Health Consultation

9053 MIDDLEBROOK PIKE

AIR SAMPLING RESULTS EVALUATION

KNOXVILLE, KNOX COUNTY, TENNESSEE

OCTOBER 3, 2012

Preparation of this report was supported by funds from a
Cooperative Agreement with the Agency for Toxic Substances and Disease Registry,
U.S. Department of Health and Human Services.

This document was prepared by the
Tennessee Department of Health's Environmental Epidemiology Program.
This document has not been formally reviewed and cleared by ATSDR.

Foreword

This document summarizes an environmental public health investigation performed by the Environmental Epidemiology Program of the State of Tennessee Department of Health. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people have the potential to be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of the Environmental Epidemiology Program in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

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Introduction

The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation's (DoR) State Remediation Program (SRP) asked the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) to review the results of vapor intrusion testing at 9053 Middlebrook Pike in Knoxville, Tennessee (the site). The building on the site has undergone redevelopment. Its reuse will likely be different from its previous use. The building is not used. The environmental consultant for the property buyer, S&ME of Louisville, Tennessee, collected sub-slab soil-gas samples in March 2012. Follow-up indoor air samples were collected in May 2012 (S&ME 2012). This vapor intrusion evaluation is not intended to be an in-depth comprehensive evaluation of the site as it is only based on samples collected during these two sampling events. This evaluation is intended to understand what, if any risk, site contamination might have on future users of the site building.

A Phase 1 Environmental Site Assessment (ESA) indicated past tenants at the property included a gas station and at least two different drycleaners (Partner 2011a). The Phase 1 ESA was prepared as part of a potential sale of the 9053 Middlebrook Pike property. Two Phase 2 ESAs were conducted at the site in October and December 2011 based on the information learned from the Phase 1 ESA (Partner 2011a and 2011b). The volatile organic compounds (VOCs) tetrachloroethylene (PCE) and its breakdown products trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-1,2-DCE) were found in site soil. Vinyl chloride and petroleum-related chemicals such as benzene, toluene, ethylbenzene, and xylene were not found in site soil. Levels of PCE were above its U.S. Environmental Protection Agency residential soil screening level. One groundwater sample was collected in the later Phase 2 ESA. No VOCs were found in the groundwater sample tested.

As a result of the soil testing, TDEC was contacted by the potential property buyer's environmental consultant to discuss data requirements for a Brownfield Agreement to be administered by TDEC's Voluntary Oversight and Assistance Program (VOAP). TDEC responded that one of its primary concerns was the potential health risk from onsite contamination to those occupying the site building. In response to their concern, S&ME tested both passive and active soil-gas as well as indoor air.

This review specifically evaluated the active soil-gas and indoor air testing results from below and inside the site building. The preparation of this health consultation was done to document the evaluation of the vapor intrusion sampling results and provide useful information on site conditions to those who may work in the building in the future.

Background

The site is located at 9053 Middlebrook Pike in Knoxville, Tennessee 37923. The investigation area focused on an approximate 4,500 square foot retail building located on an approximate 0.46 acre parcel located on the north side of Middlebrook Pike (Figure 1). The site building was divided into three 1,500-square foot lease spaces. The lease spaces were not occupied at the time of the air testing.

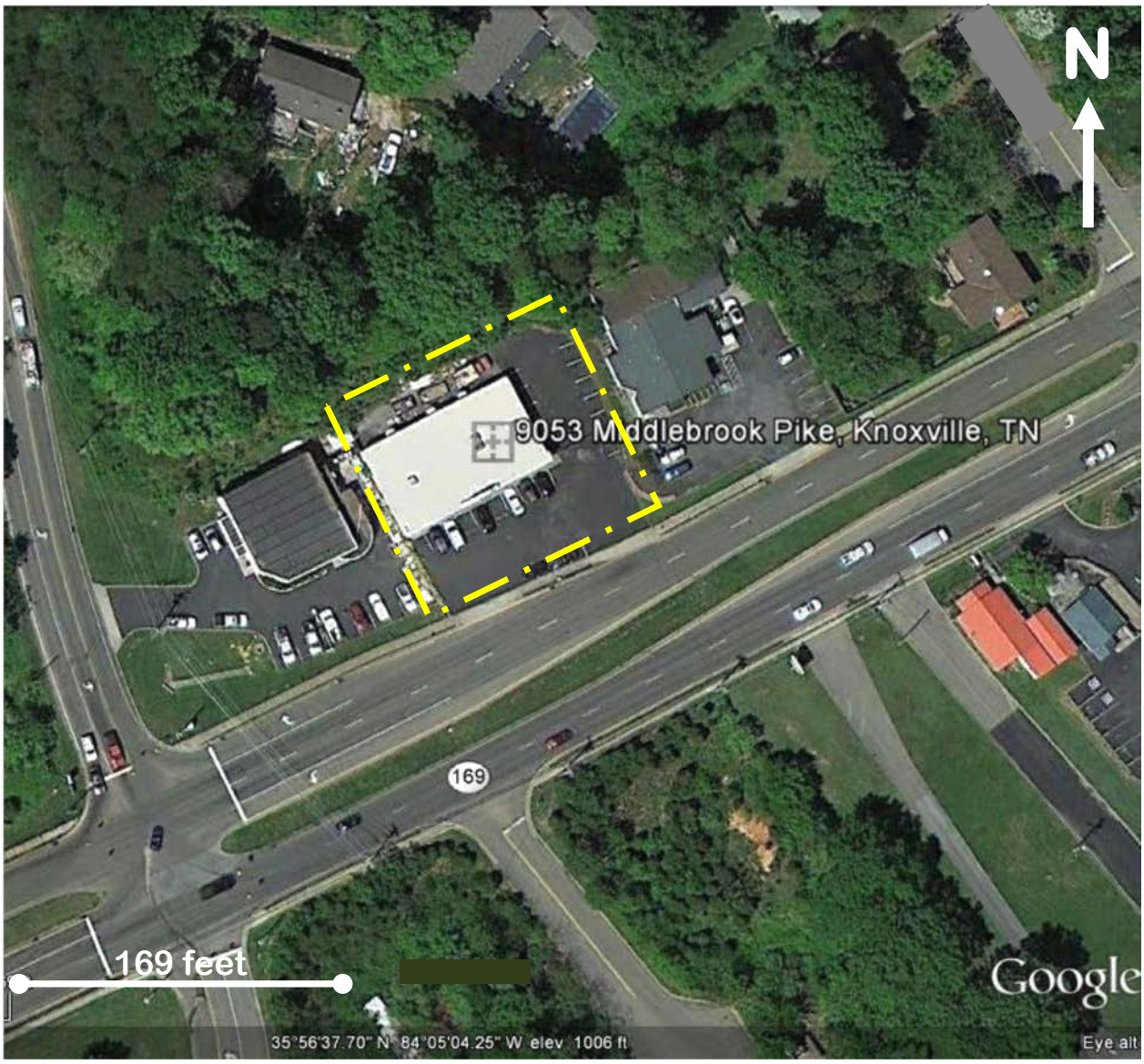


Figure 1. 9053 Middlebrook Pike Site location in Knoxville, Knox County, Tennessee 37923. The building at this address is currently vacant. The building was formerly a gas station and drycleaner. The dashed yellow line is the approximate site property boundary. Single family homes are located north of the site. An animal clinic is located to the east. Vacant land and single family homes are located to the south. Its closest neighbor is an exterior siding company that is located to the west. Environmental investigations showed that there is VOC soil contamination in the northwest corner of the site property. Much of the site is paved with asphalt. The groundwater flow direction at the site is unknown. (Source: Google Earth 2012).

According to the Phase 1 ESA (Partner 2011a), the site was undeveloped from at least 1939 to 1959. Between 1960 and 1974, it was not known if the site was developed as there was no information in City Directories. The site was developed with a gasoline station with a convenience store and a full-service drycleaner by 1974. Both businesses operated until at least 1989. It is also not known if there were businesses in the building after 1989. There was no information in City Directories for this time period (Partner 2011a).

The former gas station had two 8,000-gallon gasoline underground storage tanks (USTs), one 4,000-gallon gasoline UST, and one 2,000-gallon kerosene UST located on the property. The two 8,000-gallon USTs were installed in November 1970. The 2,000- and 4,000-gallon USTs were installed in November 1974. All the USTs were installed beneath paved areas of the site and not beneath the site building. All tanks were removed in 1992. Petroleum-impacted soil was found during the UST removals. A total of 538 cubic yards of impacted soil was removed from the site. There were no reported groundwater impacts. A No Further Action (NFA) status was granted for the site by TDEC's Division of Underground Storage Tanks in August 1992 (Partner 2011a).

The original site building was razed and the site was redeveloped with the current site building in 1994 (Partner 2011a). Since 1994, a number of different commercial businesses have operated in the building including a bakery, a fashion store, a Martial Arts academy, and a drop-off only location of a drycleaner. Those businesses left the property at some time before this redevelopment.

The site is located in a mixed use residential and light-industrial area of Knoxville (Figure 1). An undeveloped parcel of land is located immediately north of the site. Beyond this undeveloped parcel are single family homes. An animal clinic is located immediately to the east of the site. An undeveloped area is located to the south beyond Middlebrook Pike. An exterior siding company is located immediately west of the site. Paved asphalt areas cover much of the adjacent properties. Given the close proximity of the neighboring properties, there is concern for off-site migration of the site-related chemicals to these areas.

Findings of Previous Investigations

As part of the potential sale of the property, the site has transitioned from being managed by the Division of Underground Storage Tanks to TDEC SRP. The site was designated State Remediation Program Site SRS-01251. Soil and groundwater investigations have been performed over the last year at the site.

PCE was found in soil beneath the western portion of the site building at the levels above soil-screening values (Partner 2011b). Breakdown products, TCE and cis-1,2-DCE, were found at levels below their respective soil screening levels. Vinyl chloride and petroleum-related chemicals were not found in the soil samples. These chemicals were not found in a single groundwater sample collected from the site (Partner 2011b).

S&ME in 2012, performed a passive soil-gas survey. PCE, TCE, cis-1,2-DCE, benzene-toluene-ethylbenzene-xylene (BTEX), and total petroleum hydrocarbons (TPH) were found in soil-gas beneath the site. The levels of these chemicals measured through passive soil-gas sampling

techniques could not be compared to soil screening levels. Further active sub-slab soil-gas and active indoor air testing was done by S&ME. These active tests allowed for comparison of the results to health risk screening values published by both the Agency for Toxic Substances and Disease Registry (ATSDR) and U.S. Environmental Protection Agency (EPA).

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates mechanisms that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. If there is no contact with a contaminant, no exposure occurs. Therefore, no exposure-related health effects could occur. An exposure pathway contains five parts:

- a source of contamination,
- contaminant transport through an environmental medium,
- a point of exposure,
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements have been, are, or will be present at the site. An exposure pathway is considered incomplete if one of the five elements is missing.

The source is the place where the chemical was released. For this site, the source is spills from past activities performed at the site. The environmental media (such as, soil, surface water, groundwater, or air) transport the contaminants. For this site, the chemicals are transported through the soil and indoor air. The point of exposure is the place where persons come into contact with the contaminated media. Indoor air is the potential point of exposure for this site. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. For this site, if the indoor air has measureable levels of VOCs, the route of exposure would be breathing of indoor air.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will be harmed. A chemical's ability to affect health is controlled by a number of other factors, including:

- the amount of the chemical that a person is exposed to (dose),
- the length of time that a person is exposed to the chemical (duration),
- the number of times a person is exposed to the chemical (frequency),
- the person's age and health status, and
- the person's diet and nutritional habits.

For this project, the people who would be exposed if vapor intrusion was occurring are the workers and customers of the future businesses that may be located in the site building.

Vapor Intrusion

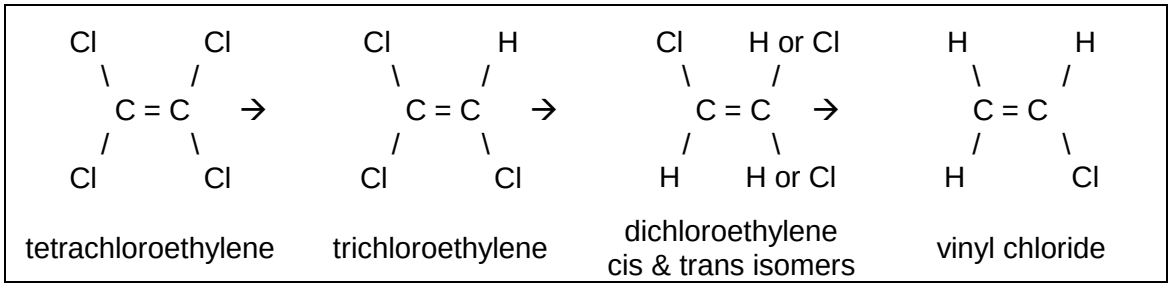
Volatile and semi-volatile chemicals can evaporate from impacted subsurface soil and/or groundwater beneath a building and move toward areas of lower chemical levels such as in the atmosphere, utility conduits, or basements. This process is called vapor intrusion. Subsurface vapors can enter a building due to two main factors: environmental effects and building effects. Some examples of these factors are barometric pressure changes, wind load, temperature currents, or depressurization from building exhaust fans. Chemicals can migrate up and enter indoor air through foundation slabs, crawl spaces, or basements. The chemical migration depends on the construction of the building, unsealed joints or cracks in the foundation, the building's heating and ventilation characteristics, and other factors. The amount of movement of the vapors into the building is difficult to measure and depends on soil type, chemical properties, building design and condition, and pressure differences between the outside and inside air (ITRC 2007). Upon entry into a structure, chemical vapors mix with the existing air through the natural or mechanical ventilation of the building.

Vapors may accumulate in buildings to levels that pose safety hazards, health risks, or odor problems. Vapor intrusion has been documented in buildings with basement, crawlspace, or slab-on-grade foundation types. Vapor intrusion can be an acute health hazard. Usually, indoor vapor levels are low. Low levels of vapors, breathed over a long period of time, may or may not be a chronic health concern.

Drycleaner Solvent Explanation

The process of drycleaning is not truly dry, but it uses so little water that it has come to be known as drycleaning. Instead of water, chemical solvents are used in the cleaning process. The most commonly used solvent for drycleaning is tetrachloroethylene (perc or PCE). It is a colorless liquid and has sweet smell (ATSDR 1997). PCE is a volatile organic compound. It will quickly evaporate into a gas at room temperature. Therefore, for this evaluation we will focus on PCE and its chemical breakdown products.

As its name implies, tetrachloroethylene has four chlorine anions on a two-carbon molecule. The molecule breaks down once it enters the soil or groundwater through chemical and microbial processes into other chlorinated volatile organics. Each of these breakdown chemicals has slightly different chemical properties and toxicities. The following diagram is an example of how one chemical can break down to form another.



In this example, PCE can break down to TCE, and then to DCE, and then to vinyl chloride (VC). The only way to truly know the ratio of these breakdown chemicals is to collect environmental samples. The degradation products TCE and cis-1,2-DCE, have been noted in soil samples collected at the site. PCE appears to be the dominant chemical present in site soil. The solvents, PCE and TCE were carefully considered in developing this report.

Environmental Sampling

Previous passive soil-gas sampling found PCE, TCE, cis-1,2-DCE, BTEX, and TPH in soil-gas samples in the northwestern and western portion of the site (S&ME 2012). Passive soil-gas sampling locations are shown in Figure 2. Based on this data, one sub-slab soil gas sample was collected beneath the site building (S&ME 2012). PCE and its breakdown chemicals were likely related to spills, handling practices, and other activities over the many years of operation of the former drycleaners at the site. BTEX and TPH are likely related to spills and leaks over many years from the USTs and associated piping related to the gasoline storage and sales at the former convenience store on the site.

Sub-Slab Soil-Gas Sampling

The sub-slab soil-gas sample was collected from the northwestern corner of the site building (Figure 2). Sample SS-1 was collected by S&ME on March 28, 2012, from about 19-inches below the existing floor of the building (S&ME 2012). The sample was collected over an 8-hour sampling period using a 6-liter Summa canister. The sample was sent for testing to ESC Lab Sciences of Mount Juliet, Tennessee. Table 1 shows the sub-slab soil-gas sample results. PCE, TCE, cis- and trans-1,2-DCE, and benzene were detected in sub-slab soil-gas.

The relatively high sub-slab soil-gas results were modified by an attenuation factor to calculate potential indoor air levels. The estimated indoor air levels of chemicals found in sub-slab soil-gas can be calculated by multiplying the soil-gas result by an EPA-recommended sub-slab soil-gas to indoor air attenuation factor of 0.1 (EPA 2002). The attenuation-adjusted results were compared to residential indoor air comparison values from both ATSDR and EPA. Both PCE and TCE attenuation-adjusted results were above their respective residential indoor air comparison values. Based on this evaluation, S&ME recommended sampling indoor air to evaluate whether vapors from PCE and TCE beneath the building were migrating to the building's indoor air through the process of vapor intrusion.

Preliminary Soil-Gas Results Evaluation

Chemicals found in soil-gas at the site were first evaluated by inputting the soil-gas concentrations measured into EPA's simplified Johnson and Ettinger (J&E) vapor intrusion model (EPA 2012). The model is a one-dimensional analytical solution, which incorporates both advection and diffusion transport mechanisms to produce a unit-less "attenuation factor." This attenuation factor is a measure of how soil and building properties limit how the organic vapors move into overlying buildings. The attenuation factor can be defined as the amount of the compound in indoor air divided by the amount of the compound in soil-gas or groundwater.

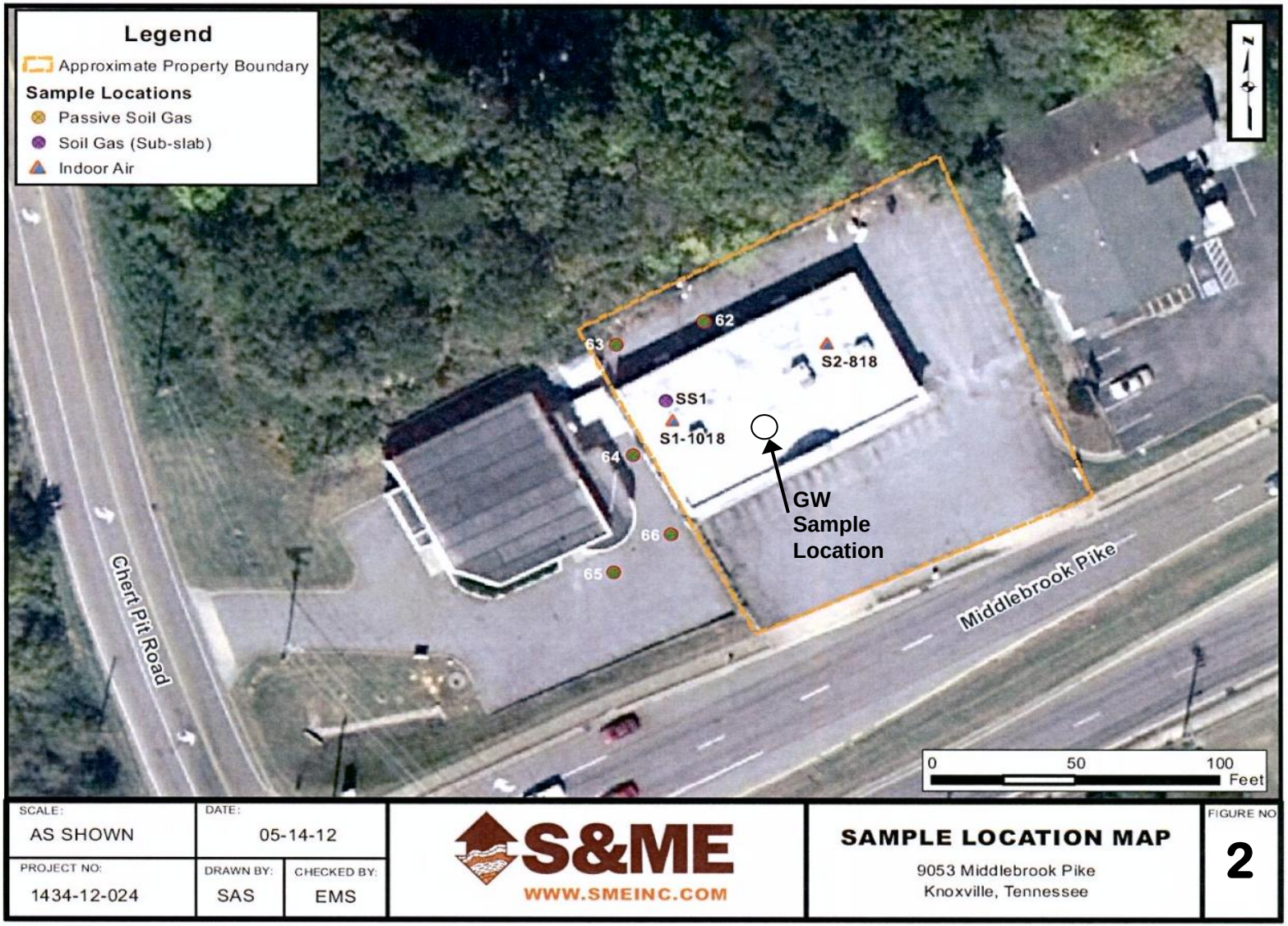


Figure 2. 9053 Middlebrook Pike Site passive soil-gas, sub-slab soil-gas, indoor air, and groundwater sampling locations (S&ME 2012).

TABLE 1. Sub-slab soil-gas sampling results for the 9053 Middlebrook Pike Site, Knoxville, Knox County, TN. Site-related chemicals are shown. The sample was collected on March 28, 2012, over 8 hours using a Summa canister (S&ME 2012). The location of the sub-slab soil-gas sample is shown on Figure 2. Values reported in parts per billion (ppb). ATSDR and EPA residential indoor air comparison values are also reported in ppb. The attenuation-adjusted concentration was the conversion of soil-gas results to indoor air results based on an EPA attenuation factor of 0.1.

Chemical / Sampling Data and Location Name	Acronym	Reported SS-1 Sub-slab Concentration (ppb)	Attenuated-Adjusted Indoor Air Concentration[1] (ppb)	ATSDR EMEG (non-cancer) (ppb)	ATSDR CREG (10^{-6} excess cancer risk) (ppb)	EPA RSL (10^{-6} excess cancer risk) (ppb)
tetrachloroethylene	PCE	*290*	*29*	40	0.57	0.6*
trichloroethylene	TCE	*34*	*3.4*	0.37	0.045	0.08
cis-1,2-dichloroethylene	cis-1,2-DCE	10	1.0	ngv	nc	nc
trans-1,2-dichloroethylene	trans1,2-DCE	0.41	0.041	200i	nc	nc
1,1-dichloroethylene	1,1-DCE	<0.40	<0.04	20i	nc	ngv
vinyl chloride	VC	<0.40	<0.04	30i	0.04	0.06
benzene	—	*1.8*	*0.18*	3	0.04	0.1

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2012). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2012). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk).

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2012). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a lifetime.

0.6* = PCE Integrated Risk Information System (IRIS) air concentration RSL at a $1x10^{-6}$ (1 in 1,000,000) and $1x10^{-4}$ (1 in 10,000) excess risk, March 13, 2012.

[1] EPA OSWER Guidance (2002) suggests a recommended sub-slab to indoor air attenuation factor of 0.1 or the sub-slab vapor result x 0.1 = indoor air concentration.

Modifiers:

<0.20 = Not detected in the air sample. Numerical values represent the analytical reporting limit.

0.27 = Measurement in air that is above one or more comparison values.

i = ATSDR comparison value for intermediate exposures (15-365 days); typically higher than a chronic value.

nc = Not classified as to carcinogenicity and no guidance value is available.

ngv = No guidance value available. EPA has not found suggestive evidence of carcinogenic potential and has not developed a guidance value.

Chemical concentrations in groundwater will attenuate more than chemicals in soil-gas because of certain limitations in the transfer of mass across the area immediately above the water table.

Site-specific characteristics and properties can be put into the model if they are available. In this case, they were not. The J&E model also uses conservative assumptions about the fate and transport of the chemicals in the subsurface.

The soil-gas concentrations of PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, and benzene were put into the J&E model to understand if they could lead to a vapor intrusion concern. J&E model output showed that there would not be a potential for non-cancer health effects. Model output also suggested that only levels of PCE and TCE in soil-gas would result in an estimated excess lifetime cancer risk of between 1 in one hundred thousand to 1 in 1 million. This risk is slightly higher than the standard assumed excess lifetime cancer risk for a residential setting of 1 excess cancer in 1 million people.

The measured soil-gas levels of PCE and TCE revealed there was the potential for vapor intrusion of chemicals in the sub-slab soil-gas to migrate into the indoor air of the building. To understand if these chemicals were migrating into indoor air, S&ME collected indoor air samples. The indoor air sampling and results evaluation is discussed in the sections that follow.

Indoor Air Sampling

Two indoor air samples were collected by S&ME inside the site building on May 4, 2012 (S&ME 2012). Sample 1 was collected in the northwestern portion of the building in the vicinity of the sub-slab sample location. Sample 2 was collected in the center of a large open room in the east end of the building (S&ME 2012).

Summa canisters were used to collect the indoor air samples. The canisters were placed at breathing height approximately 5 feet above the floor and were fitted with 8-hour flow controls provided by the testing laboratory. The buildings heating, ventilation, and air conditioning (HVAC) system was not operating at the time of sampling. Samples were tested for benzene, PCE, and TCE using EPA method TO-15. Benzene was included in the testing to determine if there was any legacy petroleum contamination at the site that could be migrating into the indoor air. Samples were shipped in their appropriate containers under chain-of-custody procedures to the testing laboratory, ESC Lab Sciences, of Mount Juliet, Tennessee.

Comparison Values

To evaluate exposure to a hazardous substance, health assessors often use health comparison values. If the chemical concentrations are below the comparison value, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the comparison values (ATSDR 2012) for a particular chemical, then further evaluation is needed. The chemicals evaluated in this health consultation were PCE, TCE, and benzene.

The Agency for Toxic Substances and Disease Registry's (ATSDR) develops Minimal Risk Levels (MRLs) using conservative assumptions. ATSDR uses the term 'conservative' to refer to values that are protective of public health in essentially all situations. Environmental Media Evaluation Guidelines (EMEGs) are calculated by ATSDR from their MRLs. EMEGs consider

non-cancer adverse health effects (ATSDR 2012a) and are used for comparison to the indoor air data that was collected. Exposure durations are defined as acute (14 days or less), intermediate (15–365 days), and chronic (365 days or more) exposures. ATSDR does not use serious health effects, such as irreparable damage to the liver or kidneys, or birth defects, as a basis for establishing EMEGs. Chronic EMEGs assume exposure for 24 hours per day, 7 days per week, 52 weeks, 365 days per year, over a 70-year lifetime exposure. It should be noted that chemicals found at levels above their respective comparison values do not necessarily represent a health threat. Instead the results of the comparison value screening identify those chemicals that warrant a more detailed, site-specific evaluation (ATSDR 2012b). ATSDR also has cancer risk evaluation guides (CREGs) for cancer health effects evaluation. ATSDR residential indoor air comparison values are shown in Table 2 below.

EPA's Regional Screening Levels (RSLs) for residential air inhalation were also used in evaluating the results of the indoor air testing (EPA 2012). EPA residential indoor air comparison values are also shown in Table 2 below. EPA RSLs for both non-cancer and cancer health effects were used as comparison values for the chemicals tested.

Table 2. ATSDR and EPA residential indoor air comparison values for chemicals found in the indoor air of the onsite building at 9053 Middlebrook Pike, Knoxville, TN. Residential indoor air comparison values are shown in parts per billion (ppb).

Chemical	Acronym	ATSDR Chronic EMEG (non-cancer) (in ppb)	ATSDR CREG (10^{-6} excess cancer risk) (in ppb)	EPA RSL non-cancer health effects (in ppb)	EPA RSL (10^{-6} excess cancer risk (in ppb)
tetrachloroethylene	PCE	40	0.57	6.2	0.6*
trichloroethylene	TCE	0.37	0.045	0.39	0.06
benzene	—	3	0.04	9.7	0.1

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2012). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2012). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk).

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2012). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a lifetime.

0.6* = PCE Integrated Risk Information System (IRIS) air concentration RSL at a $1x10^{-6}$ (1 in 1,000,000) excess risk, March 13, 2012.

PCE and its breakdown chemical TCE were of special interest at the site and were evaluated because they are thought to be *"reasonably anticipated to be human carcinogens"* (IARC 1995, NTP 2011). Several VOCs were identified in sub-slab soil-gas samples. Only PCE and benzene were found in the indoor air. PCE is readily absorbed following inhalation and oral exposure as

well as from direct exposure to the skin. For this site, we are concerned with the inhalation of PCE from vapor intrusion into indoor air. Compared to pulmonary and ingestion exposure, uptake of PCE vapors by the skin is minimal (ATSDR 1997a, 1997b).

Results

Indoor air testing results showed detections of PCE and benzene. TCE was not measured in either of the two samples. No outdoor air samples were collected for comparison purposes. Table 3 shows the results of the indoor air sampling. Sample detection limits were very low, at 0.2 parts per billion (ppb).

TABLE 3. Indoor air sampling results for the 9053 Middlebrook Pike Site, Knoxville, Knox County, TN. Site-related chemicals are shown. The samples were collected on May 4, 2012, over 8 hours using a Summa canister (S&ME 2012). The location of indoor air samples are shown on Figure 2. Values reported in parts per billion (ppb). ATSDR and EPA residential indoor air comparison values are also reported in ppb.

Chemical / Sampling Data and Location Name	Acronym	S-1 Indoor air (west end)	S-2 Indoor air (east end)	ATSDR EMEG (non-cancer) (ppb)	ATSDR CREG (10^{-6} excess cancer risk) (ppb)	EPA RSL (10^{-6} excess cancer risk) (ppb)
tetrachloroethylene	PCE	*1.6*	*1.3*	40	0.57	0.6*
trichloroethylene	TCE	<0.2	<0.2	0.37	0.045	0.08
benzene	—	*0.61*	*0.64*	3	0.04	0.1

Notes:

ATSDR EMEG	= Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2012). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.
ATSDR CREG	= Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2012). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk).
EPA RSL	= Environmental Protection Agency Regional Screening Level (EPA 2012). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a lifetime.
0.6*	= PCE Integrated Risk Information System (IRIS) air concentration RSL at a $1x10^{-6}$ (1 in 1,000,000) and $1x10^{-4}$ (1 in 10,000) excess risk, March 13, 2012.

Modifiers:

<0.2	= Not detected in the air sample. Numerical values represent the analytical reporting limit.
0.27	= Measurement in air that is above one or more comparison values.

Health Risk Evaluation

For this health consultation, the evaluation of the health risk at the site will consider the chemicals that have been confirmed to be present in the indoor air and have potential health risks. The only chemicals that were detected in indoor air were PCE and benzene. TCE was

considered because its comparison values are very low and lower than the detection limits of the testing. It appears that residual PCE and possibly TCE contamination remains in soil, soil vapor and perhaps groundwater beneath the site building. Based on both the soil-gas and indoor air testing results, the process of vapor intrusion appears to be occurring at the site, although at a minor extent.

Benzene will not be considered further in the analysis because the concentrations found in the indoor air were within the range of normal concentrations of both indoor and ambient air across the United States. Schuver, in 2004, published a memorandum listing benzene levels in both ambient and indoor air. For indoor air, a best estimate of typical levels ranged from 1.5 to 2.0 ppb. EPA (1998) published a value of 1.6 ppb for average benzene levels for US homes. Benzene levels in the ambient air of urban environments of the US referenced in this document range from 4 to 160 ppb. In remote and rural areas of the US, ambient air benzene levels were found to range from 0.35 to 1.6 ppb. A best estimate of benzene levels in ambient urban air ranged from 0.5 to 1.0 ppb. The measured levels of benzene at 0.61 and 0.64 ppb found in the indoor air at the site were well within these ranges. Given that the location of the site is on a busy State highway near an intersection, the benzene levels may be associated with traffic exhaust.

Indoor Air Non-Cancer Evaluation

Levels of PCE and benzene were below their respective non-cancer indoor air health comparison values published by the ATSDR (2012). TCE was not detected in the indoor air samples. TCE detection limits were below its ATSDR non-cancer health comparison value.

Building Indoor Air Cancer Evaluation

PCE was detected in indoor air in Sample 1 at 1.6 ppb. The level of PCE in Sample 2 was 1.3 ppb. PCE indoor air concentrations were compared to ATSDR's CREG for one excess cancer in one million people health risk comparison value of 0.57 (ATSDR 2012) and EPA's RSL for an excess lifetime cancer risk (ELCR) of one in a million of 0.6 ppb (IRIS 2012). Measured PCE levels were about two times higher than both its ATSDR CREG and EPA cancer health effects RSL. Therefore, further analysis was done using the inhalation unit risk value for PCE.

An estimated risk was calculated using the measured PCE levels and EPA's inhalation unit risk (IUR). Because the lease spaces in the site building are separate areas, both PCE sample measurements were evaluated independently. Using both PCE concentrations of 1.6 ppb (11 $\mu g/m^3$) and 1.3 ppb (8.8 $\mu g/m^3$) and multiplying them by the IUR for PCE of 2.6×10^{-7} $(\mu g/m^3)^{-1}$, ELCRs of 2.8×10^{-6} and 2.3×10^{-6} were calculated. Therefore, the estimated ELCRs due to PCE would be between 2 and 3 extra cancers in 1 million people, in addition to the background cancer risk. The normal every-day risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (NTP 2011). This possible extra cancer risk is negligible when added to the background risk and is considered acceptable by EPA (1991).

TCE was not detected in indoor air samples collected at the site. The detection limit for TCE was 0.2 ppb. The detection limit value is greater than both its ATSDR CREG and EPA cancer

effects RSL at a $1x10^{-6}$ risk. Therefore, TCE was evaluated further, as if it was present at the detection limit level, as a worst-case evaluation. Using the worst-case 0.2 ppb TCE concentration (1.1 $\mu g/m^3$) and multiplying it by the IUR for TCE of $4.1x10^{-6}$ $(\mu g/m^3)^{-1}$, an estimated ELCR of $4.5x10^{-6}$ was calculated. Therefore, the estimated ELCR due to TCE would be about 5 extra cancers in 1 million people. This is in addition to the background cancer risk. This possible extra cancer risk based on the levels in indoor air is negligible when added to the background risk and is considered acceptable by EPA (1991).

Even though the process of vapor intrusion appears to be occurring at the site, there should not be any concern about adults breathing the trace levels of PCE, TCE, or benzene in the indoor air. The additional risk of breathing the indoor air in the building is not zero, but very low.

Child Health Considerations

The health of children was considered as part of this health consultation. The many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances (ATSDR 1997, 1998). Children have lower body weights than adults. Although children's lungs are usually smaller than adults, children breathe a greater relative volume of air compared to adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage.

There is no indication that tetrachloroethylene (PCE) or its breakdown chemicals affects children's bodies differently than adults (ATSDR 1997). Children may be more sensitive to the carcinogenic effects of PCE than adults (IRIS 2011). ATSDR considered this increased sensitivity when they developed their CREG comparison value.

Future site workers would likely be adults. Children would likely not be part of the population that would work inside the building nor would children spend any significant time in the building. To protect public health, it would be prudent not to establish a child care or similar business in the building where children would be exposed to the measured low levels of PCE. This should be ensured through deed restrictions on the property, unless corrective actions at the site are taken.

Limitations and Uncertainties in Vapor Intrusion

Having and following an accepted protocol for conducting indoor air investigations is important. A general protocol was developed for this investigation. Still, even a good protocol cannot remove all limitations and uncertainties related to vapor intrusion investigations.

Several characteristics of buildings may influence the indoor air testing. Some examples of limitations and uncertainties include the detail of the design of the building not being readily available. The number of breaks in floor slabs or utility perforations entering the buildings were also variables that could influence test results. For example, the exact amount of contamination under the building is an unknown. The amount and frequency of vapor off-gassing is likely not

constant. It is unknown if there were background amounts of the chemicals in the indoor air. No building inventory or measurement of background sources was done. The use of cleaning products that sometimes contain many of the same chemicals that are tested for could influence the results of the testing.

The HVAC system was not operating during the testing. This likely represents a worst-case level of the chemicals in the indoor air. HVAC systems mix some air from outside the building with indoor air. The concentrations of chemicals in the indoor air would likely be less or not detectible during operation of the HVAC system.

A single indoor air test was done inside the 9053 Middlebrook Pike building. All conclusions and recommendations presented in this Health Consultation were based on the results of this test. Levels of chemicals in the indoor air of the site building could vary depending on vapor flux, precipitation events, and seasonal effects. If additional tests were performed, there is a possibility they would have different results.

What happened in the past at the site is another uncertainty. The petroleum-related chemicals were likely removed through the excavation of impacted soils during the removal of the USTs and dispensing lines at the site. Since the source of the petroleum-related chemicals is gone, any remaining contributions from these chemicals to indoor air should be minimal and decreasing. The amounts and locations of any or all spills from the former drycleaner were likely undocumented. Basic handling practices of chemicals were also different during the time period that the businesses operated.

Neighboring Property

The groundwater flow direction is not known at the site. Depending on the groundwater flow direction and site conditions the PCE contaminant plume may extend under 1 or more neighboring properties. It would be prudent for TDEC to consider the possibility that vapor intrusion may be occurring at neighboring properties.

Conclusion

TDH EEP concludes that it does not appear that chemical vapors in the indoor air of the site building will harm the health of adults breathing the indoor air.

Soil-gas testing revealed drycleaner-related chemicals and petroleum-related chemicals in soil beneath the site building. These chemicals were from the past use of the site as a drycleaner and a gas station. Indoor air testing showed low levels of these same chemicals in the indoor air. Evaluation of the indoor air showed the levels within ATSDR's and EPA's accepted risk levels. Breathing air inside the 9053 Middlebrook Pike Site building having the levels of chemicals measured should not result in adverse health effects for adults.

As mentioned in the Child Health Considerations section, it would be prudent not to establish a child care or other business in the building where sensitive populations (children, elderly, or immunocomprimised) would be exposed to the measured low levels of PCE.

Recommendations

The focus of this health consultation was to make sure the indoor air breathed by future site workers and visitors to the building will not lead to harmful health effects. Based on the results of this indoor air sampling investigation, TDH EEP recommends sealing the floor of the building to prevent migration of sub-slab vapors into the indoor air of the building. This action could be accomplished without much disruption since the building is not occupied. EEP also recommends sealing any utility penetrations through the floor or walls into the 3 lease spaces. Another indoor air test is recommended to be done at some time in the future. This confirmatory indoor air test should ideally be done in the late fall or winter season. An outdoor air sample is recommended to be collected at the time indoor samples are collected. Also, a building inventory should also be done to understand any potential sources of chemicals stored or used in the building that could influence the test. This second test would help to confirm that levels of chemicals in the indoor air would not harm the health of those working and visiting the site building.

If there would be any future excavations or drilling into the 9053 Middlebrook Pike building floor slab in the area of the soil vapor, extra ventilation should be provided to prevent PCE and TCE vapor concentrations from increasing in the indoor air. If not already being done in the building, a program of crack repair and floor slab inspection and maintenance should be instituted. Crack repair can be done with a colorless, low odor filler to completely seal off pathways for sub-slab vapor to migrate into the indoor air.

Deed restrictions should be placed on the property, unless corrective actions are taken, to avoid establishment of a business that involves unhealthy or sensitive populations.

Public Health Action Plan

The public health action plan for the 9053 Middlebrook Pike Site contains a list of actions that have been or will be taken by TDH EEP and other agencies. The purpose of the public health action plan is to ensure that this health consultation identifies public health concerns and offers a plan of action designed to mitigate and prevent harmful health effects that result from breathing, eating, drinking, or touching hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that have been taken by TDH's EEP include:

- Reviewed indoor air data from the 9053 Middlebrook Pike building.
- Prepared this Health Consultation.

Public health actions that will be taken include:

- TDH EEP will provide copies of this health consultation to state and federal government agencies interested in the site and to the environmental contractor for the site.
- TDH EEP will maintain dialogue with ATSDR, TDEC, EPA, and other interested stakeholders to safeguard public health.
- TDH EEP staff will be available to answer questions regarding the interpretation of the indoor air results and to review additional environmental data, as requested.

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Appendix: Glossary of Terms and Acronyms

adverse health effect: A change in body function or cell structure that might lead to disease or health problems

ATSDR: Agency for Toxic Substances and Disease Registry.

cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as $1x10^{-6}$ for one excess cancer in 1 million people.

carcinogen: A substance that may cause cancer.

chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

Comparison Value (CV): Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

concentration: The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Cancer Risk Evaluation Guide (CREG): soil, water or air comparison values that are used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population.

contaminant: A substance that is either present in an environment where it does not belong.

detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

EEP: Environmental Epidemiology Program of the Tennessee Department of Health.

Environmental Media Evaluation Guide (EMEG): Concentrations of substances in water, soil, or air to which humans may be exposed during a specified period of time (acute, intermediate, chronic) without experiencing adverse health effects.

EPA: United States Environmental Protection Agency.

epidemiology: The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1. a source of contamination (such as an abandoned business), 2. an environmental media and transport mechanism (such as movement through groundwater), 3. a point of exposure (such as a private well), 4. a route of exposure (eating, drinking, breathing, or touching), and 5. a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

groundwater: Water beneath the Earth's surface in the spaces between soil particles and between rock surfaces.

hazard: A source of potential harm from past, current, or future exposures.

health consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical.

inhalation: The act of breathing. A hazardous substance can enter the body this way.

intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year.

migration: Chemical movement from one location to another.

Minimal Risk Level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

plume: A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

ppb: parts per billion.

reference dose: An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Regional Screening Level (RSL): comparison levels prepared by the U.S. Environmental Protection Agency that are chemical-specific concentrations for individual contaminants in air, drinking water, and soil that may warrant further investigation or site cleanup.

remediation: 1. Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site.

Remedial Investigation (RI): The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process of determining the type and extent of hazardous material contamination at a site.

risk: The probability that something will cause injury or harm. For non-carcinogen health effects, it is evaluated by comparing an exposure level over a period to a reference dose derived from experiments on animals. For carcinogenic health effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime (70 years) as a result of exposure to a potential carcinogen.

route of exposure: The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

sample: A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population. An environmental sample, such as a small amount of soil or water, might be collected to measure contamination in the environment at a specific location.

soil-gas: Gaseous elements and compounds in the small spaces between particles of earth and soil. Such gases can be moved or driven out under pressure.

solvent: A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

source area: The location of or the zone of highest soil or groundwater concentrations, or both, of the chemical of concern. The source of contamination is the first part of an exposure pathway.

TDEC: Tennessee Department of Environment and Conservation

Tetrachloroethylene (PCE or Perc): A chemical this is a nonflammable liquid at room temperature. It is a colorless liquid and has a sweet smell. It is widely used as a solvent and is the most common chemical used in drycleaning garments.

Trichloroethylene (TCE): A chemical this is a nonflammable liquid at room temperature. It is also called TCE. It is a manufactured chemical that is widely used to remove grease from metal parts. Trichloroethylene is also an ingredient in other consumer products. It evaporates easily into the air from surface water and has a somewhat sweet odor.

toxicological profile: An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology: The study of the harmful effects of substances on humans or animals.

µg/m^3: micrograms per cubic meter. Air results are usually measured in both µg/m^3 and ppb.

vapor intrusion: The process by which volatile chemicals migrate from an underground source into the indoor air of buildings.

Volatile Organic Compounds (VOCs): Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, dichloroethylene, toluene, trichloroethylene, methylene chloride, methyl chloroform, and vinyl chloride.

Certification

This Public Health Consultation: *Evaluation of Air Sampling Results for the 9053 Middlebrook Pike Site, Knoxville, Knox County, Tennessee*, was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was begun.

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