. These values, where the average chemical concentrations are greater in the indoor air, do not indicate a subsurface source of contamination.

> 1,2-Dicholoroethane is a manufactured chemical that is not found naturally in the environment. It is used in the production of vinyl chloride and is added to leaded gasoline to remove lead. It is a probable human carcinogen. In a 1996 survey of New Jersey and Pennsylvania residences by Heavner et al., 1,2-dichloroethane was detected in the homes of nonsmokers at a mean concentration of 0.03 $\mu g/m^3$ and in the homes of smokers at a mean concentration of 0.32 $\mu g/m^3$. The maximum concentration of 1,2-dichloroethane reported in nonsmoking households was 0.54 $\mu g/m^3$, while the maximum concentration in households where at least one family member smoked was 9.72 $\mu g/m^3$. (ATSDR, 2001)

HHS has classified 1,2-dicholoroethane as *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP, 2016). IARC has classified 1,2-dicholoroethane as *possibly* carcinogenic to humans (IARC, 2017).

The estimated increased cancer risk using the maximum exposure concentration of 1.58 $\mu g/m^3$ (detected in the basement indoor air of unit 70 during October 2014) was $1.74 \times 10^{-5}$ (Table 2c), which falls within EPA's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. There is no apparent increased cancer risk from exposure to 1,2-dicholoroethane at the levels detected. Additionally, the estimated increased cancer risk using the maximum background concentration of 0.54 $\mu g/m^3$ identified in a 1996 study (ATSDR, 2001) is $5.94 \times 10^{-6}$, which is less than the risk estimated for exposure at the site.

1,3-Butadiene

During this investigation, the maximum *exposure* concentration of 1,3-butadiene (from an indoor air detection to which residents could be exposed, as opposed to a sub-slab detection) was 0.23 $\mu g/m^3$ in the first-floor indoor air of unit 50 during January 2014 (Table 2d). 1,3-Butadiene was detected at an overall maximum concentration of 0.5 $\mu g/m^3$ in the sub-slab of unit 116 during January 2014. The basement indoor air and first-floor indoor air concentration in January 2014 was 0.150 $\mu g/m^3$ and 0.190 $\mu g/m^3$, respectively. 1,3-Butadiene was undetected in all other sub-slab samples. The average 1,3-butadiene concentration in the sub-slab, basement indoor air, and first-

floor indoor air across all units and sampling periods was 0.035 μg/m$^3$, 0.047 μg/m$^3$, and 0.063 μg/m$^3$, respectively. These values, where the average chemical concentrations are greater in the indoor air, do not indicate a subsurface source of contamination.

> 1,3-Butadiene is a chemical made from the processing of petroleum. It evaporates easily and as such, it is not expected to be found in water or soil. Automobile exhaust and cigarette smoke are common sources of 1,3-butadiene release into the air. A 2004 Sax et al. study measured 1,3-butadiene in indoor air of homes in New York. The mean concentrations were 1.0 μg/m$^3$ during the winter and 1.2 μg/m$^3$ during the summer (ATSDR, 2012).

HHS has classified 1,3-butadiene as a human carcinogen (NTP, 2016). IARC has also classified 1,3-butadiene as a human carcinogen (IARC, 2017).

The estimated increased cancer risk using the maximum exposure concentration of 0.23 μg/m$^3$ (detected in the first-floor indoor air of unit 50 during January 2014) was 2.92 x 10$^{-6}$ (Table 2d), which falls within EPA's target cancer risk range of 1 x 10$^{-4}$ to 1 x 10$^{-6}$. There is no apparent increased cancer risk from exposure to 1,3-butadiene at the levels detected. Additionally, the estimated increased cancer risk using the higher background concentration of 1.2 μg/m$^3$ (ATSDR, 2012) is 1.52 x 10$^{-5}$, which is greater than the risk estimated for exposure at the site.

Carbon tetrachloride

During this investigation, the maximum *exposure* concentration of carbon tetrachloride (from an indoor air detection to which residents could be exposed, as opposed to a sub-slab detection) was 0.72 μg/m$^3$ in the first-floor indoor air of unit 34 during January 2014 (Table 2e). Carbon tetrachloride was detected at an overall maximum concentration of 135 μg/m$^3$ in the sub-slab of unit 175 during October of 2014. The concentration in the basement indoor air was 0.467 μg/m$^3$ during the same sampling period – October 2014. The average carbon tetrachloride concentration in the sub-slab, basement indoor air, and first-floor indoor air across all units and sampling periods was 7.642 μg/m$^3$, 0.437 μg/m$^3$, and 0.315 μg/m$^3$, respectively (Excluding the outlying detection of 135 μg/m$^3$ in the sub-slab, the average sub-slab concentration is 0.143 μg/m$^3$). Carbon tetrachloride was undetected in 12 of the 18 sub-slab samples. These values, where the average chemical concentrations are greater in the indoor air, do not indicate a subsurface source of contamination.

> Carbon tetrachloride is a manufactured chemical that is not found naturally in the environment. Typical indoor concentrations in homes in several U.S. cities were around 1.0 μg/m$^3$, with some values up to 9 μg/m$^3$. (ATSDR, 2005b)

HHS has classified carbon tetrachloride as *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP, 2016). IARC has classified carbon tetrachloride as *possibly* carcinogenic to humans (IARC, 2017).

The estimated increased cancer risk using the maximum *exposure* concentration of 0.72 μg/m$^3$ (detected in the first-floor indoor air of unit 34 during January 2014) was 1.83 x 10$^{-6}$ (Table 2e), which falls within EPA's target cancer risk range of 1 x 10$^{-4}$ to 1 x 10$^{-6}$. There is no apparent

increased cancer risk from exposure to carbon tetrachloride at the levels detected. Additionally, the estimated increased cancer risk using the higher background concentration of 9 $\mu g/m^3$ (ATSDR, 2005b) is $2.28 \times 10^{-5}$, which is greater than the risk estimated for exposure at the site.

Tetrachloroethylene

During this investigation, the maximum *exposure* concentration of tetrachloroethylene (from an indoor air detection to which residents could be exposed, as opposed to a sub-slab detection) was 6.81 $\mu g/m^3$ in the first-floor indoor air of unit 34 during March 2016 (Table 2f). Tetrachloroethylene was detected at an overall maximum concentration of 27.1 $\mu g/m^3$ in the sub-slab of unit 116 during October 2014. The tetrachloroethylene concentration in the basement indoor air was 0.526 $\mu g/m^3$ during the same sampling period – October 2014. The average tetrachloroethylene concentration in the sub-slab, basement indoor air, and first-floor indoor air across all units and sampling periods was 3.856 $\mu g/m^3$, 0.315 $\mu g/m^3$, and 0.537 $\mu g/m^3$, respectively. Tetrachloroethylene was undetected in four of the 18 sub-slab samples. The higher average concentration in the sub-slab indicates a potential subsurface source of contamination, though the first-floor average is higher than the basement, indicating an alternate source of contamination.

> Tetrachloroethylene is one of the most commonly detected chemicals in background indoor sources. The median value for indoor air in the United States, from 2,195 entries in the EPA's database of volatile organic contaminants (VOC-AMBI), was approximately 4.9 $\mu g/m^3$, with an average value of 20.7 $\mu g/m^3$. The use of tetrachloroethylene as a dry-cleaning agent, chemical intermediate, and metal degreasing solvent has led to its release to the environment. It is also used in some consumer products. (ATSDR, 2014a)

HHS has classified tetrachloroethylene as *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP, 2016). IARC has classified tetrachloroethylene as *probably* carcinogenic to humans (IARC, 2017).

The estimated increased cancer risk using the maximum *exposure* concentration of 6.81 $\mu g/m^3$ (detected in the first-floor indoor air of unit 34 during March 2016) was $7.49 \times 10^{-7}$ (Table 2f), which falls within EPA's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. There is no apparent increased cancer risk from exposure to tetrachloroethylene at the levels detected. Additionally, the estimated increased cancer risk using average background concentration of 20.7 $\mu g/m^3$ (ATSDR, 2014a) is $2.28 \times 10^{-6}$, which is greater than the risk estimated for exposure at the site.

Trichloroethylene

During this investigation, the maximum *exposure* concentration of trichloroethylene was 0.627 $\mu g/m^3$ in the first-floor indoor air of unit 175 during October 2014 (Table 2g). Trichloroethylene was detected at an overall maximum concentration of 8.4 $\mu g/m^3$ in the sub-slab of unit 175 during January 2014. Trichloroethylene was undetected in the basement indoor air during that sampling period. The average trichloroethylene concentration in the sub-slab, basement indoor air, and first-floor indoor air across all units and sampling periods was 0.591 $\mu g/m^3$, 0.135 $\mu g/m^3$, and 0.095 $\mu g/m^3$, respectively. Trichloroethylene was undetected in 15 of the 18 sub-slab samples. The higher average concentration in the sub-slab indicates a potential subsurface source of contamination.

However, individual basement indoor air detections do not correspond to elevated concentrations in the sub-slab for the same residential unit during the same sampling period, indicating an alternate source of contamination.

> Major uses of trichloroethylene are as a solvent to remove grease from metal parts and as an intermediate chemical in the multi-step process of manufacturing of refrigerant chemicals. Exposure most often occurs by drinking water that has been contaminated by trichloroethylene or by breathing trichloroethylene released to the air from contaminated water. Arithmetic mean trichloroethylene concentrations measured in air at locations across the United States are generally between 0.05 $\mu g/m^3$ and 1.61 $\mu g/m^3$, although mean levels as high as 18.27 $\mu g/m^3$ have been reported. (ATSDR, 2014b)

HHS has classified trichloroethylene as *known to be a human carcinogen* (NTP, 2016). IARC has also classified trichloroethylene as a human carcinogen (IARC, 2017).

The estimated increased cancer risk using the maximum *exposure* concentration of 0.627 $\mu g/m^3$ (detected in the first-floor indoor air of unit 175 during October 2014) was $1.09 \times 10^{-6}$ (Table 2g), which falls within EPA's target cancer risk range of $1 \times 10^{-4}$ to $1 \times 10^{-6}$. There is no apparent increased cancer risk from exposure to trichloroethylene at the levels detected. Additionally, the estimated increased cancer risk using the higher background concentration of 1.61 $\mu g/m^3$ (ATSDR, 2014b) is $2.79 \times 10^{-6}$, which is greater than the risk estimated for exposure at the site.

*Cumulative cancer risk health effects*

For this health evaluation, cumulative cancer risk was estimated using the summation of each individual chemical's cancer risk estimate. A cumulative cancer risk estimate was calculated separately for the first floor and basement of each residential unit for each sampling period. The cumulative cancer risk estimates in the basement indoor air samples ranged from $6.18 \times 10^{-6}$ to $3.27 \times 10^{-5}$ and from $1.81 \times 10^{-6}$ to $1.42 \times 10^{-4}$ in the first-floor indoor air (Table 3).

The highest estimate of $1.42 \times 10^{-4}$ (from the first-floor indoor air of unit 175 during October 2014) falls outside of EPA's target cancer risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ and was evaluated further. The elevated risk in that location is attributable to benzene and chloroform outliers, which are likely due to a source or sources other than vapor intrusion. While long-term exposure to benzene and chloroform can cause certain cancers, short-term exposure to the levels detected at the site during October 2014 is not expected to increase cancer risk.

Based on our analysis, there is no apparent increased cancer risk from exposure to the contaminants at the levels detected in the indoor air of residential units at the site.

**LIMITATIONS**

- There is no data to assess indoor air contamination during the summer months. The effects of temperature and other weather variations should be considered when evaluating the concentration of volatile organic compounds in the air.
- Background sources of contamination – such as furniture and flooring inside the home, or automobile exhaust and industrial emissions entering the home from outside – can affect environmental evaluations where vapor intrusion is the source of concern. Particularly in urban areas, contaminants from ambient sources can be present in indoor air (DEP, 2002).

**CONCLUSIONS AND RECOMMENDATIONS**

- Exposures to indoor air contaminants at the levels detected are not expected to result in adverse health effects.
- Most indoor air detections did not exceed background levels common in urban environments.
- The data do not indicate that the contaminants detected in the indoor air originated entirely from the sub-slab soil gas. Elevated detections of first-floor and basement indoor air contaminants did not correspond to elevated levels of that chemical in the sub-slab in the same unit during the same sampling period. Additionally, when elevated levels of contaminants were detected in the sub-slab, there was not a corresponding and proportionally elevated detection in the basement indoor air.
- Contaminants detected in the indoor air likely originated from sources of contamination other than vapor intrusion. To protect the current and future health of individuals, DOH recommends that EPA provide health education to these residents to limit their chemical exposure from indoor sources.

Please contact me with any questions you may have regarding this letter health consultation.

Sincerely,

Bevin Durant, MPH
Epidemiology Research Associate
Pennsylvania Department of Health
bdurant@pa.gov

Cc: Farhad Ahmed, MBBS, MPH; DOH
Anil Nair, PhD, MPH; DOH

## REFERENCES


Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for chloroform. https://www.atsdr.cdc.gov/toxprofiles/tp6.pdf

ATSDR. 2001. Toxicological profile for 1,2-dichloroethane. https://www.atsdr.cdc.gov/toxprofiles/tp38.pdf

ATSDR. 2005a. Public Health Assessment Guidance Manual. http://www.atsdr.cdc.gov/HAC/PHAmanual/

ATSDR. 2005b. Toxicological profile for carbon tetrachloride. https://www.atsdr.cdc.gov/ToxProfiles/tp30.pdf

ATSDR. 2007. Toxicological profile for benzene. https://www.atsdr.cdc.gov/toxprofiles/tp3.pdf

ATSDR. 2012. Toxicological profile for 1,3-butadiene. https://www.atsdr.cdc.gov/toxprofiles/tp28.pdf

ATSDR. 2014a. Draft toxicological profile for tetrachloroethylene. https://www.atsdr.cdc.gov/toxprofiles/tp18.pdf

ATSDR. 2014b. Draft toxicological profile for trichloroethylene. https://www.atsdr.cdc.gov/ToxProfiles/tp19.pdf

ATSR. 2016. ATSDR Division of Community Health Investigations Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, October 26.

Clayton, C.A., Pellizzari, E.D., Whitmore, R.W., Perritt, R.L., Quackenboss, J.J. 1999. National Human Exposure Assessment Survey (NHEXAS): distributions and associations of lead, arsenic and volatile organic compounds in EPA region 5. *Journal of Exposure Analysis and Environmental Epidemiology. 9*(5), 381-392.

Environmental Protection Agency, U.S. (EPA). 1991a. Role of the baseline risk assessment in superfund remedy selection decisions. https://www.epa.gov/sites/production/files/2015-11/documents/baseline.pdf

EPA. 1991b. Regional Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments. https://www.epa.gov/risk/regional-guidance-handling-chemical-concentration-data-near-detection-limit-risk-assessments

EPA. 2015. OSWER technical guide for assessing and mitigating the vapor intrusion pathway from subsurface vapor sources to indoor air. https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf

EPA. 2017. Basic information about the integrated risk information system. https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system

International Agency for Research on Cancer (IARC). 2012. IARC monographs on the evaluation of carcinogenic risks to humans, volume 100F. http://monographs.iarc.fr/ENG/Monographs/vol100F/mono100F.pdf

IARC. 2017. Agents classified by the IARC monographs, volumes 1-119. http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf

National Toxicology Program (NTP). 2016. Report on Carcinogens, Fourteenth Edition; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. http://ntp.niehs.nih.gov/go/roc14/

## TABLES

### Table 1: Maximum Contaminant Concentrations and Health–Based Comparison Values

| Contaminants | Maximum Indoor Air µg/m$^3$ | ATSDR CREG µg/m$^3$ | ATSDR Chronic MRL µg/m$^3$ | ATSDR Acute MRL µg/m$^3$ | EPA RfC µg/m$^3$ |
|---|---|---|---|---|---|
| Acetone | 260 | — | 31000 | 62000 | — |
| Benzene | **14.2** | 0.13 | 9.6 | 29 | 30 |
| Bromoform | 0.327 | 0.91 | — | — | — |
| 1,3-Butadiene | **0.23** | 0.033 | — | — | 2 |
| 2-Butanone | 16 | — | — | — | 5000 |
| Carbon Tetrachloride | **0.72** | 0.17 | 190 | — | 100 |
| Chlorobenzene | 0.0955 | — | — | — | — |
| Chloroethane | 0.331 | — | — | 40000 | 10000 |
| Chloroform | **9.26** | 0.043 | 98 | 490 | — |
| Chloromethane | 2.41 | — | 100 | 1000 | 90 |
| Cyclohexane | 3.06 | — | — | — | 6000 |
| Dibromochloromethane | 2.35 | — | — | — | — |
| 1,4-Dichlorobenzene | 2.83 | — | 60 | 12000 | 800 |
| Dichlorodifluoromethane | 3.2 | — | — | — | — |
| 1,1-Dichloroethane | 0.186 | — | — | — | — |
| 1,2-Dichloroethane | **1.58** | 0.038 | 2400 | — | — |
| Ethyl Acetate | 20.8 | — | — | — | — |
| Ethylbenzene | 11.8 | — | 260 | 22000 | 1000 |
| 4-Ethyltoluene | 1.59 | — | — | — | — |
| Heptane, N- | 8.59 | | — | — | — |
| Hexane, N- | 28 | — | 2100 | — | 700 |
| 2-Hexanone | 0.49 | — | — | — | 30 |
| Isopropanol | 1250 | — | — | — | — |
| Methyl Isobutyl Ketone | 1.59 | — | — | — | 3000 |
| Methyl tert-Butyl Ether (MTBE) | 0.22 | — | 2500 | 7200 | 3000 |
| Methylene Chloride | 61 | 63 | 1000 | 2100 | 600 |
| Naphthalene | 1.02 | — | 3.7 | — | 3 |
| Propene | 146 | — | — | — | — |
| Styrene | 1.55 | — | 850 | 21000 | 1000 |
| Tetrachloroethylene | **6.81** | 3.8 | 41 | 41 | 40 |
| Tetrahydrofuran | 245 | — | — | — | 2000 |
| Toluene | 13 | — | 3800 | 7500 | 5000 |
| Trichloro-1,2,2-trifluoroethane, | 33.7 | — | — | — | — |
| Trichloroethane, 1,1,1- | 32.6 | — | — | 11000 | 5000 |
| Trichloroethylene | **0.627** | 0.22 | 2.1 | — | 2 |
| Trichlorofluoromethane | 11 | — | — | — | — |
| Trimethylbenzene, 1,2,4- | 8.66 | — | — | — | 60 |
| Trimethylbenzene, 1,3,5- | 3.38 | — | — | — | 60 |
| Vinyl Acetate | 8.45 | — | — | — | 200 |
| Xylene, m&p- | 14.3 | — | 220 | 8700 | 100 |
| Xylene, o- | 6.73 | — | 220 | 8700 | 100 |

Cells with "–" = no available comparison value
Bold text = contaminant exceeded a CV

## Tables 2a–2g: Sub-slab, Basement Indoor Air, and First-Floor Indoor Air Detections for Contaminants that Exceeded CREG Values; µg/m$^3$

### Table 2a: Benzene (µg/m$^3$)

CREG = 0.13, MDL = 0.008

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 0.004 | 0.116 | 0.004 | 0.670 | 0.606 | 1.970 | 0.760 | 1.140 | 1.670 |
| **Unit 50** | 0.004 | 0.426 | 1.870 | 0.840 | 1.370 | 1.400 | 2.300 | 0.941 | 1.260 |
| **Unit 84** | 0.340 | 0.084 | 0.004 | 0.700 | 0.567 | 1.820 | 0.940 | 0.547 | 1.630 |
| **Unit 70** | 0.004 | 0.104 | 0.004 | 0.750 | 1.090 | 1.370 | 0.720 | 1.040 | 0.939 |
| **Unit 116** | 1.200 | 0.266 | 2.190 | 0.780 | 0.591 | 2.050 | 1.100 | 0.542 | 1.740 |
| **Unit 175** | 0.004 | 0.004 | 0.004 | 1.300 | 2.240 | 1.320 | 1.300 | **14.20*** | 1.040 |

*Cancer risk estimate for maximum exposure concentration: 4.69 x $10^{-5}$

### Table 2b: Chloroform (µg/m$^3$)

CREG = 0.043, MDL = 0.011

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 3.600 | 0.705 | 0.005 | 0.410 | 0.266 | 1.750 | 0.530 | 0.616 | 1.240 |
| **Unit 50** | 2.400 | 0.511 | 0.005 | 0.220 | 0.214 | 0.767 | 0.190 | 0.167 | 0.620 |
| **Unit 84** | 0.005 | 1.970 | 0.793 | 0.170 | 0.578 | 0.138 | 0.220 | 0.235 | 0.143 |
| **Unit 70** | 0.005 | 0.123 | 0.005 | 0.190 | 0.758 | 1.080 | 0.190 | 0.788 | 0.690 |
| **Unit 116** | 0.770 | 17.100 | 0.005 | 0.210 | 0.588 | 0.167 | 0.220 | 0.005 | 0.201 |
| **Unit 175** | 0.780 | 5.190 | *67.00* | 2.600 | 0.841 | 0.780 | 0.950 | **9.26*** | 0.748 |

*Cancer risk estimate for maximum exposure concentration: 9.01 x $10^{-5}$

### Table 2c: 1,2-Dichloroethane (µg/m$^3$)

CREG = 0.038, MDL = 0.019

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 0.009 | 0.009 | 0.009 | 0.180 | 0.009 | 0.187 | 0.210 | 1.290 | 0.260 |
| **Unit 50** | 0.009 | 0.009 | 0.009 | 0.009 | 0.167 | 0.508 | 0.009 | 0.114 | 0.937 |
| **Unit 84** | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.181 | 0.082 | 0.009 | 0.343 |
| **Unit 70** | 0.009 | 0.009 | 0.009 | 0.150 | **1.58*** | 0.226 | 0.150 | 1.570 | 0.144 |
| **Unit 116** | 0.009 | 0.009 | 0.009 | 0.009 | 0.107 | 0.255 | 0.130 | 0.009 | 0.433 |
| **Unit 175** | 0.009 | 0.009 | 0.009 | 0.009 | 0.092 | 0.755 | 0.009 | 0.241 | 0.217 |

*Cancer risk estimate for maximum exposure concentration: 1.74 x $10^{-5}$

---

Blue cells = Undetected result. Here, MDL/2 is used to estimate level of non-detects.
Green cells = Lab-estimated result
Red text = Maximum exposure concentration
Italicized text = Maximum detected concentration (if different from the maximum exposure concentration)

**Tables 2a–2g (continued): Sub-slab, Basement Indoor Air, and First-Floor Indoor Air Detections for Contaminants that Exceeded CREG Values; µg/m$^3$**

**Table 2d: 1,3-Butadiene (µg/m$^3$)**

CREG = 0.033, MDL = 0.016

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 0.008 | 0.008 | 0.008 | 0.082 | 0.008 | 0.008 | 0.140 | 0.008 | 0.008 |
| **Unit 50** | 0.008 | 0.008 | 0.008 | 0.190 | 0.008 | 0.008 | **0.230*** | 0.008 | 0.008 |
| **Unit 84** | 0.008 | 0.008 | 0.008 | 0.081 | 0.008 | 0.008 | 0.170 | 0.008 | 0.008 |
| **Unit 70** | 0.008 | 0.008 | 0.008 | 0.110 | 0.008 | 0.008 | 0.093 | 0.008 | 0.008 |
| **Unit 116** | *0.500* | 0.008 | 0.008 | 0.150 | 0.008 | 0.008 | 0.190 | 0.008 | 0.008 |
| **Unit 175** | 0.008 | 0.008 | 0.008 | 0.130 | 0.008 | 0.008 | 0.210 | 0.008 | 0.008 |

*Cancer risk estimate for maximum exposure concentration: 2.92 x $10^{-6}$

**Table 2e: Carbon Tetrachloride (µg/m$^3$)**

CREG = 0.017, MDL = 0.015

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 0.008 | 0.636 | 0.008 | 0.370 | 0.417 | 0.464 | **0.720*** | 0.415 | 0.495 |
| **Unit 50** | 0.008 | 0.442 | 0.008 | 0.410 | 0.428 | 0.417 | 0.008 | 0.466 | 0.453 |
| **Unit 84** | 0.008 | 0.446 | 0.008 | 0.360 | 0.429 | 0.456 | 0.008 | 0.084 | 0.446 |
| **Unit 70** | 0.008 | 0.439 | 0.008 | 0.350 | 0.442 | 0.487 | 0.410 | 0.078 | 0.331 |
| **Unit 116** | 0.008 | 0.197 | 0.008 | 0.410 | 0.442 | 0.471 | 0.008 | 0.008 | 0.447 |
| **Unit 175** | 0.008 | *135.0* | 0.315 | 0.550 | 0.467 | 0.501 | 0.390 | 0.445 | 0.460 |

*Cancer risk estimate for maximum exposure concentration: 1.83 x $10^{-6}$

**Table 2f: Tetrachloroethylene (µg/m$^3$)**

CREG = 3.8, MDL = 0.022

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 3.800 | 14.300 | 0.011 | 0.550 | 0.234 | 1.620 | 0.580 | 0.178 | **6.81*** |
| **Unit 50** | 0.011 | 2.520 | 1.180 | 0.450 | 0.237 | 0.324 | 0.011 | 0.179 | 0.011 |
| **Unit 84** | 1.000 | 4.420 | 0.011 | 0.011 | 0.011 | 0.194 | 0.011 | 0.011 | 0.157 |
| **Unit 70** | 1.500 | 1.260 | 0.721 | 0.011 | 0.197 | 0.011 | 0.011 | 0.011 | 0.154 |
| **Unit 116** | 0.810 | *27.100* | 0.011 | 0.130 | 0.526 | 0.311 | 0.011 | 0.011 | 0.200 |
| **Unit 175** | 0.920 | 8.560 | 1.280 | 0.310 | 0.324 | 0.219 | 0.011 | 1.130 | 0.178 |

*Cancer risk estimate for maximum exposure concentration: 7.49 x $10^{-7}$

Blue cells = Undetected result. Here, MDL/2 is used to estimate level of non-detects.
Green cells = Lab-estimated result
Red text = Maximum exposure concentration
Italicized text = Maximum detected concentration (if different from maximum exposure concentration)

**Tables 2a–2g (continued): Sub-slab, Basement Indoor Air, and First-Floor Indoor Air Detections for Contaminants that Exceeded CREG Values; µg/m$^3$**

**Table 2g: Trichloroethylene (µg/m$^3$)**

CREG = 0.22, MDL = 0.019

| Residential Units | Basement Sub Slab | | | Basement Indoor Air | | | First-Floor Indoor Air | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 | Jan-14 | Oct-14 | Mar-16 |
| **Unit 34** | 0.009 | 0.009 | 0.009 | 0.009 | 0.292 | 0.009 | 0.009 | 0.226 | 0.108 |
| **Unit 50** | 0.550 | 1.550 | 0.009 | 0.009 | 0.553 | 0.118 | 0.009 | 0.622 | 0.009 |
| **Unit 84** | 0.009 | 0.009 | 0.009 | 0.009 | 0.537 | 0.009 | 0.009 | 0.009 | 0.009 |
| **Unit 70** | 0.009 | 0.009 | 0.009 | 0.009 | 0.247 | 0.009 | 0.009 | 0.009 | 0.009 |
| **Unit 116** | 0.009 | 0.009 | 0.009 | 0.009 | 0.573 | 0.009 | 0.009 | 0.009 | 0.009 |
| **Unit 175** | *8.400* | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.627*** | 0.009 |

*Cancer risk estimate for maximum exposure concentration: 1.09 x 10$^{-6}$

Blue cells = Undetected result. Here, MDL/2 is used to estimate level of non-detects.
Green cells = Lab-estimated result
Red text = Maximum exposure concentration
Italicized text = Maximum detected concentration (if different from maximum exposure concentration)

## Table 3: Cumulative Cancer Risk per Residential Unit per Sampling Event

| Location | Contaminants | Maximum Indoor Air µg/m$^3$ | | | CREG µg/m$^3$ | EPA IUR (µg/m$^3$)$^{-1}$ | Cancer Risk Estimates for contaminants exceeding CREG* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Jan-14 | Oct-14 | Mar-16 | | | Jan-14 | Oct-14 | Mar-16 |
| UT34 Basement Indoor Air | 1,2-Dichloroethane | 0.18 | NA | 0.187 | 0.038 | 2.60E-05 | 1.98E-06 | NA | 2.06E-06 |
| | 1,3-Butadiene | 0.082 | NA | NA | 0.033 | 3.00E-05 | 1.041E-06 | NA | NA |
| | Benzene | 0.67 | 0.606 | 1.97 | 0.13 | 7.80E-06 | 2.211E-06 | 2E-06 | 6.50E-06 |
| | Carbon Tetrachloride | 0.37 | 0.417 | 0.464 | 0.17 | 6.00E-06 | 9.392E-07 | 1.06E-06 | 1.18E-06 |
| | Chloroform | 0.41 | 0.266 | 1.75 | 0.043 | 2.30E-05 | 3.99E-06 | 2.59E-06 | 1.70E-05 |
| | Tetrachloroethylene | 0.55 | 0.234 | 1.62 | 3.8 | 2.60E-07 | 6.05E-08 | 2.57E-08 | 1.78E-07 |
| | Trichloroethylene | NA | 0.292 | NA | 0.22 | 4.10E-06 | NA | 5.065E-07 | NA |
| **CUMULATIVE CANCER RISK - UT34 Basement Indoor Air** | | | | | | | **1.02E-05** | **6.18E-06** | **2.69E-05** |
| UT34 First Floor Indoor Air | 1,2-Dichloroethane | 0.21 | 1.29 | 0.26 | 0.038 | 2.60E-05 | 2.31E-06 | 1.42E-05 | 2.86E-06 |
| | 1,3-Butadiene | 0.14 | NA | NA | 0.033 | 3.00E-05 | 1.78E-06 | NA | NA |
| | Benzene | 0.76 | 1.14 | 1.67 | 0.13 | 7.80E-06 | 2.51E-06 | 3.76E-06 | 5.51E-06 |
| | Carbon Tetrachloride | 0.72 | 0.415 | 0.495 | 0.17 | 6.00E-06 | 1.83E-06 | 1.05E-06 | 1.26E-06 |
| | Chloroform | 0.53 | 0.616 | 1.24 | 0.043 | 2.30E-05 | 5.16E-06 | 5.99E-06 | 1.21E-05 |
| | Tetrachloroethylene | 0.58 | 0.178 | 6.81 | 3.8 | 2.60E-07 | 6.38E-08 | 1.96E-08 | 7.49E-07 |
| | Trichloroethylene | NA | 0.226 | 0.108 | 0.22 | 4.10E-06 | NA | 3.92E-07 | 1.87E-07 |
| **CUMULATIVE CANCER RISK - UT34 First Floor Indoor Air** | | | | | | | **1.36E-05** | **2.54E-05** | **2.26E-05** |
| UT50 Basement Indoor Air | 1,2-Dichloroethane | NA | 0.167 | 0.508 | 0.038 | 2.60E-05 | NA | 1.84E-06 | 5.59E-06 |
| | 1,3-Butadiene | 0.19 | NA | NA | 0.033 | 3.00E-05 | 2.41E-06 | NA | NA |
| | Benzene | 0.84 | 1.37 | 1.4 | 0.13 | 7.80E-06 | 2.77E-06 | 4.52E-06 | 4.62E-06 |
| | Carbon Tetrachloride | 0.41 | 0.428 | 0.417 | 0.17 | 6.00E-06 | 1.04E-06 | 1.09E-06 | 1.06E-06 |
| | Chloroform | 0.22 | 0.214 | 0.767 | 0.043 | 2.30E-05 | 2.14E-06 | 2.08E-06 | 7.46E-06 |
| | Tetrachloroethylene | 0.45 | 0.237 | 0.324 | 3.8 | 2.60E-07 | 4.95E-08 | 2.61E-08 | 3.56E-08 |
| | Trichloroethylene | NA | 0.553 | 0.118 | 0.22 | 4.10E-06 | NA | 9.59E-07 | 2.05E-07 |
| **CUMULATIVE CANCER RISK - UT50 Basement Indoor Air** | | | | | | | **8.41E-06** | **1.05E-05** | **1.90E-05** |
| UT50 First Floor Indoor Air | 1,2-Dichloroethane | NA | 0.114 | 0.937 | 0.038 | 2.60E-05 | NA | 1.25E-06 | 1.03E-05 |
| | 1,3-Butadiene | 0.23 | NA | NA | 0.033 | 3.00E-05 | 2.92E-06 | NA | NA |
| | Benzene | 2.3 | 0.941 | 1.26 | 0.13 | 7.80E-06 | 7.59E-06 | 3.11E-06 | 4.16E-06 |
| | Carbon Tetrachloride | NA | 0.466 | 0.453 | 0.17 | 6.00E-06 | NA | 1.18E-06 | 1.15E-06 |
| | Chloroform | 0.19 | 0.167 | 0.62 | 0.043 | 2.30E-05 | 1.85E-06 | 1.63E-06 | 6.03E-06 |
| | Tetrachloroethylene | NA | 0.179 | NA | 3.8 | 2.60E-07 | NA | 1.97E-08 | NA |
| | Trichloroethylene | NA | 0.622 | NA | 0.22 | 4.10E-06 | NA | 1.08E-06 | NA |
| **CUMULATIVE CANCER RISK - UT50 First Floor Indoor Air** | | | | | | | **1.24E-05** | **8.27E-06** | **2.16E-05** |
| UT70 Basement Indoor Air | 1,2-Dichloroethane | 0.15 | 1.58 | 0.226 | 0.038 | 2.60E-05 | 1.65E-06 | 1.74E-05 | 2.49E-06 |
| | 1,3-Butadiene | 0.11 | NA | NA | 0.033 | 3.00E-05 | 1.40E-06 | NA | NA |
| | Benzene | 0.75 | 1.09 | 1.37 | 0.13 | 7.80E-06 | 2.48E-06 | 3.60E-06 | 4.52E-06 |
| | Carbon Tetrachloride | 0.35 | 0.442 | 0.487 | 0.17 | 6.00E-06 | 8.88E-07 | 1.12E-06 | 1.24E-06 |
| | Chloroform | 0.19 | 0.758 | 1.08 | 0.043 | 2.30E-05 | 1.85E-06 | 7.38E-06 | 1.05E-05 |
| | Tetrachloroethylene | NA | 0.197 | NA | 3.8 | 2.60E-07 | NA | 2.17E-08 | NA |
| | Trichloroethylene | 1.2 | 1.34 | 0.909 | 0.22 | 4.10E-06 | 2.08E-06 | 2.32E-06 | 1.58E-06 |
| **CUMULATIVE CANCER RISK - UT70 Basement Indoor Air** | | | | | | | **1.03E-05** | **3.18E-05** | **2.03E-05** |
| UT70 First Floor Indoor Air | 1,2-Dichloroethane | 0.15 | 1.57 | 0.144 | 0.038 | 2.60E-05 | 1.65E-06 | 1.73E-05 | 1.58E-06 |
| | 1,3-Butadiene | 0.093 | NA | NA | 0.033 | 3.00E-05 | 1.18E-06 | NA | NA |
| | Benzene | 0.72 | 1.04 | 0.939 | 0.13 | 7.80E-06 | 2.38E-06 | 3.43E-06 | 3.10E-06 |
| | Carbon Tetrachloride | 0.41 | NA | 0.331 | 0.17 | 6.00E-06 | 1.04E-06 | NA | 8.40E-07 |
| | Chloroform | 0.19 | 0.788 | 0.69 | 0.043 | 2.30E-05 | 1.85E-06 | 7.67E-06 | 6.71E-06 |
| | Tetrachloroethylene | NA | NA | 0.154 | 3.8 | 2.60E-07 | NA | NA | 1.69E-08 |
| | Trichloroethylene | NA | NA | NA | 0.22 | 4.10E-06 | NA | NA | NA |
| **CUMULATIVE CANCER RISK - UT70 First Floor Indoor Air** | | | | | | | **8.10E-06** | **2.84E-05** | **1.23E-05** |

NA = Contaminants were undetected or results were estimated
Red text = maximum exposure concentration
Green text = detections did not exceed CREG but were included in cumulative cancer risk evaluation

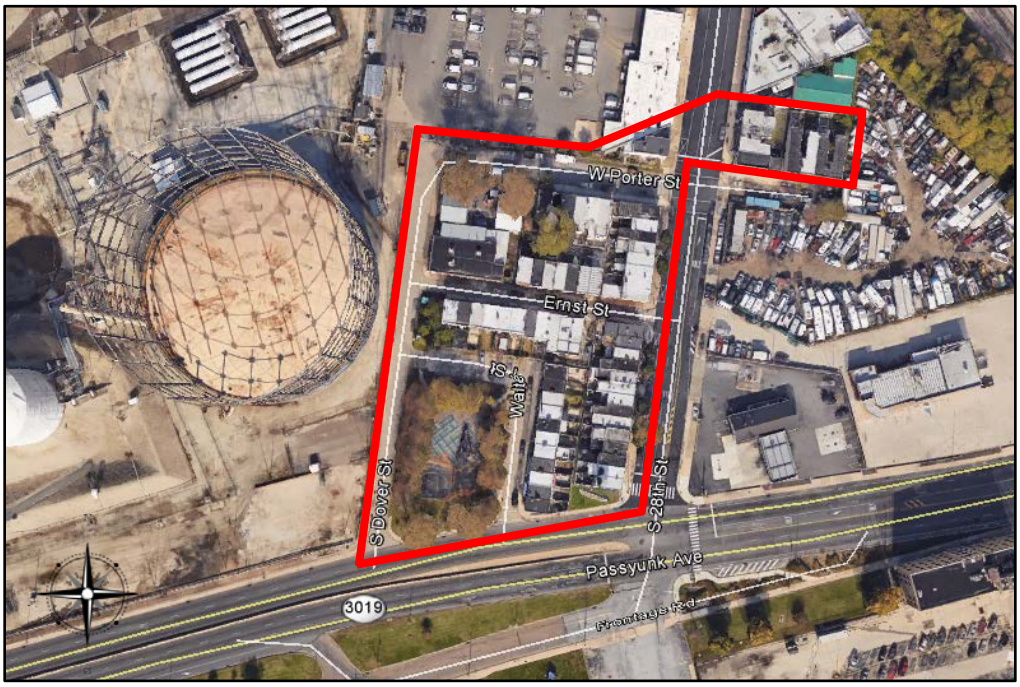
## Table 3 (continued): Cumulative Cancer Risk per Residential Unit per Sampling Event

| Location | Contaminants | Maximum Indoor Air µg/m$^3$ | | | CREG µg/m$^3$ | EPA IUR (µg/m$^3$)$^{-1}$ | Cancer Risk Estimates for contaminants exceeding CREG* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Jan-14 | Oct-14 | Mar-16 | | | Jan-14 | Oct-14 | Mar-16 |
| UT84 Basement Indoor Air | 1,2-Dichloroethane | NA | NA | 0.181 | 0.038 | 2.60E-05 | NA | NA | 1.99E-06 |
| | 1,3-Butadiene | 0.081 | NA | NA | 0.033 | 3.00E-05 | 1.03E-06 | NA | NA |
| | Benzene | 0.7 | 0.567 | 1.82 | 0.13 | 7.80E-06 | 2.31E-06 | 1.87E-06 | 6.01E-06 |
| | Carbon Tetrachloride | 0.36 | NA | 0.456 | 0.17 | 6.00E-06 | 9.14E-07 | NA | 1.16E-06 |
| | Chloroform | 0.17 | 0.578 | 0.138 | 0.043 | 2.30E-05 | 1.65E-06 | 5.62E-06 | 1.34E-06 |
| | Tetrachloroethylene | NA | NA | **0.194** | 3.8 | 2.60E-07 | NA | NA | **2.13E-08** |
| | Trichloroethylene | NA | NA | NA | 0.22 | 4.10E-06 | NA | NA | NA |
| **CUMULATIVE CANCER RISK - UT84 Basement Indoor Air** | | | | | | | **5.91E-06** | **7.50E-06** | **1.05E-05** |
| UT84 First Floor Indoor Air | 1,2-Dichloroethane | 0.082 | NA | 0.343 | 0.038 | 2.60E-05 | 9.02E-07 | NA | 3.77E-06 |
| | 1,3-Butadiene | 0.17 | NA | NA | 0.033 | 3.00E-05 | 2.16E-06 | NA | NA |
| | Benzene | 0.94 | 0.547 | 1.63 | 0.13 | 7.80E-06 | 3.10E-06 | 1.81E-06 | 5.38E-06 |
| | Carbon Tetrachloride | NA | NA | 0.446 | 0.17 | 6.00E-06 | NA | NA | 1.13E-06 |
| | Chloroform | 0.22 | NA | 0.143 | 0.043 | 2.30E-05 | 2.14E-06 | NA | 1.39E-06 |
| | Tetrachloroethylene | NA | NA | 0.157 | 3.8 | 2.60E-07 | NA | NA | 1.73E-08 |
| | Trichloroethylene | NA | NA | NA | 0.22 | 4.10E-06 | NA | NA | NA |
| **CUMULATIVE CANCER RISK - UT84 First Floor Indoor Air** | | | | | | | **8.30E-06** | **1.81E-06** | **1.17E-05** |
| UT116 Basement Indoor Air | 1,2-Dichloroethane | NA | 0.107 | 0.255 | 0.038 | 2.60E-05 | NA | 1.18E-06 | 2.81E-06 |
| | 1,3-Butadiene | 0.15 | NA | NA | 0.033 | 3.00E-05 | 1.90E-06 | NA | NA |
| | Benzene | 0.78 | 0.591 | 2.05 | 0.13 | 7.80E-06 | 2.57E-06 | 1.95E-06 | 6.77E-06 |
| | Carbon Tetrachloride | 0.41 | 0.442 | 0.471 | 0.17 | 6.00E-06 | 1.04E-06 | 1.12E-06 | 1.20E-06 |
| | Chloroform | 0.21 | 0.588 | 0.167 | 0.043 | 2.30E-05 | 2.04E-06 | 5.72E-06 | 1.63E-06 |
| | Tetrachloroethylene | **0.13** | **0.526** | **0.311** | 3.8 | 2.60E-07 | 1.43E-08 | 5.79E-08 | 3.42E-08 |
| | Trichloroethylene | NA | 0.573 | NA | 0.22 | 4.10E-06 | NA | 9.94E-07 | NA |
| **CUMULATIVE CANCER RISK - UT116 Basement Indoor Air** | | | | | | | **7.58E-06** | **1.10E-05** | **1.24E-05** |
| UT116 First Floor Indoor Air | 1,2-Dichloroethane | 0.13 | NA | 0.433 | 0.038 | 2.60E-05 | 1.43E-06 | NA | 4.76E-06 |
| | 1,3-Butadiene | 0.19 | NA | NA | 0.033 | 3.00E-05 | 2.41E-06 | NA | NA |
| | Benzene | 1.1 | 0.542 | 1.74 | 0.13 | 7.80E-06 | 3.63E-06 | 1.79E-06 | 5.74E-06 |
| | Carbon Tetrachloride | NA | NA | 0.447 | 0.17 | 6.00E-06 | NA | NA | 1.13E-06 |
| | Chloroform | 0.22 | NA | 0.201 | 0.043 | 2.30E-05 | 2.14E-06 | NA | 1.96E-06 |
| | Tetrachloroethylene | NA | NA | **0.2** | 3.8 | 2.60E-07 | NA | NA | 2.20E-08 |
| | Trichloroethylene | NA | NA | NA | 0.22 | 4.10E-06 | NA | NA | NA |
| **CUMULATIVE CANCER RISK - UT116 First Floor Indoor Air** | | | | | | | **9.61E-06** | **1.79E-06** | **1.36E-05** |
| UT175 Basement Indoor Air | 1,2-Dichloroethane | NA | 0.0919 | 0.755 | 0.038 | 2.60E-05 | NA | 1.01E-06 | NA |
| | 1,3-Butadiene | 0.13 | NA | NA | 0.033 | 3.00E-05 | 1.65E-06 | NA | NA |
| | Benzene | 1.3 | 2.24 | 1.32 | 0.13 | 7.80E-06 | 4.29E-06 | 7.39E-06 | 4.36E-06 |
| | Carbon Tetrachloride | 0.55 | 0.467 | 0.501 | 0.17 | 6.00E-06 | 1.40E-06 | 1.19E-06 | 1.27E-06 |
| | Chloroform | 2.6 | 0.841 | 0.78 | 0.043 | 2.30E-05 | 2.53E-05 | 8.18E-06 | 7.59E-06 |
| | Tetrachloroethylene | **0.31** | **0.324** | **0.219** | 3.8 | 2.60E-07 | 3.41E-08 | 3.56E-08 | 2.41E-08 |
| | Trichloroethylene | NA | NA | NA | 0.22 | 4.10E-06 | NA | NA | NA |
| **CUMULATIVE CANCER RISK - UT175 Basement Indoor Air** | | | | | | | **3.27E-05** | **1.78E-05** | **1.32E-05** |
| UT175 First Floor Indoor Air | 1,2-Dichloroethane | NA | 0.241 | 0.217 | 0.038 | 2.60E-05 | NA | 2.65E-06 | 2.39E-06 |
| | 1,3-Butadiene | 0.21 | NA | NA | 0.033 | 3.00E-05 | 2.67E-06 | NA | NA |
| | Benzene | 1.3 | **14.2** | 1.04 | 0.13 | 7.80E-06 | 4.29E-06 | 4.69E-05 | 3.43E-06 |
| | Carbon Tetrachloride | 0.39 | 0.445 | 0.46 | 0.17 | 6.00E-06 | 9.90E-07 | 1.13E-06 | 1.17E-06 |
| | Chloroform | 0.95 | **9.26** | 0.748 | 0.043 | 2.30E-05 | 9.24E-06 | 9.01E-05 | 7.28E-06 |
| | Tetrachloroethylene | NA | **1.13** | **0.178** | 3.8 | 2.60E-07 | NA | 1.24E-07 | 1.96E-08 |
| | Trichloroethylene | NA | 0.627 | NA | 0.22 | 4.10E-06 | NA | 1.09E-06 | NA |
| **CUMULATIVE CANCER RISK - UT175 First Floor Indoor Air** | | | | | | | **1.72E-05** | **1.42E-04** | **1.43E-05** |

NA = Contaminants were undetected or results were estimated
Red text = maximum exposure concentration
Green text = detections did not exceed CREG but were included in cumulative cancer risk evaluation

## APPENDIX A – Site Maps


The Passyunk Soil Gas Site is outlined in red. Philadelphia Gas Works (PGW) is to the west, Philadelphia Energy Solutions Refinery (PESR) is to the south, outlined in blue.




A close-up of the Passyunk Soil Gas Site perimeter.

**APPENDIX B – ATSDR Vapor Intrusion Fact Sheet**

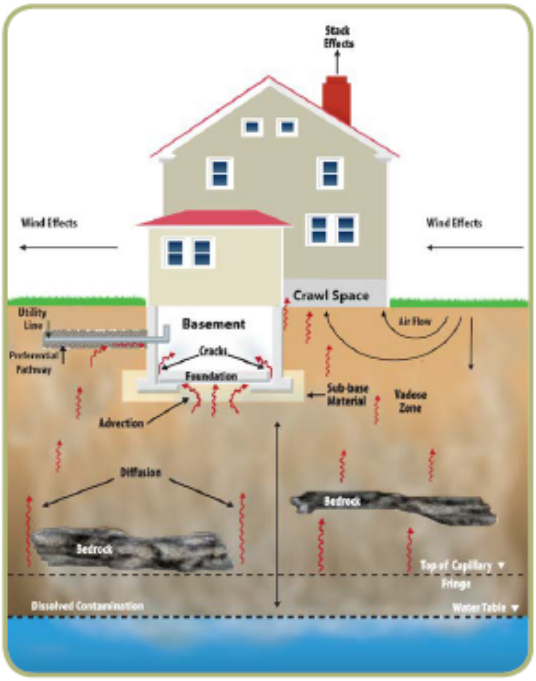
# Overview of Vapor Intrusion

## What is vapor intrusion?

Vapor intrusion is a way that volatile chemicals in soil and groundwater can enter and build-up inside buildings. Volatile chemicals are a class of chemicals that are volatile (evaporate easily) and form a vapor in the air.

- Common sources of volatile chemicals include gas stations, dry cleaners, and industrial operations.
- When a chemical is spilled or leaks into the ground, it can contaminate the soil and the groundwater.
- The chemical can move with the groundwater and travel under a building (migration route).
- If that chemical is volatile, it can become a gas and seep into nearby buildings and contaminate indoor air.

This fact sheet explains how vapor intrusion occurs and what factors can cause vapors (sometimes called gases) to move into indoor air.




## Why is vapor intrusion important to me?

When chemicals move indoors, you can be exposed to them by breathing indoor air. This exposure can cause health effects, depending on the type and amount of chemical and the length of exposure.

You can learn more about the possible health effects of individual volatile chemicals in ATSDR's Toxic Substances Portal: http://www.atsdr.cdc.gov/substances/index.asp.

## How does vapor intrusion occur?

Vapor intrusion does not occur every time there is contaminated soil or groundwater. It occurs only when volatile chemicals move from a source (like a chemical spill) along an underground migration route and into a building.

The type and amount of chemicals coming from a source will determine whether vapor intrusion occurs at levels of possible health concern.


Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations

CS276662-A

03/23/2017

## What factors affect vapor intrusion?

The following factors affect vapor intrusion:

- The type of soil beneath your building
- The type and condition of your building (foundation, leaks, air exchange)
- The weather conditions in your area

The amount of vapors entering a building can be different over time—changing hourly, daily, weekly, and seasonally.

The amount of vapor intrusion can also be different on different floors and in different rooms of the same building or in buildings right next to each other.

If scientists suspect vapor intrusion in buildings in a specific location, they may decide to conduct an investigation. See ATSDR's fact sheet "Investigating Vapor Intrusion" for information on what to expect if a vapor intrusion investigation is planned for buildings in your area.

## Where can I learn more about vapor intrusion?

**U.S. Environmental Protection Agency**

- Vapor intrusion website, visit: http://www2.epa.gov/vaporintrusion

**Interstate Technology & Regulatory Council**

- Vapor intrusion website, visit: http://www.itrcweb.org/Team/Public?teamID=22

**Agency for Toxic Substances and Disease Registry**

- Investigating vapor intrusion, visit: https://www.atsdr.cdc.gov/docs/atsdr_vapor_investigation.pdf