Health Consultation

Public Health Implications of Site-Related Exposures to
Trichloroethylene in Indoor Air

MANSFIELD TRAIL DUMP SUPERFUND SITE
SUSSEX COUNTY, NEW JERSEY

EPA FACILITY ID: NJN000206345

Prepared by:
New Jersey Department of Health

DECEMBER 30, 2016

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Public Health Implications of Site-Related Exposures to Trichloroethylene in Indoor Air

MANSFIELD TRAIL DUMP SUPERFUND SITE
SUSSEX COUNTY, NEW JERSEY

EPA FACILITY ID: NJN000206345

Prepared By:

New Jersey Department of Health
Environmental and Occupational Health Surveillance Program

Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Heath Investigations
Atlanta, Georgia 30333

Table of Contents

Summary

Introduction

On March 10, 2011, the United States Environmental Protection Agency (USEPA) listed the Mansfield Trail Dump site, located in Sussex County, New Jersey, to the National Priorities List (NPL). The New Jersey Department of Health (NJDOH), in cooperation with the Agency for Toxic Substances and Disease registry (ATSDR), released a public health assessment in September 2013 that recommended additional indoor air sampling. This health consultation is a follow-up to the public health assessment and it evaluates the public health implications of potential exposures to chemicals found in indoor air.

The top priority of ATSDR and NJDOH at this site is to ensure that the community around the site has the best information possible to safeguard its health.

Conclusion

The NJDOH and ATSDR have reached the following conclusions in this health consultation on the Mansfield Trail Dump site:

Conclusion 1

NJDOH and ATSDR conclude that past exposures to TCE vapors in indoor air in two properties (9 and 28) may have harmed people's health.

Basis for Conclusion

Residents in two properties (9 and 28) may have been exposed to indoor air contaminated with trichloroethylene (TCE) at levels that could harm their health. Despite the presence of sub-slab depressurization systems (SSDs) in both of these properties, there were past TCE concentrations that would approach or exceed effect levels from toxicological studies and would be of health concern. The health effect of greatest concern is the potential for cardiac malformations in children whose mothers were exposed to elevated levels of TCE during the first trimester of their pregnancy. If exposure to TCE vapors in indoor air occurred for extended time periods, additional health effects of concern might include impacts on the immune system and kidney of children and adults. Based on the highest detected concentration of TCE in indoor air in Property 9, the Lifetime Excess Cancer Risk (LECR) was calculated to be 1 x 10^{-4} or one excess cancer case in a population of 10,000 over a lifetime of exposure. This is considered an increased cancer risk. For Property 28, the LECR was calculated to be 4 x 10^{-5} or 4 excess cancer cases

in a population of 100,000 over a lifetime of exposure. This is considered a low increased risk of cancers. To put these risks in perspective, based on U.S. cancer rates, the lifetime risk of cancer in the general population is about 1 in 2.5, or about 4,000 out of every 10,000.

For properties without SSDs (5, 6, 16, 17, 26, and 31), although the TCE levels were above the comparison values in the past, they are not expected to have resulted in adverse health effects. For properties with SSD and/or radon systems (10, 14, 22, and 23), although the indoor air TCE was detected above comparison values at properties 10, 14, 22, and 23, the highest concentrations measured would not likely result in adverse health effects.

Next Steps

Continued monitoring for TCE in sub-slab soil gas and indoor air at properties that have been mitigated is strongly recommended to confirm that the mitigation systems continue to be effective in reducing exposures. Changes to the SSD at Property 9 and 28 resolved the presence of very high levels of TCE that were definitely of concern, but TCE is still present to some extent (as with other properties) and could change/fluctuate. The NJDOH and ATSDR strongly recommend that residents regularly check system pressure readings. Resampling is recommended for property 26 for a better reassessment of indoor air quality.

Conclusion 2

NJDOH and ATSDR conclude that future exposures to TCE vapors in indoor air in five properties (9, 10, 14, 26, and 28) may harm people's health.

Basis for Conclusion

Given the narrow window of time for health effects on a developing fetus, NJDOH and ATSDR is concerned that future exposures may be a public health hazard for these properties: 9, 10, 14, 26 and 28. Although SSDs are present at properties 9, 10, 14 and 28, there is still a potential for inhalation exposures to TCE if these systems are not operating properly as TCE levels have been detected above the MRL. Additionally, all four of these properties have had documented engineering/maintenance issues with the SSD in the past. Property 26 had an indoor TCE level detected above the chronic MRL in the last sampling round in November 2014 and this residence does not have a SSD. Residents at this property may be exposed to TCE and other contaminants through vapor intrusion although potential indoor sources for TCE for this property cannot be ruled out.

Next Steps

Residents at all properties with SSD and/or radon systems are strongly encouraged to remain vigilant and monitor the system to ensure that they remain under pressure and are functioning in the manner in which they were designed. It is also recommended residents use and store commercial products according to labels and manufacturer instructions as improper storage and use can contribute to the proliferation of volatile organic compounds in indoor air. The NJDEP can provide guidance on proper operation and maintenance for the SSDs for residences that are not eligible for state funding due to changes in home ownership.

Conclusion 3

NJDOH and ATSDR conclude that current exposures to TCE vapors in indoor air in all properties is not expected to harm people's health.

Basis for Conclusion

TCE is not expected to harm people's health at the levels detected during the most recent round of sampling. The TCE levels in indoor air are slightly above the chronic Minimum Risk Level for three properties (9, 10 and 26); however, the highest concentrations measured are not likely to result in adverse health effects. The TCE levels were below the MRL for the remaining properties. The higher indoor air TCE levels detected previously were associated with either the system not working properly or optimally; thus, with properly operating systems, the current levels are not expected to harm people's health. Routine operation and maintenance checks in March 2016 for properties 9 and 10 noted that the SSDs were operating as designed.

Next Steps

Residents at all properties with SSD and/or radon systems are strongly encouraged to remain vigilant and monitor the system to ensure that they remain under pressure and are functioning in the manner in which they were designed. It is also recommended residents use and store commercial products according to labels and manufacturer instructions as improper storage and use can contribute to the proliferation of volatile organic compounds in indoor air.

Conclusion 4

NJDOH and ATSDR conclude that past, current, and future exposure to PCE in indoor air is not expected to harm people's health.

Basis for Conclusion	Based on comparison to ATSDR health guideline values, there is not an increased risk of non-cancer health effects from inhaling PCE in indoor air. The estimated lifetime excess cancer risk of 3 x 10^{-6} represents about three possible excess cancer cases in a population of 1,000,000 over a lifetime of exposure and is considered a low increased cancer risk.
Next Steps	Further monitoring to ensure concentrations remain below the MRL at properties is recommended for reasons mentioned in Next Steps for Conclusion 1.
For More Information	Copies of this report will be provided to concerned residents near the site via the township libraries and the internet. Questions about this public health assessment should be directed to the NJDOH at (609) 826-4984.

Statement of Issues

On March 10, 2011, the United States Environmental Protection Agency (USEPA) listed the Mansfield Trail Dump site, located in Sussex County, New Jersey, to the National Priorities List (NPL). The New Jersey Department of Health (NJDOH), in cooperation with the Agency for Toxic Substances and Disease registry (ATSDR), prepared a public health assessment and reviewed environmental data to evaluate potential human exposure to volatile organic compounds (VOCs) in September 2013. As part of the previous assessment, NJDOH and ATSDR recommended that USEPA conduct additional indoor air sampling. This current health consultation is a follow-up to the public health assessment and evaluates the public health implications of potential exposures to chemicals found in indoor air. The impacted community consists of residents in a neighborhood adjacent to the Mansfield Trail Dump site.

Background

Regulatory and Remedial History

Trichloroethene (TCE) contamination was first discovered in a Brookwood Road home during a routine water test as part of a real estate transaction. In 2005, the Sussex County Health Department and the New Jersey Department of Environmental Protection (NJDEP) sampled 75 private drinking wells along Brookwood Drive, Brookwood Road, and Ross Roads in Byram Township, New Jersey. The NJDEP installed carbon water filtration and treatment systems in 17 homes to remove VOCs from the private residential drinking water wells (ATSDR 2013). From 2006-2008, the NJDEP collected indoor air and sub-slab soil gas samples from 15 residential properties throughout the Brookwood and Ross Roads neighborhood (USEPA 2010a). The NJDEP installed or enhanced existing sub-slab depressurization systems (SSD) in five properties in 2007-2008, where sub-slab soil gas sampling beneath these homes revealed TCE concentrations above NJDEP soil gas screening levels (USEPA 2010a). In 2010, the USEPA confirmed the presence of TCE in 15 of the private residential drinking water wells, which serve 56 residents in the Brookwood Drive, Brookwood Road, and Ross Roads neighborhood. Currently, 18 homes utilize a point of entry treatment (POET) system to remove the contamination (USEPA 2010b).

Demographics

The land use in this rural area is mixed residential and recreational. Based upon the 2010 United States Census, population demographics indicate that there are approximately 3,600 individuals residing within a one-mile radius of the site.

Past ATSDR/NJDOH Involvement

In September 2013, the NJDOH and ATSDR released a public health assessment for the Mansfield Trail Dump Superfund site, which addressed the public health implications of site-related exposures to TCE (ATSDR 2013). At the time of the report, the NJDOH and ATSDR could not conclude whether past, current, and future exposures to TCE in indoor air could have harmed people's health because more indoor air sampling was needed. This health consultation is based on new vapor intrusion data collected by the USEPA during their investigations of the residential area for the period of October 2011 through April 2016.

Environmental Contamination

We used a two-stage evaluation process in the assessment of indoor air data. The first step was to review available sampling data and to select contaminants that warrant further evaluation, based on the potential for exposure to these contaminants to result in adverse health effects. NJDOH examines the types and concentrations of contaminants of concern, and then evaluates them against comparison values generally established by ATSDR and EPA. Comparison Values (CVs) are concentrations of a contaminant that can reasonably (and conservatively) be regarded as harmless to human health, assuming default conditions of exposure. CVs include ample uncertainty factors to ensure protection of sensitive populations. Because CVs do not represent thresholds of toxicity, exposure to contaminant concentrations above CVs will not necessarily lead to adverse health effects (ATSDR 2005). If concentrations exceed the environmental CV, these substances are referred to as Contaminants of Concern (COC). The next step in the evaluation process involves an in-depth health-effects evaluation of the contaminants detected in the site media (in this case, indoor air) above their respective CVs. The primary focus of this effort is to evaluate the potential for the contaminant(s) to produce cancer and non-cancer health effects as a result of human exposure.

Environmental Guideline Comparison

There are a number of environmental CVs available for screening environmental contaminants to identify COCs (ATSDR 2005). Contaminants of concern were determined by employing a screening process that compares sampling results to chemical-specific, health-based screening levels developed by ATSDR for cancer and non-cancer effects [ATSDR's minimal risk levels (MRLs), and ATSDR's cancer risk evaluation guides (CREGs)]. An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of adverse, non-cancer health effects. CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed over their lifetime. These CVs offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. The NJDEP has indoor air screening levels and evaluates vapor intrusion (VI) sampling data presented in detail at http://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html.

A brief summary is provided below for sub-slab soil gas and indoor air sampling as conducted by NJDEP and USEPA at properties adjacent to the site. Sub-slab soil gas results are discussed primarily to ensure completeness of data presented as NJDOH does not evaluate health effects to contaminants based on soil gas data. The following section focuses on indoor air results from sampling conducted by USEPA in March 2012, January 2014 and November 2014.

Vapor Intrusion (VI) Investigation

From 2006-2008, NJDEP collected indoor air and sub-slab soil gas samples from 15 residential properties throughout the Brookwood and Ross Roads neighborhood (USEPA 2010a). NJDEP installed or enhanced existing SSD systems in five properties in 2007-2008, where the sub-slab sampling revealed TCE concentrations above NJDEP soil gas screening levels (USEPA 2010a). We evaluated these data in the Public Health Assessment published in 2013 (ATSDR 2013). NJDEP conducts a quarterly visit to ensure proper Operation and Maintenance (O&M) of the installed SSD systems at affected residences which meet certain eligibility requirements. However, as of March 2, 2009, due to an amendment modifying the New Jersey Spill Fund claim rules and regulations, the purchaser of a property on which a SSD system was installed and maintained at the expense of the State is not eligible for compensation for ongoing maintenance and monitoring costs (NJDEP 2012).

In October 2011, the USEPA evaluated the sub-slab soil gas (Tedlar® bags and SUMMA® canisters were both used to evaluate sub-slab soil gas)) at twenty-seven residential properties and two schools adjacent to the site. Twelve of the fifteen properties previously sampled in 2006-2008 were included in this sampling round. The highest results from Tedlar® bags were measured at 97 micrograms of contaminant per cubic meter of air ($\mu g/m^3$) and 35 $\mu g/m^3$ for TCE and PCE, respectively. cis-1,2-Dichloroethene (cis-1,2-DCE) was also detected at a maximum concentration of 63 $\mu g/m^3$. The NJDEP soil-gas screening levels for TCE and PCE are 27 and 470 µg/m3, respectively. The other VOCs were not detected above their reporting limits in any sub-slab soil gas samples. Sub-slab soil gas samples collected using SUMMA® canisters had maximum concentration of TCE, PCE, and cis-1-2-DCE at 72, 14 and 11 $\mu g/m^3$, respectively. In addition, trans-1,2-dichloroethene (trans-1,2-DCE) and vinyl chloride were also detected at a maximum concentration of 3.2 and 0.17 $\mu g/m^3$, respectively. The ambient air sample had no reportable detection of any VOCs. Sub-slab soil gas samples collected at the two schools had no reportable detection of any VOCs. There were no indoor air samples collected at these schools in this sampling round. ATSDR typically recommends concurrent sub-slab gas, indoor air, and outdoor air sampling when contaminants are within plausible range for vapor migration to occur. Previous sampling at one of the schools conducted by the NJDEP in February 2007 showed that there were no VOCs detected above screening levels in the indoor air (NJDEP 2007).

Further sampling was conducted from March 2012 and April 2016 that included the evaluation of sub-slab soil gas, indoor air, and outdoor ambient air at these residences. A summary of the results is described below and shown in Table 1 (page 11). Indoor samples were collected in the basement and the first floor of the residence. The table depicts the maximum value measured at each property.

<u>March 2012 results</u>: Of the 38 indoor air samples collected, detections for PCE ranged from non-detect (ND) to 8.6 $\mu g/m^3$ and detections for TCE ranged from ND to 4.2 $\mu g/m^3$. cis-1,2-DCE concentrations ranged from ND to 1.86 $\mu g/m^3$. The other VOCs were not detected above their reporting limits in indoor air samples. Two outdoor ambient air samples were also collected (at Properties 14 and 29). The ambient air sample on Property 29 sample had a reportable result for PCE at 4.6 $\mu g/m^3$. The other ambient sample did not register detectable concentrations of TCE or PCE.

Exceedances of the environmental CVs based on cancer health effects for PCE and TCE detected in indoor air were as follows: PCE at one location (26); TCE at six locations (9, 10, 14, 28, 22 and 26). Locations 7, 9, 10, 14 and 28 have operational SSD systems that were installed between 2007 and 2009. There is no comparison value available for cis-1,2-DCE.

January 2014 results: Of the thirty-two indoor air samples collected, detections for PCE ranged from ND to 1.2 $\mu g/m^3$ and detections for TCE ranged from ND to 23 $\mu g/m^3$. Benzene was detected in every indoor air sample (0.64 – 12 $\mu g/m^3$) and is not considered a site related contaminant. The other VOCs were not detected above their CVs in indoor air samples. Six ambient air samples were collected at Properties 9, 17, 24, 26, 29, and 31. TCE was detected at 0.27 $\mu g/m^3$ and 9.2 $\mu g/m^3$ at Properties 9 and 26, respectively. PCE was not detected in any of the ambient samples.

Table 1: VOCs detected above screening levels from indoor air samples (March 2012, January 2014, and November 2014 sampling events)

Property	Sub-Slab[1a] (µg/m³)			Indoor Air[1b] (Max conc.) (µg/m³)			Environmental Guideline Comparison Values (CV) µg/m³	Contaminant of Potential Concern
	PCE	TCE	1,2-DCE	PCE	TCE	cis-1,2-DCE		
Property 5							**PCE**: 3.8 (CREG) **PCE**: 41 (MRL) **TCE**: 0.24 (CREG) **TCE**: 2 (MRL) **cis-1,2-DCE**: NA	
Mar-12	0.37	2.6	ND	1.2	ND	ND		None
Jan-14	ND	1.3	ND	ND	**1.3**[2]	ND		TCE
Nov-14	0.68	1.7	ND	0.47	**0.43**[3]	ND		TCE
Property 6								
Mar-12	0.40	0.43	ND	2.8	ND	ND		None
Jan-14	ND	1.2	ND	1.1	**0.48**[3]	ND		TCE
Nov-14	1.9	0.64	ND	**4.5**[3]	ND	ND		PCE
Property 16								
Mar-12	0.94	1.8	ND	ND	ND	ND		None
Jan-14	0.81	4.1	ND	ND	**0.27**[3]	ND		TCE
Nov-14	1.6	2.5	ND	ND	ND	ND		None
Property 17								
Mar-12	3.2	ND	ND	0.23	0.23	ND		None
Jan-14	3.5	2.5	0.16	ND	ND	ND		None
Nov-14	11	ND	ND	1.6	**0.32**[3]	ND		TCE
Property 19								
Mar-12	1.0	2.4	ND	ND	ND	ND		None
Jan-14	0.54	1.6	ND	ND	ND	ND		None
Nov-14	2.6	4.2	ND	0.54	ND	ND		None
Property 22 Radon System Installed								
Mar-12	0.41	7.4	1.5	2.4	**0.29**[3]	ND		TCE
Jan-14	ND	10	0.83	0.95	**1.8**[3]	0.6		TCE
Nov-14	0.27	0.91	ND	2.4	ND	ND		None
Property 23 Radon System Installed								
Mar-12	ND	14.6	0.8	2.38	ND	ND		None
Jan-14	ND	6.9	ND	ND	**0.27**[3]	ND		TCE
Nov-14	0.27	19	ND	**7.3**[2]	ND	ND		PCE
Property 24 Radon System Installed								
Mar-12	0.53	22.3	3.6	ND	ND	ND		None
Jan-14	ND	11	1.1	ND	ND	ND		None
Nov-14	ND	5.8	ND	ND	ND	ND		None
Property 26*								
Mar-12	14.8	0.35	ND	**8.6**[2]	**0.35**[2,3]	ND		PCE, TCE
Jan-14	10	ND	ND	1.2	ND	ND		None
Nov-14	28	ND	ND	**9.4**[2]	**2.4**[2]	ND		PCE, TCE

Table 1: - continued -

Property	Sub Slab[1a] (µg/m³)			Indoor Air[1b] (Max conc.) (µg/m³)			Environmental Guideline Comparison Values (CV)	Contaminant of Potential Concern
	PCE	TCE	1,2-DCE	PCE	TCE	cis-1,2-DCE		
Property 29							**PCE**: 3.8 (CREG) **PCE**: 41 (MRL) **TCE**: 0.24 (CREG) **TCE**: 2 (MRL) **cis-1,2-DCE**: NA	
Mar-12	ND	ND	ND	0.79	ND	ND		None
Jan-14	0.68	ND	ND	ND	ND	ND		None
Nov-14	1.4	ND	ND	1.5	ND	ND		None
Property 30								
Mar-12	0.96	ND	ND	0.87	ND	ND		None
Jan-14	0.54	ND	ND	ND	ND	ND		None
Nov-14	1.2	ND	ND	ND	ND	ND		None
Property 31								
Mar-12	0.49	ND	ND	0.35	ND	ND		None
Jan-14	ND	0.54	ND	ND	**1.5**[2]	ND		TCE
Nov-14	0.27	ND	ND	0.34	ND	ND		None
Property 7 SSD Installed								
Mar-12	0.25	0.25	ND	2.81	ND	ND		None
Jan-14	ND	ND	ND	0.88	ND	ND		None
Nov-14	1.2	0.27	ND	2.6	ND	ND		None
Property 9 SSD Installed								
Mar-12	0.25	1.9	0.16	ND	**1.8**[3]	0.7		TCE
Jan-14	ND	13	0.59	ND	**23**[3]	5.3		TCE
Apr-14*	1.8	7.7	0.16	2.9	**21**	3.5		TCE
Aug-14*	1	1	0.8	1	**2**[3]	0.8		TCE
Nov-14	NS	NS	NS	NS	NS	NS		NS
Property 10 SSD Installed								
Mar-12	ND	12.3	7.3	0.7	**0.8**[2]	0.2		TCE
Jan-14	ND	67	23	ND	**4.7**[3]	2.1		TCE
Nov-14	0.61	7.8	0.67	**10**	**2.4**[2]	1.2		TCE
Property 14 SSD Installed								
Mar-12	ND	12.3	7.3	0.51	**1.1**[3]	0.86		TCE
Jan-14	NS	NS	NS	NS	NS	NS		NS
Nov-14	NS	NS	NS	NS	NS	NS		NS
Apr-16[2]	ND	4.5	0.67	ND	**0.97**	0.87		TCE

Table 1: - continued

Property	Sub Slab[1a] (µg/m³)			Indoor Air[1b] (Max conc.) (µg/m³)			Environmental Guideline Comparison Values (CV)	Contaminant of Potential Concern
	PCE	TCE	1,2-DCE	PCE	TCE	cis-1,2-DCE		
Property 28 SSD Installed							**PCE**: 3.8 (CREG) **PCE**: 41 (MRL) **TCE**: 0.24 (CREG) **TCE**: 2 (MRL) **cis-1,2-DCE**: NA	
Mar-12	0.28	103	62.8	ND	**4.2**[3]	1.8		TCE
Jan-14	1.7	1,400	170	ND	**8.6**[3]	1.9		TCE
Nov-14	ND	2.4	0.2	ND	ND	ND		No
Apr-16[4]	ND	26	5	ND	**0.91**	ND		TCE

[*] The maximum ambient air concentration for TCE was 9.2 µg/m³ in January 2014.[1a,b]: NJDEP Soil-gas screening/Indoor Air levels are 27 µg/m³/3 µg/m³ for TCE and 470 µg/m³/9 µg/m³ for PCE; [2]**:** max detected in the First Floor; [3]**:** max detected in the Basement; [4]: Properties changed ownership therefore these homes were resampled; * April sampling to determine cause of elevated TCE in Jan; Aug sampling to confirm that actions taken reduced indoor TCE; ND: Not Detected; NS: Not Sampled; Cancer Risk Evaluation Guide (ATSDR); NA: Not available; **Bolded** results are above CVs

PCE was not detected above its CV in any indoor air sample. All detected TCE values were above the CREG (nine properties: 5, 6, 9, 10, 16, 22, 23, 28 and 31). At five of these properties, TCE was not elevated above the CV based on non-cancer health effects (2 µg/m³). Although benzene was elevated above the screening level in all indoor air samples, it is not considered a site-related contaminant as it was not detected in the groundwater. It is likely from an indoor source or an ambient source (ATSDR 2007). Outdoor air contains low levels of benzene from tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions. Indoor air generally contains higher levels of benzene from products such as glues, paints, furniture wax, gas cans stored in garages and detergents. Since benzene is a known human carcinogen, efforts should be made to reduce exposure to this contaminant. Appendix A has information on how to address exposures from common indoor contaminants.

November 2014 to present results: Of the thirty indoor air samples collected, PCE ranged from ND to 10 µg/m³ and TCE ranged from ND to 2.4 µg/m³. Benzene was detected in every indoor air sample (0.64 – 44 µg/m³) and is not considered a site related contaminant. Exceedances of the environmental CVs based on cancer health effects for PCE and TCE detected in indoor air in were as follows: PCE at three locations (6, 10 and 26); TCE at four locations (5, 10, 17, and 26). Properties 9 and 14 were not sampled because access was not granted in this sampling round. Six ambient air samples were collected at Properties 10, 17, 24, 26, 29, and 31. All results were non-detects for TCE and PCE.

O&M (Operation and Maintenance) issues: For residences with SSDs, certain issues were noted during the O&M monitoring which included vent blockage from debris, broken fans, moisture seeping into the SSDs. These led to the resampling of these properties with an amended schedule. Measures taken included installation of moisture traps, and other engineering controls to enable the SSDs to function as designed.

Investigation continued at Property 9 to resolve the presence of TCE in indoor air. Access was granted in April 2014 and PCE, TCE, and cis-1,2-DCE were detected at 2.9 µg/m³, 21 µg/m³, and 3.5 µg/m³, respectively. The property was resampled in August 2014 and the TCE results were 1 µg/m³ in sub-slab soil gas, 2 µg/m³ in the basement, and 1 µg/m³ on the first floor.

Owner could not be contacted for sampling in November 2014. A routine O&M check in March 2016 showed that the SSD was operating under proper pressure and there was good airflow (personal communication NJDEP 2016). During sampling and O&M visits, contractor noted that the basement of this property houses an extensive array of home improvement products (e.g., paints and spray cans) and home maintenance machinery (e.g., lawnmower and snow blower).

Similarly, the SSD systems at properties 10 and 28 have undergone several engineering changes to resolve continued TCE detection in indoor air over multiple sampling rounds. For Property 10, a routine O&M check in March 2016 showed that the SSD was operating under proper pressure and there was good airflow (personal communication NJDEP 2016). For Property 28, the November 2014 sampling results are likely the most representative of the fully functioning SSD as engineering changes were made to optimize the system.

Of note, properties undergoing changes in ownership are not eligible for compensation for ongoing maintenance and monitoring costs (NJDEP 2012). The owners of these properties have been made well aware that NJDEP will not continuing the quarterly O&M on their SSD systems and that they have been instructed to inspect the manometers at their properties on a regular basis to ensure that the systems continue to operate under a vacuum.

Summary of sampling results: The contaminants of concern in indoor air based on results from sampling conducted from March 2012 to April 2016 are PCE (for cancer health effects) and TCE (for non-cancer and cancer health effects) and will be evaluated in the following section. There is no cis-1,2-Dichloroethylene (cis-1,2-DCE) CV. The detections are lower than the CV for trans-1,2-DCE, for which there is a CV. There is somewhat conflicting evidence on the relative toxicity of the two isomers. Generally, DCE is considered less toxic than other chlorinated hydrocarbons. So while the DCE detections could pose some risk, the PCE and TCE will be the main drivers and the DCE detections do not change the overall conclusion.

Either PCE or TCE or both were elevated above indoor air CVs at the following twelve properties: 5, 6, 9, 10, 14, 16, 17, 22, 23, 26, 28 and 31 (see Table 2 below). Of these twelve properties, four have SSD systems that were installed in 2007-2009 (properties 9, 10, 14 and 28) and two of these properties have radon mitigation systems installed (properties 22 and 23).

Table 2: Summary of contaminants of concern in properties

Location	PCE above CV	TCE above CV	SSD and/or radon System
5	No	Yes	No
6	No	Yes	No
9	No	Yes	Yes
10	Yes	Yes	Yes
14	No	Yes	Yes
16	No	Yes	No
17	No	Yes	No
22	No	Yes	Yes
23	No	Yes	Yes
26	Yes	Yes	No
28	No	Yes	Yes
31	No	Yes	No

Discussion

The method for assessing whether a health hazard exists to a community is to determine whether there is a completed exposure pathway from a contaminant source to a receptor population and whether exposures to contamination are high enough to be of health concern. Site-specific exposure doses can be calculated and compared with health guideline CVs.

Assessment Methodology

An exposure pathway is a series of steps starting with the release of a contaminant in environmental media and ending at the interface with the human body. A completed exposure pathway consists of five elements:

1. source of contamination;
2. environmental media and transport mechanisms;
3. point of exposure;
4. route of exposure; and
5. receptor population.

Generally, the ATSDR considers three exposure categories: 1) completed exposure pathways, that is, all five elements of a pathway are present; 2) potential exposure pathways, that is, one or more of the elements may not be present, but information is insufficient to eliminate or exclude the element; and 3) eliminated exposure pathways, that is, a receptor population does not come into contact with contaminated media. Exposure pathways are used to evaluate specific ways in which people were, are, or will be exposed to environmental contamination in the past, present, and future.

The VI pathway warrants consideration because of the volatile nature of PCE and TCE and because the groundwater plume is located beneath the homes. VI is the migration of VOCs from the subsurface-contaminated groundwater and soil through the pore spaces of soil into the indoor air of buildings. The concentrations of contaminants entering the indoor air from the subsurface are dependent upon site and building-specific factors such as building construction, number and spacing of cracks and holes in the foundation, and the impact of the heating and air conditioning system on increasing or decreasing flow from the subsurface.

Completed Exposure Pathway

Inhalation of COCs in Indoor Air (Past, Present, and Future)

There is a completed past, present, and future exposure pathway at twelve locations regarding the inhalation of air contaminated with PCE and TCE. The exposure pathway involves these contaminant vapors migrating upwards through contaminated subsurface media, groundwater and soil, and entering the interior of these residences. Vapor intrusion sampling results from fifteen residences in 2006 indicated the need for the NJDEP to install or enhance existing SSD systems in five of the affected residences that had sub-slab TCE elevations. Twelve properties showed indoor air levels of PCE and TCE above CVs in samples collected in March 2012, January 2014, and November 2014; eight of these properties had elevated PCE and TCE above CVs in at least two sampling events. Of note, four of the twelve properties identified as having contaminants of potential concern have existing SSD systems that were installed in 2007 and two additional properties have existing radon mitigation systems.

Based on the installation of SSD and/or radon systems, the properties were categorized into the following groups for pathway analysis:

- Properties with a SSD and/or radon systems with COCs above CVs
- Properties with a SSD and/or radon systems with COCs below CVs
- Properties without a SSD and/or radon systems with COCs above CVs
- Properties without a SSD and/or radon systems with COCs below CVs

A summary of health effects from VOC exposure in indoor air via vapor intrusion for properties categorized in to the above four groupings will be provided after the following section.

Public Health Implications of the Completed Exposure Pathway

Health Guideline Comparison – Non-Cancer Health Effects

To assess non-cancer health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites (ATSDR 2005). An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of adverse, non-cancer health effects. MRLs are developed for a route of exposure, i.e., ingestion or inhalation, over a specified time period, e.g., acute (less than 14 days); intermediate (15-364 days); and chronic (365 days or more). MRLs are based largely on toxicological studies in animals and on reports of human occupational (workplace) exposures. MRLs are usually extrapolated doses from observed effect levels in animal toxicological studies or occupational studies, and are adjusted by a series of uncertainty (or safety) factors or through the use of statistical models. In toxicological literature, observed effect levels include:

- no-observed-adverse-effect level (NOAEL); and
- lowest-observed-adverse-effect level (LOAEL).

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals. LOAEL is the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals. In order to provide additional perspective on these health effects, the calculated exposure doses were then compared to observed effect levels (e.g., NOAEL, LOAEL). As the exposure dose increases beyond the MRL to the level of the NOAEL and/or LOAEL, the likelihood of adverse health effects increases.

When MRLs for specific contaminants are unavailable, other health based comparison values such as the USEPA's Reference Dose (RfD) are used. The RfD is an estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure.

When assessing an exposure risk to a COC, the USEPA recommends use of the 95 percent upper confidence limit (95% UCL) of the arithmetic mean contaminant concentration to determine the exposure point concentrations (EPC) (USEPA 2013). Statistical analysis for data sets of four to six observations are not considered to be adequate for reliable analysis. Therefore, in this case as five or more sample results were unavailable for each property, the EPC was determined based on maximum COC concentrations detected. The maximum detected indoor air concentration detected in any property for PCE and TCE during the March 2012, January 2014, and November 2014 sampling events is 10 $\mu g/m^3$ and 23 $\mu g/m^3$, respectively (see Table 1). These maximum values were used as the Exposure Point Concentrations (EPC) for PCE and TCE in the following section to assess non-cancer health effects.

Inhalation of COCs in Indoor Air via Vapor Intrusion

Tetrachloroethene (PCE): Tetrachloroethene (also known as tetrachloroethylene or perchloroethylene) is a synthetic chemical that is widely used for dry cleaning of fabrics and for metal-degreasing operations. It is also used as a building block for making other chemicals and is used in some consumer products. PCE enters the environment mostly by evaporating into the air during use. It can also get into water supplies and soil during disposal of sewage sludge and factory waste and when leaking from underground storage tanks. It can stay in the air for several months before it is broken down into other chemicals or is brought back down to soil and water from rain (ATSDR 1997b). Consumer products that may contain PCE includes water repellants, silicone lubricants, fabric softeners, spot removers, adhesives, and wood cleaners.

The highest measured concentration of PCE (10 $\mu g/m^3$) is below ATSDR's chronic MRL of 41 $\mu g/m^3$ and USEPA's chronic RfC of 40 $\mu g/m^3$ (ATSDR 1997a; USEPA 2012b). This and other measured concentrations are below levels of health concern and suggest there is not an increased risk of non-cancer health effects from inhaling PCE in indoor air.

Trichloroethene (TCE): Trichloroethene (also known as trichloroethylene) is used mainly as a degreaser for metal parts. It is also used as a solvent in other ways and is used to make other chemicals. TCE can also be found in some household products, including typewriter correction fluid, paint removers, adhesives, and spot removers. The biggest source of TCE in the environment is evaporation from factories that use it. Once TCE is in the air, about half will be broken down within a week. If released to the soil, TCE generally does not break down in the soil but migrates into groundwater where it does break down, but at a very slow rate (ATSDR 1997b). People are usually exposed to TCE from breathing air or drinking water containing TCE. If you breathe the chemical, about half the amount you breathe will get into your bloodstream and organs. You will exhale the rest. If TCE comes into contact with your skin, some of it can enter your body, although not as easily as when you breathe or swallow it (ATSDR 1997b).

Once in your blood, your liver changes much of the TCE into other chemicals. The majority of these breakdown products leave your body in the urine within a day. You will also quickly breathe out much of the TCE in your bloodstream. Some of the TCE or its breakdown products can be stored in body fat for a brief period, and thus may build up in your body if exposure continues (ATSDR 1997b).

The maximum detected level of TCE in indoor air (23 μg/m^3) was used for evaluating public health implication of TCE levels in indoor air as this would provide the most conservative estimate.

In October 2014, ATSDR published a chronic MRL of 2.1 μg/m^3 for chronic (more than 365 days) and intermediate (2 weeks to 365 days) inhalation exposure to TCE (ATSDR 2014). In USEPA's TCE Integrated Risk Information System (IRIS) toxicological profile, the most sensitive observed adverse effects, which were used as the primary basis for the RfC, were those affecting the immune system and the developing fetus (USEPA 2012c). The RfC of 2 μg/m^3 is based on route-to-route extrapolated results from oral studies for the critical effects of heart malformations (rats) and immunotoxicity (mice). Kidney toxicity is considered supportive of the critical effect, but it was not used as a principal basis for the RfC. Although these studies were conducted in rats and mice exposed to TCE in drinking water, physiological-based pharmacokinetic (PBPK) modeling was used to extrapolate oral dose in animals to human equivalent concentrations (HECs) in air. Based on the animal study data as reviewed in the IRIS toxicological profile, EPA predicts that:

- A small risk of fetal heart malformations exists for pregnant women exposed to TCE levels approaching or exceeding 21 μg/m^3;
- A small risk of decreased thymus weight exists for humans exposed to TCE levels approaching or exceeding 190 μg/m^3; and
- A small risk of kidney impacts, including toxic nephropathy and increased kidney weights exists for humans exposed to TCE levels approaching or exceeding 30 μg/m^3.

The most sensitive endpoint of the MRL is an increase in fetal cardiac malformations in rats, with an uncertainty (safety) factor built in. The major milestones for cardiac heart development in humans occur over a three-week period in the first trimester of pregnancy and exposures to TCE during this critical period may increase the risk of heart malformations in the developing fetus. With an uncertainty factor of only 10 applied to the effect level for fetal heart impacts, concentrations of TCE of about three times greater than the MRL may become a concern for health effects.

The maximum detected TCE in indoor air (23 μg/m^3) is above the chronic MRL. There are a total of four properties (9, 10, 26 and 28) which have had TCE indoor air levels that have exceeded the MRL (see Table 1). Of these, Property 26 is the only property without a SSD. It should be noted that TCE was not detected in the soil gas for this property and therefore potential indoor sources for TCE cannot be ruled out.

The HECs for the two RfC studies are 21 μg/m^3 and 190 μg/m^3. The USEPA attributes a small risk of developing the associated health effects when humans are chronically exposed to TCE at these concentrations (USEPA 2012c). ATSDR expects individuals exposed to TCE concentrations near predicted HECs to have a lower risk for harmful effects to occur while exposures exceeding predicted HECs have a higher risk for harmful effects to occur. Two properties (9 and 28) had TCE concentrations that would approach or exceed effect levels from toxicological studies and would be of concern.

One property (9; see Table 1) has had TCE indoor air levels greater than the HEC of 21 µg/m^3. Thus, there is a potential for developmental effects if a pregnant woman was exposed even for a fairly short period of time (i.e., under three weeks) to these levels when the heart is developing during the first trimester of pregnancy. Exposure of pregnant women to TCE levels above the chronic MRL does not mean that fetal heart development will be impaired. However, breathing air exceeding these levels of TCE begins to introduce a small amount of risk to proper fetal development and should be avoided. Although the highest indoor air concentration detected at this residence is approximately 9 times lower than the HEC of 190 µg/m^3 for decreased thymus weight observed in mice, a small amount of risk to impacts on immune system may exist in immunosuppressed populations. Given the narrow window of time for health effects on a developing fetus, ATSDR is concerned that exposures at this level could have posed a public health hazard

This is also applicable to another property (28; see Table 1) that had an indoor air concentration of 8.6 µg/m^3 detected in January 2014. This concentration of TCE is four times greater than the MRL and therefore there exists the possibility of fetal heart malformations with short-term exposures.

Indoor air TCE concentrations slightly above the chronic MRL at properties 10 and 26 are not likely to result in non-cancer health effects, but could change and are very close to levels of concern. Of note, Property 26 does not have a SSD so it is important to keep monitoring the indoor air levels. TCE was either not detected or was below NJDEP soil gas screening levels for this property, so potential indoor sources for TCE cannot be ruled out.

Based on evaluation of the available literature, indoor air TCE concentrations below the chronic MRL at properties 5, 6, 14, 16, 17, 22, 23, and 31 are not expected to result in adverse health effects.

Health Guideline Comparison – Cancer Health Effects

The site-specific lifetime excess cancer risk (LECR) indicates the cancer potential of contaminants. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 44 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of several common types of cancer ranges between approximately 1 in 6 and 1 in 100 (ACS 2011). Typically, health guideline CVs developed for carcinogens are based on one excess cancer case per 1,000,000 exposed individuals. The NJDOH considers estimated cancer risks of less than one additional cancer case among one million persons exposed as insignificant or no increased risk (expressed exponentially as 10^{-6}). Cancer risk less than 1 in 10,000 (or 1×10^{-4}) is within EPA's cancer risk range used for guiding remedial activities.

Increases in cancer risk can be estimated by multiplying the maximum concentrations of carcinogenic pollutants by the USEPA's inhalation unit risk (IUR) for each pollutant and summing the results. The IUR is defined by the USEPA as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/m^3 in air.

The following section details the cancer health effects from exposure to maximum levels of PCE and TCE detected in indoor air from data collected in March 2012, January 2014, and November 2014.

PCE: The USEPA has recently classified PCE as “likely to be carcinogenic to humans” by all routes of exposure. Although exposure to PCE has not been directly shown to cause cancer in humans, the U.S. Department of Health and Human Services has determined that PCE may reasonably be anticipated to be a human carcinogen (NTP 2011). The International Agency for Research on Cancer (IARC) has classified PCE as a Group 2A carcinogen—probably carcinogenic to humans (limited human evidence, sufficient evidence in animals) (IARC 1995).

The USEPA updated its health risk assessment for PCE in February 2012 (USEPA 2012). The IUR was determined to be 2.6 x 10^{-7} per µg/m^3. Using this value and the maximum PCE concentration detected in the indoor air at this site, a possible worst case lifetime excess cancer risk from exposure to PCE can be estimated:

LECR = Inhalation Unit Risk x Air Concentration

where,

LECR = estimated lifetime excess cancer risk (unitless)
Inhalation Unit Risk = $(\mu g/m^3)^{-1}$
Air Concentration = µg/m^3
LECR = 2.6 x 10^{-7} per µg/m^3 x 10 µg/m^3 = 3 x 10^{-6}

The LECR of 3 x 10^{-6} represents about three possible excess cancer cases in a population of 1,000,000 over a lifetime of exposure. This is considered a low increased cancer risk. The actual or true risk is likely to be less because exposure is likely to be intermittent (not 24 hours a day, 7-days a week, 52-weeks a year) and less than a lifetime (78 years). Additionally, the maximum PCE concentration was used to derive this estimate.

TCE: The USEPA characterizes TCE as carcinogenic to humans by all routes of exposure (USEPA 2012c). This conclusion is based on human epidemiology studies showing associations between human exposure to TCE and kidney cancer, non-Hodgkin’s lymphoma, and liver cancer. The human studies showed increased rates of liver cancer and non-Hodgkin’s lymphoma, primarily in workers who were exposed to TCE on the job. The National Toxicology Program (NTP) has determined that trichloroethylene is a "known human carcinogen". The animal studies showed increased numbers of liver, kidney, testicular, and lung tumors by two different routes of exposure (NTP 2011).

In late September 2011, the USEPA published a revised IRIS inhalation unit risk of 4.1 x 10^{-6} µg/m^3 reflecting total incidence of kidney, non-Hodgkins lymphoma, and liver cancers (USEPA 2012c). The USEPA recently concluded, by a weight of evidence evaluation, that TCE is carcinogenic by a mutagenic mode of action for induction of kidney tumors (USEPA 2011b). As a result, increased early-life susceptibility is assumed for kidney cancer, and age-dependent adjustment factors (ADAFs) are used for the kidney cancer component of the total cancer risk when estimating age-specific cancer risks. ADAFs are factors by which cancer risk is multiplied to account for increased susceptibility to mutagenic compounds early in life – standard ADAFs are 10 (for ages below 2 years old), 3 (for ages 2 up to 16 years old), and 1 (for ages greater than 16).

Using this approach, the LECR for TCE based on the highest level measured was calculated to be 1 x 10^{-4} or one excess cancer case in a population of 10,000 over a lifetime of exposure. This is considered an increased cancer risk. To put this risk in perspective, based on U.S. cancer rates, the lifetime risk of cancer in the general population is about 1 in 2.5, or about 4,000 out of every 10,000.

Summary of VOC exposure in indoor air via vapor intrusion based on March 2012, January 2014, and November 2014 indoor air sampling (see Table 1 for contaminant concentrations)

Properties without SSD systems with COCs below CVs: These following properties do not have SSD systems and the measured VOCs in indoor air were below comparison values: 19, 29 and 30. Additionally, the VOCs in sub-slab soil gas samples were also below soil-gas screening levels. No adverse health effects are expected.

Properties with SSD and/or radon systems with COCs below CVs: Two properties (7 and 24) had VOC levels below screening values in all three sampling events; therefore, adverse health effects are not expected for residents.

Properties without SSD systems with COCs above CVs: The following properties do not have SSD systems and VOCs were detected above comparison values in indoor air samples: 5, 6, 16, 17, 26, and 31. Table 3 below shows the likelihood for non-cancer and cancer health effects for residents associated with maximum detected VOC levels detected out of the three sampling events.

Table 3: Public health implications in properties without SSD with detected COCs

Location	PCE		TCE	
	Non Cancer	Cancer	Non Cancer	Cancer
5	NA[a]	NA	Not Likely	6 x 10^{-6} [b]
6	NA	NA	Not Likely	2 x 10^{-6} [b]
16	NA	NA	Not Likely	1 x 10^{-6} [b]
17	NA	NA	Not Likely	2 x 10^{-6} [b]
26	NA	2 x 10^{-6} [b]	Not Likely	1 x 10^{-5} [b]
31	NA	NA	Not Likely	7 x 10^{-6} [b]

[a] PCE levels were below comparison values
[b] Cancer risk less than 1 in 10,000 (or 1 x 10^{-4}) are within EPA's cancer risk range used for guiding remedial activities.

Although the indoor air VOCs were detected above comparison values, comparison to the chronic MRL indicates the highest concentrations measured would not likely result in adverse health effects. However, further monitoring to ensure concentrations remain low is recommended. The sub-slab soil gas levels at these properties were all below NJDEP sub-slab screening values for assessing the potential for soil vapor intrusion.

Properties with SSD and/or radon systems with COCs above CVs: Properties 9, 10, 14, 22, 23, and 28 have radon/SSD systems and VOC levels above comparison values in at least two sampling events (property 14 was only sampled in March 2012). Table 4 below shows the likelihood of non-cancer and cancer health effects related to detected VOCs at these residences.

Table 4: Public health implications in properties with SSD with detected COCs

Location	**PCE**		**TCE**	
	Non Cancer	**Cancer**	**Non Cancer**	**Cancer**
9	NA	NA	Potential	1×10^{-4} [b]
10	NA	3×10^{-6} [b]	Not Likely	2×10^{-5} [b]
14	NA	NA	Not Likely	5×10^{-6} [b]
22	NA	NA	Not Likely	8×10^{-6} [b]
23	NA	NA	Not Likely	1×10^{-6} [b]
28	NA	NA	Potential	4×10^{-5} [b]

[a] PCE levels were below comparison values
[b] Cancer risk less than 1 in 10,000 (or 1×10^{-4}) are within EPA's cancer risk range used for guiding remedial activities at Superfund sites.

Although the indoor air VOCs were detected above comparison values at properties 10, 14, 22, and 23, comparison to the chronic MRL indicates the highest concentrations measured would not likely result in adverse health effects.

To date, one property (9) had TCE indoor air levels greater than 21 $\mu g/m^3$, which is the human equivalent concentration derived from rat studies, for fetal health malformations. Therefore, there existed a potential for fetal heart effects if a pregnant woman was exposed even for a fairly short period of time (i.e., under three weeks) at these levels. The maximum TCE levels were measured in January 2014 at this property; it was noted that at the time of sampling, the SSD was not operational. Subsequent sampling in April 2014 revealed partial blockage caused by some debris build-up on the vent screen (personal communication NJDEP 2014). This resulted in reduced airflow. After clearing the blockage, the airflow returned to the normal range. The property was resampled in August 2014 and the TCE results were 1 $\mu g/m^3$ in sub-slab soil gas, 2 $\mu g/m^3$ in the basement, and 1 $\mu g/m^3$ on the first floor. The highest levels have always been detected in the basement of this property for sampling conducted in March 2012, January 2014 and August 2014. It was not resampled in November 2014 as access to sampling was not granted by the property owner. A routine O&M check in March 2016 showed that the SSD was operating under pressure and there was good airflow (personal communication NJDEP 2016).

Likewise, for Property 28, TCE vapors in indoor air measured at 8.6 $\mu g/m^3$ approached levels of health concern in the past. Even though this concentration is below the EPA's modeled concentrations of 21 $\mu g/m^3$ and 30 $\mu g/m^3$ where fetal cardiac malformations were observed in pregnant rats and kidney effects in rats, it is approaching these human equivalent concentrations that may be associated with developmental effects.

Although SSDs/ are present at properties 9, 10, 14, and 28, there is still a potential for inhalation exposures to TCE if these systems are not operating properly as TCE levels have been detected above the MRL. It is to be noted that elevated TCE results in January and April 2014 for Property 9 were when the system was not operating optimally. The SSD systems at properties 10 and 28 have undergone several engineering changes to resolve continued TCE detection in indoor air over multiple sampling rounds. For Property 10, the elevated levels observed in the sampling rounds to date are most likely associated with the system not operating efficiently. A routine O&M check in March 2016 showed that the SSDs at properties 9, 10 and 14 were operating under pressure and there was good airflow (personal communication NJDEP 2016). For Property 28, the SSD was not operational at the time of sampling in January 2014; changes were made to optimize the system. The November 2014 sampling results are likely the most representative of the fully functioning SSD.

It should be noted that as of March 2, 2009, due to an amendment modifying the New Jersey Spill Fund claim rules and regulations, the purchaser of a property on which a SSD system was installed and maintained at the expense of the Spill Fund is not eligible for compensation for ongoing maintenance and monitoring costs (NJDEP 2012). Two properties fall in this category. These properties were resampled in April 2016 to get updated results in sub-slab soil gas and indoor air (see Table 1). The owners of both these properties have been made well aware that NJDEP will not continuing the quarterly O&M on their systems and that they have been instructed to inspect the manometers at their properties on a regular basis to ensure that the systems continue to operate under a vacuum.

Additionally, the NJDOH cautions that properties with significantly elevated sub-slab soil gas levels of TCE are potentially at risk for indoor TCE air levels of health concern even if sub-slab depressurization systems have been installed as in the case of properties 10 and 28 where the sub-slab soil gas TCE levels were above NJDEP TCE soil-gas screening levels. Although SSDs are present at properties 9, 10, 14 and 28, there is still a potential for inhalation exposures to TCE if these systems are not operating properly as TCE levels have been detected above the MRL. All four of these properties have had documented engineering/maintenance issues with the SSD in the past. Given the narrow window of time for health effects on a developing fetus, NJDOH and ATSDR is concerned that future exposures may be a public health hazard for these properties: 9, 10, 14, 26, and 28. Property 26 had a TCE level detected above the chronic MRL in the last sampling round in November 2014 and this residence does not have a SSD (see Table 1). As noted earlier, potential indoor sources for TCE for this property cannot be ruled out.

Residents at all properties with SSD and/or radon systems are encouraged to remain vigilant (and this message has been communicated by NJDEP and USEPA as well) and monitor the system to ensure that they remain under pressure and are functioning in the manner in which they were designed.

Ambient measurements of TCE in January 2014 (9.2 $\mu g/m^3$) also approached levels of concern at one property. The source of TCE in ambient air has not been determined.

Child Health Considerations

ATSDR recognizes that infants and children can be more sensitive to environmental exposure than adults in communities faced with contamination of their water, soil, air, or food. Children are not small adults; a child's exposure can differ from an adult's in many ways. Developing fetuses, infants, and children have unique vulnerabilities. This sensitivity is a result of (1) children's higher probability of exposure to certain media because they crawl on the floor, put things in their mouths, play closer to the ground, and spend more time outdoors; (2) children's shorter height allows them to breathe dust, soil, and vapors close to the ground; and (3) children's generally smaller stature will result in higher doses of chemicals per body weight (i.e., a child drinks more liquid, eats more food, and breathes more air per unit of body weight than an adult). Also, young children have less ability to avoid hazards because they lack knowledge and depend on adults for decisions. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the site.

TCE exposures are a particular concern during the development of the fetus (Johnson 2003, EPA 2011). Exposures during the critical fetal heart developmental period in the first trimester are of special concern. The NJDOH and ATSDR evaluated the potential risk for children residing in the Mansfield Trail Dump site who were exposed to VOCs via the vapor intrusion pathway. Our toxicity discussion above addresses these exposure concerns.

Conclusions

The Mansfield Trail Dump site consists of waste disposal trenches in a wooded area and groundwater contamination extending into an adjacent residential neighborhood. There is a completed exposure pathway via inhalation of indoor air in the past, present, and future. Contaminants of concerns are PCE and TCE detected above comparison values established by the ATSDR. The exposed populations are the area residents. NJDOH evaluated past and current exposure to PCE and TCE from breathing indoor air at residences located adjacent to the Mansfield Trail Dump site where indoor air sampling data was available. The results sampling events between March 2012 and April 2014 show indoor air TCE levels elevated above comparison values at twelve properties (5, 6, 9, 10, 14, 16, 17, 22, 23, 26, 28, and 31). This evaluation included an assessment of exposure doses and estimated cancer risk from inhalation of contaminants present in indoor air. NJDOH reached the following conclusion:

NJDOH and ATSDR conclude that past exposures to TCE vapors in indoor air in two properties may have harmed people's health. Residents in two properties (9 and 28) may have been exposed to indoor air contaminated with trichloroethylene (TCE) at levels that could harm their health. Despite the presence of sub-slab depressurization systems (SSDs) in both of these, there were past TCE concentrations that would approach or exceed effect levels from toxicological studies and would be of health concern. The health effect of greatest concern is the potential for cardiac malformations in children whose mothers were exposed to elevated levels of TCE during the first trimester of their pregnancy. If TCE exposures occurred for extended time periods, additional health effects of concern might include impacts on the immune system and kidney of children and adults. Based on the highest detected concentration of TCE in indoor air in Property 9, the LECR was calculated to be 1×10^{-4} or one excess cancer case in a population of 10,000 over a lifetime of exposure. This is considered an increased cancer risk. For Property 28, the LECR was calculated to be 4×10^{-5} or four excess cancer cases in a population of 100,000 over a lifetime of exposure. This is considered a low increased risk of cancers. To put these risks in perspective, based on U.S. cancer rates, the lifetime risk of cancer in the general population is about 1 in 2.5, or about 4,000 out of every 10,000.

For properties without SSDs (5, 6, 16, 17, 26 and 31), although the TCE levels in indoor air were above the comparison values in the past, they are not expected to have resulted in adverse health effects when compared to the TCE chronic MRL. For properties with SSD and/or radon systems (10, 14, 22 and 23), although the indoor air TCE was detected above comparison values at properties 10, 14, 22 and 23, comparison to the chronic MRL indicates the highest concentrations measured would not likely result in adverse health effects.

NJDOH and ATSDR conclude that future exposures to TCE vapors in indoor air in five properties may harm people's health. Given the narrow window of time for health effects on a developing fetus, NJDOH and ATSDR is concerned that future exposures may be a public health hazard for these properties: 9, 10, 14, 26 and 28. Although SSDs are present at properties 9, 10, 14 and 28, there is still a potential for inhalation exposures to TCE if these systems are not operating properly as TCE levels have been detected above the MRL. Additionally, all four of these properties have had documented engineering/maintenance issues with the SSD in the past. Property 26 had an indoor TCE level detected above the chronic MRL in the last sampling round in November 2014 and this residence does not have a SSD. Residents at this property may be exposed to TCE and other contaminants through vapor intrusion although potential indoor sources for TCE for this property cannot be ruled out.

NJDOH and ATSDR conclude that current exposures to TCE vapors in indoor air in all properties is not likely to harm people's health. Currently, no harm is expected for residences based on available data. The indoor air TCE levels are slightly above the MRL for three properties (9, 10 and 26) and comparison to the chronic MRL indicates the highest concentrations measured would not likely result in adverse health effects. The TCE levels were below the MRL for the remaining properties. The highest TCE levels have been associated with either the system not working properly or optimally. Fluctuating levels noted in the past are likely due to operation and maintenance issues. Furthermore, routine operation and maintenance checks in March 2016 for properties 9 and 10 noted that the SSDs are were operating as designed.

NJDOH and ATSDR conclude that past, current, and future exposure to PCE in indoor air is not likely to harm people's health. Based on comparison to ATSDR health guideline values, there is not an increased risk of non-cancer health effects from inhaling PCE in indoor air. The estimated lifetime excess cancer risk of 3×10^{-6} represents about three possible excess cancer cases in a population of 1,000,000 over a lifetime of exposure and is considered a low increased cancer risk.

Recommendations

Based upon these conclusions, NJDOH and ATSDR recommend:

1. Continued monitoring for TCE in sub-slab soil gas and indoor air at properties that have been mitigated is strongly recommended to confirm that the mitigation systems continue to be effective in reducing exposures. Changes to the SSD at Property 9 and 28 resolved the presence of very high levels of TCE that were definitely of concern, but TCE is still

present to some extent (as with other properties) and could change/fluctuate. Resampling is recommended for property 26 for a better reassessment of indoor air quality.

2. Residents at all properties with SSD/radon mitigation systems are strongly encouraged to remain vigilant and monitor the system to ensure that they remain under pressure and are functioning in the manner in which they were designed. It is also recommended residents use and store commercial products according to labels and manufacturer instructions.

3. The NJDEP can provide guidance on proper operation and maintenance for the SSDs for residences that are not eligible for state funding due to changes in home ownership.

4. Residents contact their primary health care physician to discuss health concerns regarding exposure to site-related contaminants. Additionally, as the USEPA is actively addressing site contamination through remedial measures, residents are encouraged to follow their recommendations and allow them to take the measures necessary to reduce or prevent exposures.

5. Additional recommendations for USEPA include: (a) identify and address the source(s) of ambient air contamination, especially for TCE, (b) conduct winter and summer sampling rounds & sample if changes occur, such as structural/HVAC/landscaping modifications, and (c) continue efforts to characterize and address the contamination source and groundwater plume.

Public Health Action Plan

The purpose of a Public Health Action Plan is to ensure that this Public Health Assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of the ATSDR and the NJDOH to follow-up on this plan to ensure that it is implemented. The public health actions to be implemented by the ATSDR and NJDOH are as follows:

Public Health Actions Taken

1. The ATSDR and NJDOH reviewed information and relevant data to evaluate the potential health implications for VOCs in indoor air for affected residences near the Mansfield Trail Dump site.

2. A public health assessment for the site was completed and released in September 2013. The document evaluated the potential health implications for exposures to site-related contaminants in drinking water and indoor air. The NJDOH and ATSDR concluded that additional indoor air investigation into source areas and areas of potential concern for exposures was needed to more fully assess the extent of risk associated with the vapor intrusion pathway.

Public Health Actions Planned

1. Copies of this health consultation will be made available to concerned residents in the vicinity of the site in the township libraries and on the internet.

2. The NJDOH will attend the USEPA Community Advisory Group (CAG) meetings as needed and when requested.

3. The NJDOH and the ATSDR will continue to review data as it is made available. This includes new information related to investigations and remedial actions taken for areas of concern on-site as it is completed in the future.

Report Preparation

This Health Consultation for inhalation exposures related to the Mansfield Trail Dump site was prepared by the New Jersey Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

Author

Somia Aluwalia, Ph.D.
Environmental and Occupational Health Surveillance Program
New Jersey Department of Health

ATSDR Technical Project Officer

Eva McLanahan, Ph.D., REHS/RS
Commander, US Public Health Service
Technical Project Officer
Division of Community Health Investigations, ATSDR Headquarters, Atlanta, GA

ATSDR Regional Representatives

Leah T. Graziano, R.S.
Regional Director
Division of Community Health Investigations, Eastern Branch, Region 2

Elena Vaouli, M.P.H.
Commander, US Public Health Service
Associate Regional Representative
Division of Community Health Investigations, Eastern Branch, Region 2

Direct any questions concerning this document to:

Environmental and Occupational Health Surveillance Program
New Jersey Department of Health
Consumer, Environmental and Occupational Health Service
P.O. Box 369
Trenton, New Jersey 08625-0369

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1997a. Toxicological profile for tetrachloroethylene. Atlanta: US Department of Health and Human Services, Public Health Service. September. Available online at: http://www.atsdr.cdc.gov/toxprofiles/tp87.pdf

[ATSDR] Agency for Toxic Substances and Disease Registry. 1997b and 2013. Toxicological Profile for Trichloroethylene (TCE) and Addendum for Trichloroethylene (TCE). Supplement to the 1997 Toxicological Profile for Trichloroethylene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available online at:
http://www.atsdr.cdc.gov/toxprofiles/tp19.pdf
http://www.atsdr.cdc.gov/toxprofiles/tce_addendum.pdf

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public health assessment guidance manual (update). Atlanta, GA: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/HAC/PHAManual/index.html Last accessed 28 December 2009.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012. Air Comparison Values from ATSDR's Sequoia Database. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2013. Public Health Assessment for Mansfield Trail Dump Superfund Site, Sussex County, New Jersey. Prepared by the New Jersey Department of Health. September 4, 2013. Available at:
http://www.atsdr.cdc.gov/HAC/pha/MansfieldTrailDumpSite/MansfieldTrailDumpSitePHAFinal09042013_508.pdf

[IARC] International Agency for Research on Cancer. 1995. World Health Organization. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 63. Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals. 5. Summary of Data Reported and Evaluation.

Lockheed Martin. 2011. Mansfield Trail Dump Site – Trip Report. 10 November 2011

Lockheed Martin. 2012. Mansfield Trail Dump Site – Trip Report. 10 April 2012

[NJDEP] New Jersey Department of Environmental Protection. 2007. Letter to Bill Bauer, Business Administrator at Byram Township Board of Education from Edward Putnam, NJDEP concerning Soil Gas, Roof Stack and Indoor Air sampling at Byram Lakes Elementary School. Trenton, New Jersey. August 1, 2007.

[NJDEP] New Jersey Department of Environmental Protection. 2012. Available at URL:
http://www.nj.gov/dep/srp/finance/eca.htm

[NJDEP] New Jersey Department of Environmental Protection. 2013. Vapor Intrusion Guidance. Available at: http://www.state.nj.us/dep/srp/guidance/vaporintrusion/index.html

[NTP] National Toxicology Program. 2011. Report on Carcinogens, Twelfth Edition; U.S. DHHS, Public Health Service, NTP, June 10.

[USEPA] United States Environmental Protection Agency. 2010a. Integrated Assessment Report, Mansfield Trail Dump, Intersection of Ross Road and Brookwood Road, Byram Township, Sussex County, New Jersey. US Environmental Protection Agency, Region 2; December 2010.

[USEPA] United States Environmental Protection Agency. 2010b. Hazard Ranking System Documentation Record for Mansfield Trail Dump Site. Byram Township, New Jersey: US Environmental Protection Agency, Region 2; October 2010.

[USEPA] US Environmental Protection Agency. 2011. National Center for Environmental Assessment. Office of Research and Development. Exposure Factors Handbook. Washington, DC. September 2011. Available at: http://www.epa.gov/ncea/efh/pdfs/efh-complete.pdf

[USEPA] United States Environmental Protection Agency. 2012. IRIS toxicological review of tetrachloroethylene. Washington, DC: US Environmental Protection Agency, Office of Research and Development. February 2012. Available at URL: http://www.epa.gov/iris/subst/0106.htm

[USEPA] United States Environmental Protection Agency. 2012a. Risk-Based Concentration Tables for Human Health Risk Assessment: Regional Screening Level (RSL)_Residential Air Supporting Table. Available online at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

[USEPA] United States Environmental Protection Agency. 2012b. Tetrachloroethylene. Integrative Risk Information System (IRIS), US Environmental Protection Agency. February. Available at: http://www.epa.gov/iris/subst/0106.htm#refinhal.

[USEPA] United States Environmental Protection Agency. 2012c. Trichloroethylene. Integrative Risk Information System (IRIS), US Environmental Protection Agency. Available at: http://www.epa.gov/iris/subst/0199.htm#inhalrfc.

[USEPA] United States Environmental Protection Agency. 2012d. EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings. Available online at: http://www.epa.gov/oswer/vaporintrusion/index.html

[USEPA] US Environmental Protection Agency. 2013. ProUCL® Version 5.0.00 Fact Sheet. September 2013. Available at URL: http://www.epa.gov/osp/hstl/tsc/ProUCL_v5.0_fact.pdf

Appendix A

Common Indoor Air Chemical Sources

Chemical Name	Sources
1,1,1-Trichloroethane	Used as a degreaser, in solvents, and as an aerosol propellant
1,2,4-Trimethylbenzene	Used to make drugs and dyes, in gasoline and certain paints and cleaners.
1,3,5-Trimethylbenzene	Component in diesel exhaust.
2-Butanone	Found in paints, coatings, glues, cleaning agents, and cigarette smoke. It occurs naturally in some fruit and trees. Also known as Methyl Ethyl Ketone or MEK.
4-Ethyltoluene	Used as a solvent, found in kerosene and light vapor oil.
Acetone	Used as a common solvent.
Acetonitrile	Found in certain lithium batteries. Used to make plastics, synthetic rubber, and acrylic fibers. Used as a common solvent in laboratories.
Acrolein	Used in plastics, perfumes, aquatic herbicides. Also found in cigarette smoke and automobile exhaust.
Benzene	Found in cigarette smoke, gasoline, crude oil, and used as a solvent. May be an ingredient of household products such as glues, paints, furniture wax, and detergents.
Carbon Disulfide	Used in the manufacturing of rayon, in soil disinfectants, and in solvents.
Chlorobenzene	Used as a solvent for paints, pesticides.
Chloroethane	Used as a refrigerant, solvent. Also used in making cellulose, dyes, medicinal drugs.
Chloromethane	Byproduct of burning grasses, wood, cigarettes, charcoal, or plastic. Found in styrofoam insulation, aerosol propellants, and chlorinated swimming pools.
cis-1,2-Dichloroethene	Found in perfumes, dyes, lacquers, solvents, and products made from natural rubber
Dichlorodifluoromethane	Used as a refrigerant, aerosol propellant, and solvent. Also known as Freon 12.
Ethylbenzene	Used as a common solvent, and found in gasoline, inks, insecticides, and paints. Also found in cigarette smoke.

Common Indoor Air Chemical Sources, continued

Chemical Name	**Sources**
Heptane/Hexane	Found in petroleum products, is often mixed with other solvents, and is used as a filling for thermometers.
Isooctane	Found in petroleum, gasoline, solvents, and thinners. A component of the “odor” of gasoline.
Methyl t-Butyl Ether	Used as an additive in unleaded gasoline.
Pentane	Found in petroleum, gasoline.
Propene	A flammable propellant, produced from petroleum cracking.
Styrene	Found in synthetic rubbers, resins, insulators
tert-Butyl Alcohol	Found as flavors, in perfumes, in paint remover, as a gasoline booster, and in solvents.
Tetrachloroethene	Used in dry cleaning and as a degreaser. When clothes are brought home from the drycleaners, they often release small amounts of tetrachloroethylene into the air.
Toluene	Used as a common solvent, and found in gasoline, paints and lacquers. Also found in cigarette smoke.
Trichloroethene	Used as a degreasing agent. It is also a common ingredient in cleaning agents, paints, adhesives, varnishes, and inks.
Trichlorofluoromethane	Used as refrigerant, aerosol propellant, and solvent. Also known as Freon 11.
Xylenes	Used as a solvent, cleaning agent, and thinner for paints, and in fuels and gasoline.

Note: Gasoline components may be listed in the ingredients of household products as petroleum distillates or solvents.