Health Consultation

Analysis of Contaminants in Drinking Water and Indoor Air

PIKE AND MULBERRY STREETS PCE PLUME

MARTINSVILLE, MORGAN COUNTY, INDIANA

EPA FACILITY ID: INN000508678

APRIL 16, 2020

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

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

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Prepared by the
U.S. Department of Health and Human Services
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Abbreviations

ADAF	age-dependent adjustment factors
ATSDR	Agency for Toxic Substances and Disease Registry
CREG	cancer risk evaluation guide
CSF	cancer slope factor
CTE	central tendency exposure
EJSCREEN	Environmental Justice Screen
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
Fe	iron
HBCV	health-based comparison value
HEC	human equivalent concentration
HED_{99}	99^{th} percentile human equivalent dose
IDEM	Indiana Department of Environmental Management
ISDH	Indiana State Department of Health
IUR	inhalation unit risk
LOAEL	lowest observed adverse effect level
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
Mn	manganese
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
MCL	maximum contaminant limit
MRL	minimal risk level
MPWD	Martinsville Public Works Department
MCHD	Morgan County Health Department
ND	nondetect
NPL	National Priorities List
PBPK	physiologically based pharmacokinetics
PCE	tetrachloroethylene
ppm	parts per million
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RMEG	reference dose media evaluation guide
SDWR	Secondary Drinking Water Regulation
TCE	trichloroethylene
VOC	volatile organic compound

1. EXECUTIVE SUMMARY

Introduction

The Agency for Toxic Substances and Disease Registry's (ATSDR's) purpose is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent people from coming into contact with harmful toxic substances.

The Pike and Mulberry Streets PCE Plume site is in Martinsville, Indiana. The town overlays a 60-acre groundwater plume, approximately 20 feet below the surface, contaminated with chlorinated solvents, primarily tetrachloroethylene (PCE) and trichloroethylene (TCE). There are several possible sources of contamination, including Masterwear, a commercial and institutional dry cleaning and laundry operation that operated from 1986-1991 at 28 North Main Street. The Indiana Department of Environmental Management (IDEM) conducted a removal action at the Masterwear facility and several nearby properties between 2004-08. The U.S. Environmental Protection Agency (EPA) placed the site on the Superfund National Priorities List (NPL) in May 2013. The groundwater plume has contaminated Martinsville's municipal drinking water wellfield, requiring installation of an activated carbon filtration system [EPA 2017a, IDEM 2010]. Residents are also potentially exposed to solvents by breathing vapors that evaporate into their homes and workplaces from contaminated sources underground beneath these buildings through a process called soil vapor intrusion. EPA began indoor air sampling in January 2016 to determine whether vapor intrusion is occurring. Based on these initial results, ATSDR sent EPA a letter health consultation recommending expanded indoor air testing to determine whether solvent exposures could be harming people's health [ATSDR 2016a].

The purpose of this public health consultation is to evaluate the public health significance of exposures to contaminants in drinking water and indoor air in homes and commercial buildings in this community. ATSDR used drinking water data collected by the Martinsville Public Works Department (MPWD) and air data (including sub-slab gas and indoor air) collected by EPA in January, July and September 2016, and January 2017 to make this determination. EPA approved a time-critical removal action in April 2018 based on air data that exceeded EPA action levels at two properties [EPA 2018b].

Conclusions

Following its review of drinking water and indoor air data, ATSDR reached three health-based conclusions.

Conclusion 1

For people on the public drinking water supply, ATSDR concludes that people's health is not likely to be harmed by contaminants from the Pike and Mulberry Streets PCE Plume.

Basis for Conclusion 1

- MPWD discovered in 2002 that one of its wells was contaminated due to migration of the PCE plume to the northwest from the Masterwear site to the municipal drinking water wellfield.
- Residents are not exposed to PCE and TCE through their municipal drinking water since these chemicals are effectively removed by the treatment system that was installed in early 2005. Additionally, MPWD reports that their finished drinking water meets EPA standards for

disinfectants and disinfection by-products, inorganic contaminants, and lead and copper.

- MPWD is maintaining and monitoring the treatment system to ensure that it continues to remove organic solvents and residents are not exposed to these contaminants in their drinking water. If the treatment system were to fail or be discontinued, residents could potentially be exposed to PCE and TCE at levels that would require further evaluation to determine whether they could harm people's health.
- Manganese (Mn) in drinking water exceeds EPA's non-enforceable Secondary Drinking Water Regulation (SDWR) level. SDWRs are limits for non-health threatening or "nuisance" water contaminants. Elevated Mn levels may give drinking water a black or brown discoloration, cause staining of fixtures, and cause a bitter metallic taste that some customers may find objectionable. Mn is unrelated to the PCE plume and is not removed by the carbon filtration system.

Conclusion 2

For people on private residential wells, ATSDR cannot determine whether people's health could be harmed by drinking the water currently or in the past. ATSDR does not have adequate information to evaluate the PCE contamination in private residential wells.

Basis for Conclusion 2

- There are a small number of private water wells in Martinsville that may be affected by the PCE plume. ATSDR does not have a verified inventory of all private residential wells currently in use or used in the past for residential purposes.
- Limited volatile organic compound (VOC) testing of private water wells by IDEM and EPA indicate that TCE and PCE were detected and that PCE was above health screening levels in some samples. It is unknown whether any of these wells are currently being used for residential purposes. If residents are using well water for drinking, they could potentially be exposed to PCE and TCE above levels that would require further evaluation to determine whether they could harm people's health. All properties in the PCE plume area have access to treated municipal water.

Conclusion 3

For some homes and businesses, ATSDR concludes that people's health may be harmed by breathing TCE and PCE that has evaporated into their indoor air from the Pike and Mulberry Streets PCE Plume. In addition, some homes and businesses that overlie the contaminant plume have not been sampled at all and other properties require more sampling to ensure that harmful exposures can be identified and stopped, if they are occurring.

Basis for Conclusion 3

- Indoor air may be contaminated through a process called soil vapor intrusion – the movement of gaseous contaminants from contaminated groundwater and subsurface soil into buildings above the plume. EPA tested indoor air concentrations of PCE, TCE, and other gases in January, July, and September 2016, and January 2017 at a total of 33 residential and 19 commercial properties above and near the PCE plume. In addition to indoor air, EPA also sampled "sub-slab" soil vapor beneath buildings (or portions of buildings) with a concrete slab; where a slab was not present, EPA sampled air in the crawlspace or dirt floor basement area. ATSDR identified 23 residences and 11 commercial properties with indoor concentrations of PCE and/or TCE higher than health screening levels and evaluated them more extensively.

- Further evaluation indicates there are several homes and commercial properties with TCE in indoor air at a level that could potentially harm health. For the properties that exceeded the PCE screening level, ATSDR reviewed PCE research and concluded that health effects are not expected to occur at the measured concentrations.
- At two properties, EPA confirmed a link between indoor air contaminants and an underground source and is acting to mitigate the exposures [EPA 2018b]. In other cases, the contribution of sub-surface gas to indoor air, if any, could not be determined due to the possible presence of indoor sources. EPA and ATSDR have spoken to these homeowners, informing them of potential health risks and advising them to remove any solvents from their homes.
- EPA made indoor air testing available to many property owners with homes and businesses above or adjacent to the PCE plume. Some property owners denied entry, thus there are people living and working in these buildings where the exposures to the occupants cannot be evaluated. Several of the untested homes were a part of IDEM's 2004-08 removal action, indicating a history of vapor intrusion.

Recommendations

Following its review of available information, ATSDR recommends that:

1) EPA install vapor mitigation systems in homes and businesses where vapor intrusion could harm people's health, in order to reduce levels of PCE and TCE in indoor air. EPA establish plans for operation and maintenance of the systems and monitoring to ensure continued performance until the source is remediated and indoor air concentrations are below levels of concern.
2) EPA again offer air sampling to untested homes and businesses that are above or near the groundwater plume, where the potential exists for people to be exposed to PCE and TCE. Per EPA and ATSDR guidance, concurrent samples of indoor air, ambient air, and subsurface air (sub-slab or crawlspace) should be collected.
3) EPA conduct wintertime testing at properties that were previously only sampled in the summer. EPA retest buildings where findings were inconclusive due to high detection limits or other reasons.
4) EPA develop a long-term monitoring plan to check for vapor intrusion in properties that have high levels of solvents in soil vapor and future potential for vapors to migrate indoors. The plan should account for the plume's possible movement and changing shape over time. EPA consider installing preemptive mitigation systems in buildings with high risk of vapor intrusion in the future. EPA prioritize air sampling and mitigation at properties where TCE risks may be elevated, due to potential health effects even at relatively low concentrations and short duration of exposure, i.e. developmental health effects associated with a 3-week TCE exposure.
5) In the case of residences where health risks were identified but VOCs were not definitively linked to underground contamination, EPA offer follow-up testing after the homeowner has removed all solvents to determine whether indoor exposures have been eliminated. Note that some of these properties were described by EPA as having "possible" current and "potential" for future vapor intrusion.
6) MPWD continue routine testing and ensure that actions are taken if solvent levels in treated

drinking water begin to increase. MPWD continue to share testing results in its routine customer water quality reports so the public is aware of the situation and the measures that MPWD is taking to protect their health.

7) EPA work with IDEM, Indiana State Department of Health (ISDH), and Morgan County Health Department (MCHD) to determine whether any of the private residential water wells in Martinsville potentially impacted by the PCE plume are currently being used. For affected wells, residents should be advised of the potential health impacts and told to only drink treated municipal water. City water is available within the affected areas of Martinsville and residents should request service if they are not already receiving it.

Next Steps

To achieve the above recommendations, the following actions will be implemented:

1) ATSDR will assist EPA in communicating the potential health risks to property owners who previously denied access for indoor air testing or for those who may not have been contacted in the past. ATSDR will assist EPA with interpreting results and deciding on next steps once further testing is conducted.
2) ATSDR will work with EPA, IDEM, ISDH, and MCHD to determine whether private residential water wells are still in use that could be impacted by the PCE plume. ATSDR and MCHD will send a letter to these well owners advising them to stop using their well water for any household purposes.

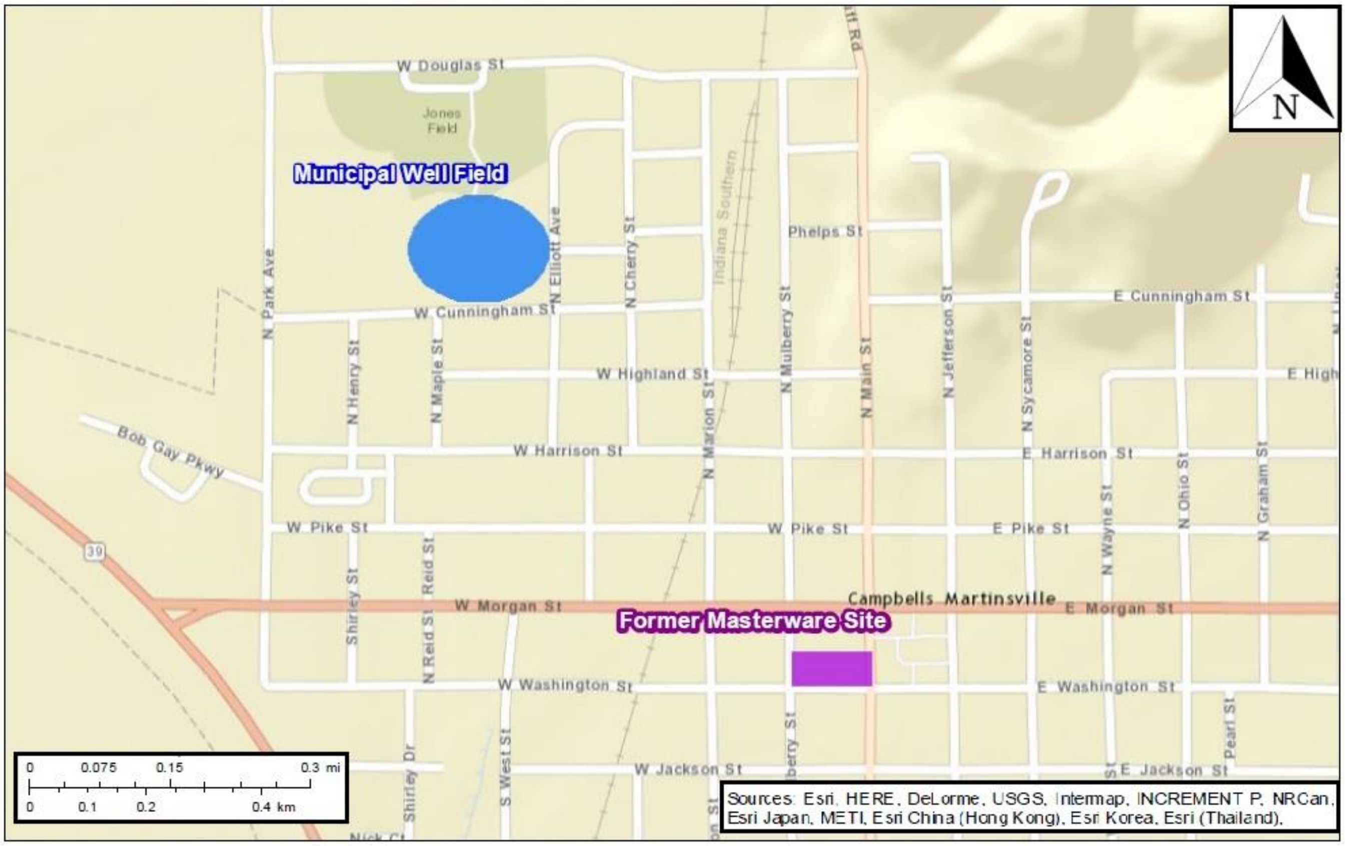
2. BACKGROUND AND STATEMENT OF ISSUES

The Pike and Mulberry Streets PCE Plume site is in Martinsville, Indiana. The town overlays a 60-acre groundwater plume contaminated with chlorinated solvents, primarily PCE and TCE. There are several possible sources of contamination, including Masterwear, a commercial and institutional dry cleaning and laundry operation that operated from 1986-1991 at 28 North Main Street. The EPA placed the site on the Superfund NPL in May 2013 [EPA 2017a]. The groundwater plume has contaminated Martinsville's municipal drinking water wellfield, requiring installation of an activated carbon filtration system. Residents are also potentially exposed to solvents by breathing vapors that evaporate into the indoor air in their homes and workplaces through a process called soil vapor intrusion.

ATSDR obtained water testing data dating back to 2004 from MPWD during a site visit on January 28, 2016. At this time EPA was conducting the first of three rounds of indoor air and sub-slab gas sampling at commercial and residential properties along the path of groundwater contamination. EPA has conducted extensive testing of groundwater and exterior soil gas to characterize the PCE plume that emanates from the Masterwear site and other local drycleaners. The map on Figure 1 provides an overview of the study area.

Martinsville is in central Indiana, about 30 miles southwest of Indianapolis. It is the county seat of Morgan County. Martinsville was once known for its many artesian mineral water health spas (sanitariums), the last of which closed in 1968 [Martinsville 2017]. There are several possible sources of PCE contamination in Martinsville, including Masterwear, a commercial and institutional dry cleaning and laundry operation that operated from 1986-1991 at 28 North Main Street.

Figure 1. Map of Martinsville Including Former Masterwear Site and Municipal Well Field.



Between 2004 and 2008, IDEM and EPA oversaw a removal action led by an insurance company representing a Potentially Responsible Party. The removal action was conducted to address contaminated soil at the Masterwear facility. EPA performed indoor air sampling in 2003 and 2004 at 35 commercial properties in the immediate vicinity of the site. IDEM set action levels after consultation with ATSDR. The action level for sub-chronic exposures was 110 micrograms per cubic meter ($\mu g/m^3$) for PCE and 2.7 $\mu g/m^3$ for TCE. Nine properties were found to have indoor concentrations that exceeded these levels, with a maximum of 2,780 $\mu g/m^3$ PCE at one site and 172 $\mu g/m^3$ TCE at another property. These buildings are all located over the area of highest PCE soil gas concentrations, as characterized by EPA in later years and discussed in detail in Section 4.

During this removal action, IDEM installed 17 air sparging wells and 15 soil vapor extraction wells in the immediate vicinity of Masterwear. Indoor air treatment was accomplished by venting indoor air or sub-slab vapors to the outside of buildings. The treatment system was initially operated from January 2005 to November 2006. IDEM conducted follow-up indoor air VOC testing over a period of several months and found that VOCs rebounded back up to their action levels. The treatment system was restarted in August 2007 and operated through the winter. IDEM conducted follow-up indoor air sampling and confirmed that indoor action levels were met. Indoor air treatment systems were turned off in March 2008 and the final indoor air sampling event was in August 2008. EPA and IDEM determined that site closure goals were achieved for soil, on-site groundwater, and indoor air. Planned restoration activities included removing remedial equipment, plugging system piping, and abandoning remedial and monitoring wells. [EPA 2008]

After the removal action, IDEM conducted additional testing showing that there was a residual groundwater plume and, consequently, that MPWD would need to continue treating drinking water indefinitely. IDEM referred the site to EPA, which placed the Pike and Mulberry Streets PCE Plume site on the Superfund NPL in May 2013. Since then EPA has been collecting soil gas and groundwater VOC data to characterize the PCE and TCE plume. EPA conducted indoor air and sub-slab sampling at 8 residential properties within the PCE plume in January 2016. Upon reviewing the results, ATSDR wrote a letter consultation [ATSDR 2016a] to EPA dated March 8, 2016 stating: "Based on the findings from our joint site visit to Martinsville on January 25-28, 2016, there is potential for solvent vapor intrusion in residences in Martinsville. Additional air sampling is needed to determine whether the indoor air concentrations pose a health hazard to local residents." ATSDR noted that, of the properties tested, the two buildings furthest away from the Masterwear site had the highest PCE concentrations in indoor air. ATSDR recommended expanding the study area to follow the direction of the PCE plume that is migrating to the northwest of the Masterwear site. EPA conducted a second round of indoor air testing in July and September 2016 and third round in January 2017. During this time EPA was also conducting extensive soil gas sampling to characterize the lateral extent of soil gas contamination. Data collected in January, July, and September 2016, and January 2017 were considered in this report.

Martinsville is a city of 11,828 residents [Census 2012]. EPA's Environmental Justice Screen (EJSCREEN) tool estimates a population of 3,065 in the area that overlies the groundwater plume. The complete EJSCREEN report for the community is provided in Appendix A. Residents in the study area are 98% White, 1% Black, and 1% Asian. The Martinsville community has a relatively low socio-economic status: the area is in the 81st Percentile for "Low Income Population" and 80th Percentile for "Population with Less Than High School Education" relative to the rest of the US population. [EPA 2016]

3. EXPOSURE PATHWAY EVALUATION

To determine whether people are 1) now exposed to contaminants or 2) were exposed in the past, ATSDR examines the path between a contaminant and a person or group of people who could be exposed. Completed exposure pathways have five required elements. ATSDR evaluates a pathway to determine whether all five factors are present. Each of these five factors or elements must be present for a person to be exposed to a contaminant:

1. A contamination source,
2. Transport through an environmental medium,
3. An exposure point,
4. A route to human exposure, and
5. People who may be exposed.

For the Pike and Mulberry Streets PCE Plume site, ATSDR considers exposures to contaminants in drinking water and indoor air to be completed pathways. Exposure to contaminants in soil, surface water, and outdoor air are not completed pathways.

People living in the Pike and Mulberry Streets PCE Plume site receive drinking water from MPWD. The groundwater drawn by the MPWD is affected by PCE and TCE from the contaminant source. This topic is discussed in detail in Section 4.1. There are a small number of private residential wells that may also be impacted by the PCE plume. This issue is discussed in Section 4.2. People were exposed to low levels of PCE and TCE, i.e. less than ATSDR health-based comparison values (HBCVs), through the drinking water before MPWD installed its filtration system. Some residents may still be exposed through their private wells. There are three potential routes of exposure currently and in the past:

- *Ingestion*: Residents may have consumed water contaminated with PCE and TCE or eaten food prepared using the water;
- *Inhalation*: Residents may have breathed in PCE and TCE while showering, bathing, or other household uses such as dishwashing and laundering; and
- *Dermal contact*: Residents may have absorbed PCE and TCE though their skin during showering, bathing, or other use.

Current exposure to PCE and TCE from contaminated municipal wells has been eliminated or reduced. However, the drinking water pathway is a potential future completed exposure pathway if the municipal water filtration system fails or is not maintained. Ingestion exposure was evaluated to provide an understanding of the importance of continued treatment. Inhalation and dermal exposures, while not included in this assessment, could contribute additionally to exposures in the event of discontinued treatment. If the water treatment system fails in the future, then inhalation and dermal exposure routes should be evaluated.

Indoor air may be contaminated through a process called vapor intrusion. Vapor intrusion is the migration of VOCs, from the subsurface-contaminated groundwater and soil through the pore spaces of soil, into buildings above the plume. The concentrations of contaminants entering the indoor air from 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. [ATSDR 2016b]

ATSDR does not consider it likely that surface water near Martinsville could be contaminated with chlorinated solvents. Spring Lake is located on the southwest edge of Martinsville, about ½-kilometer from the edge of the EPA predicted PCE groundwater plume. White River is 1-kilometer northwest of the plume. These water bodies could potentially be contaminated with solvents in the future if the plume continues to migrate. ATSDR could review surface water testing data if it were to become available.

Outdoor air may be contaminated with solvents that evaporate from underground, however the concentrations are very low when these gases mix into the ambient air. During each indoor air sampling event, EPA concurrently sampled outdoor air both upwind and downwind of the testing area. Results showed that PCE and TCE in outdoor air were typically below detection limits. Occasional results above detection were below ATSDR's health screening levels.

EPA has characterized groundwater, soil, and soil gas contamination throughout the study site. However, residents are not expected to come into contact with solvents in these media. Contaminated soil and soil gases are several feet below the ground surface where people are not likely to be exposed. Homes have access to municipal drinking water and do not have a need for private well water that could potentially be impacted by chlorinated solvent in groundwater. There are a small number of private wells near the center of Martinsville. Residents have been advised not to use the water and the wells have been abandoned.

4. ENVIRONMENTAL DATA AND HEALTH RISK SCREENING

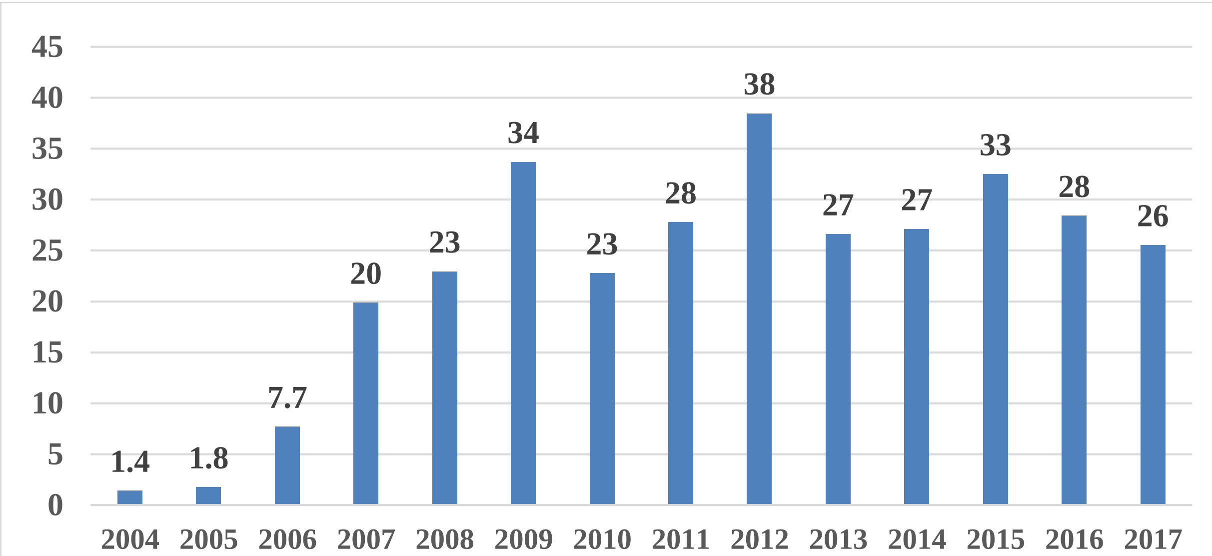
4.1 Municipal Drinking Water

MPWD provides drinking water to about 15,000 people. The utility draws groundwater from three wells located on the northwest edge of the city, about ½-mile down-gradient from the Masterwear site. The wells are numbered 3, 4, and 5. MPWD discovered in 2002 that Well #3 is contaminated with PCE and temporarily took this water source out of use. Currently the water from Well #3 is treated and then blended with water from the other two wells. MPWD performs quarterly VOC testing on water from all three wells and on the blended, finished water. MPWD made their testing data, dating back to 2004, available to ATDSR and EPA during a site visit to the water treatment facility on January 28, 2016. MPWD has since provided ATSDR with additional data through June 2017.

MPWD's water testing results show that PCE levels in untreated water from Well #3 increased during 2004-12 and appear to have leveled off (see Figure 2). The highest annual average was 38 micrograms per liter (µg/L) in 2012 and highest individual PCE sample was 51 µg/L on April 8, 2009. Long-term PCE concentrations in untreated water exceed ATSDR's cancer risk evaluation guide (CREG) of 12 µg/L; the highest annual average was 38 µg/L in 2012. CREGs are media-specific comparison values that are used to identify concentrations of cancer-causing chemicals that are unlikely to result in an increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's cancer slope factor (CSF) or inhalation unit risk (IUR), a target risk level of one additional cancer per million exposed individuals (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents a possible risk of one excess cancer case in a population of one million. EPA reports all CSFs in the Integrated Risk Information System (IRIS), available at http://www.epa.gov/iris/, providing detailed information about their derivation and basis. ATSDR's health evaluation approach is described in Appendix B. A full discussion of cancer risk from drinking PCE is presented in Section 5.2 and Appendix C. Martinsville residents have not been exposed to PCE in drinking water above ATSDR health screening values because the carbon filtration system was in operation since 2005 and PCE levels rose above the CREG after 2006. Before the treatment system was installed, residents appear to have been exposed to PCE at a concentration below ATSDR's health-based screening: the 2004 average was 1.4 µg/L, as compared to the CREG of 12 µg/L.

TCE concentrations in untreated water from Well #3 peaked with an annual average of 0.45 µg/L in 2007. This concentration is on a par with the CREG of 0.43 µg/L. The average TCE concentration for the 2-week period of February 7-20, 2007, was 3.6 µg/L, which slightly exceeds ATSDR's chronic and intermediate environmental media evaluation guide (EMEG) of 3.5 µg/L. EMEGs represent concentrations of chemicals in water, soil, and air to which humans might be exposed during a specified period of time (acute, intermediate, or chronic) without experiencing adverse health effects. ATSDR uses information about the substance toxicity (minimal risk levels, MRLs) and default exposure assumptions to derive EMEGs. EMEGs are screening values only—they are not indicators of adverse public health effects. Chemicals found at concentrations above EMEGs will not necessarily cause adverse health effects but will require further evaluation. MRLs are generally based on the most sensitive chemical-induced endpoint considered relevant to humans. The specific approach used to derive MRLs for individual chemicals are detailed in ATSDR's Toxicological Profile for each substance available at http://www.atsdr.cdc.gov/toxprofiles/index.asp. TCE non-cancer health effects are discussed in detail in Section 5.1, cancer risks in Section 5.2, and a full discussion of risks associated with untreated water from Well #3 is in Appendix C.

Figure 2. Annual Average Tetrachloroethylene (PCE) in Untreated Water from Well #3, micrograms per liter[1]



1. Martinsville water is treated with an activated carbon system that removes PCE from untreated groundwater. Residents are not exposed to these compounds in their municipal drinking water.

The most recent water results that MPWD provided were collected on June 19, 2017. The sample from Well #3 contained 26.5 µg/L PCE; TCE and other VOCs were below detection limits. Water from Wells #4 and 5 and the finished water were below detection for all VOCs.

Residents of Martinsville are not exposed to VOCs in the finished drinking water because it goes through a carbon treatment system. The above information is discussed to underscore the importance of maintaining the current treatment system. Post-treatment water samples provided by MPWD consistently show concentrations below the state and federal Maximum Contaminant Level which is 5 µg/L for both PCE and TCE. According to MPWD's 2016 Annual Drinking Water Quality Report, the treated water for this system (Public Water Supply #5255009) meets EPA standards for disinfectants and disinfection by-products, inorganic contaminants, and lead and copper.

On May 18, 2019, MPWD posted the 2018 Annual Drinking Water Quality Report. This latest report informs residents that Well #3 is known to be contaminated with PCE and that water from all three wells is filtered through a carbon treatment system. MPWD indicates that post-treatment water is tested and that all results are below the Maximum Contaminant Limit (MCL), "..ensuring that your drinking water is safe for human consumption." MPWD also posted "A Citizen's Guide to Activated Carbon Treatment", providing residents with details about how their treatment system works [Martinsville, 2019].

Since publishing the public comment version of this document in March 2019, ATSDR learned that MPWD tests treated drinking water for Mn and iron (Fe) every day. The 2018 annual average for Mn was 0.2 milligrams per liter (mg/L) and Fe was 0.05 mg/L [EPA 2018d]. ATSDR screened the Mn average against EPA's lifetime health advisory of 0.3 mg/L, concluding that Mn does not exceed this level. We do not have HBCVs for Fe.

EPA has set non-enforceable SDWRs for non-health threatening or "nuisance" water contaminants. SDWRs are set to protect against cosmetic effects (such as tooth or skin discoloration), aesthetic effects (such as taste, odor, or color), or technical effects (such as damage to water equipment) of drinking water. The SDWRs for Mn and Fe are 0.05 and 0.3 mg/L, respectively. The nuisance effects of Mn are a black to brown color to the water, black staining of fixtures, and a bitter metallic taste. Fe is known to have a rusty color, cause reddish or orange staining, and have a metallic taste [EPA 2017d, 2018a]. Mn in Martinsville's drinking water is four times higher than the SDWR and Fe is below its respective SDWR. However, the metallic content may increase after water leaves the treatment plant, because corrosive elements can leach Fe from water lines and fixtures as the water is transported to residential taps.

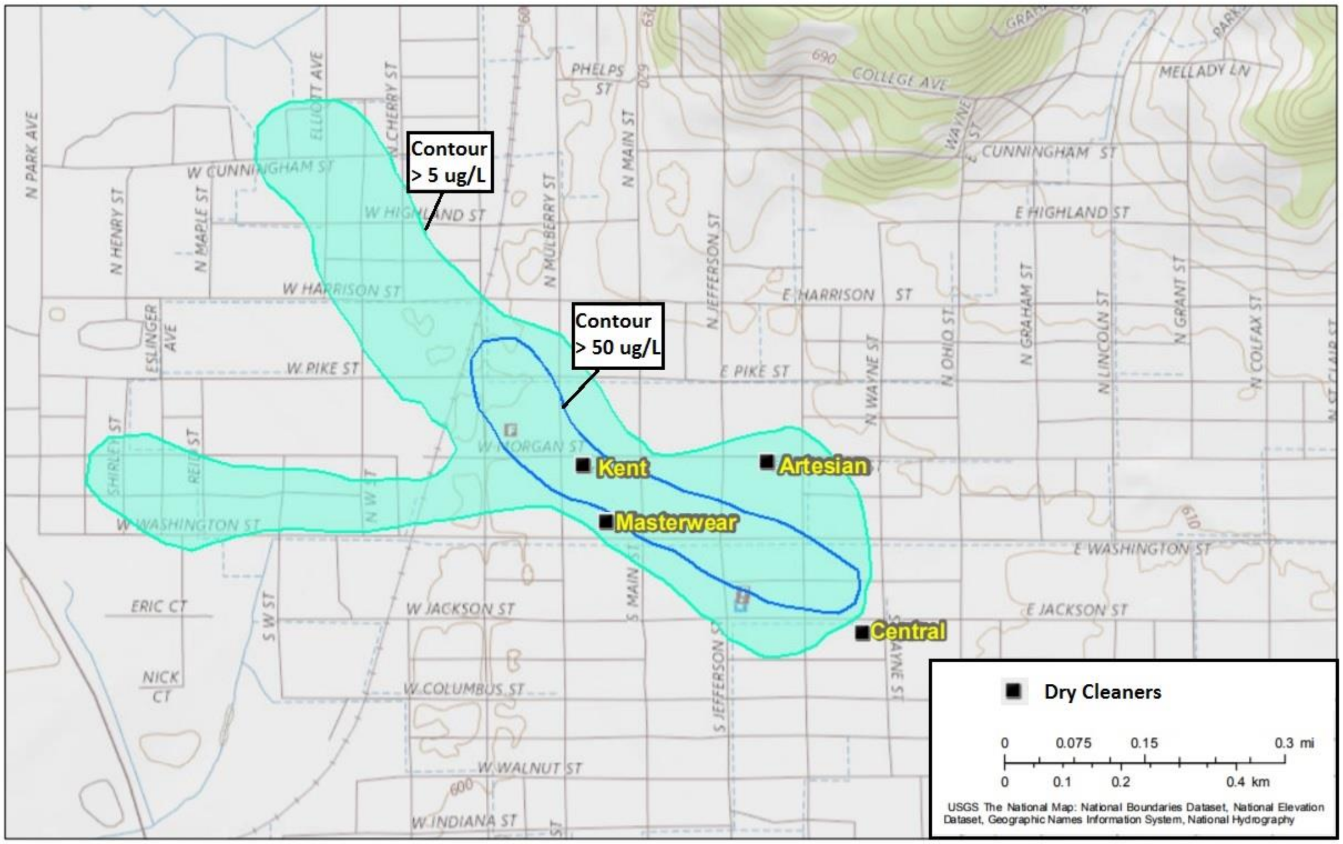
In response to one resident's request during an indoor air sampling event, EPA collected a single sample of kitchen tap water on January 28th, 2016, for VOC analysis. The results are discussed in Section 6.

4.2 Private Well Water

According to records provided by the ISDH, there are 115 water wells in the Martinsville area. Most of these addresses do not fall within the boundary of the PCE groundwater plume, as characterized by EPA in their draft remedial investigation (RI) (see Figure 3.) The historic locations of PCE-using dry cleaning facilities are also shown. The plume on Figure 3 shows the outline of the area where PCE concentrations exceed 5 µg/L, EPA's regulatory standard or the EPA MCL [EPA 2017c].

ATSDR has shared the plume map with ISDH, IDEM, and MCHD who attempted to clarify the status of several wells that could potentially be impacted by the groundwater plume. It is important to confirm the location of the wells, determine whether they are still functional and, if so, investigate whether they have an industrial or residential use. This investigation is still underway, however IDEM records have confirmed that a private well on Washington Street was tested in 2003 with a result of 87 µg/L PCE [IDEM 2005]. This concentration exceeds ATSDR HBCVs for noncancer (the reference dose media evaluation guide (RMEG) for chronic exposure in children is 42 µg/L) and cancer health effects (the CREG is 12 µg/L). A discussion of potential noncancer and cancer health effects associated with drinking this level of PCE in well water is presented in Sections 5.1 and 5.2.

Figure 3. Approximate Outline of Tetrachloroethylene Groundwater Plume and Dry Cleaner Locations[1], micrograms per liter (µg/L)



1. Data source: Environmental Protection Agency (EPA). Draft Remedial Investigation Report – Revision 1. Pike and Mulberry Streets PCE Plume Site. June 2017.

EPA sampled three private wells near the municipal wellfield in 2015. TCE was detected in two samples (0.1 and 0.4 µg/L) below HBCVs. PCE was detected in all three well samples with 18 µg/L as the highest concentration [EPA 2017c]. This level is higher than the CREG, but lower than the 2003 sample reported by IDEM. ISDH conducted a visual inspection of the property on Washington Street in 2017 and reported that it does not appear to be inhabited and the well has been abandoned. MCHD attempted to contact several other well owners in 2019 to determine their status. ATSDR and MCHD will send a letter to these well owners to recommend using only municipal water in their homes.

4.3 Indoor Air

Since the Pike and Mulberry Streets PCE Plume Site was listed as a Superfund site in 2013, EPA conducted three rounds of sampling for indoor air and soil vapor (testing beneath the concrete slab, called "sub-slab") at residential and commercial properties in Martinsville. The purpose of this testing was to determine whether people may be exposed to vapors emanating from the underground PCE plume. EPA tested 8 residential properties in January 2016, 21 homes in July and September 2016, and 24 in January 2017. There were 33 individual residences tested: 9 were tested one time, typically during one of the winter sampling events, and the rest were tested twice or three times, including a summer and winter event. There were 6 commercial properties tested in July and September 2016; these buildings were resampled along with 13 others (total of 19) in January 2017 [EPA 2017c].

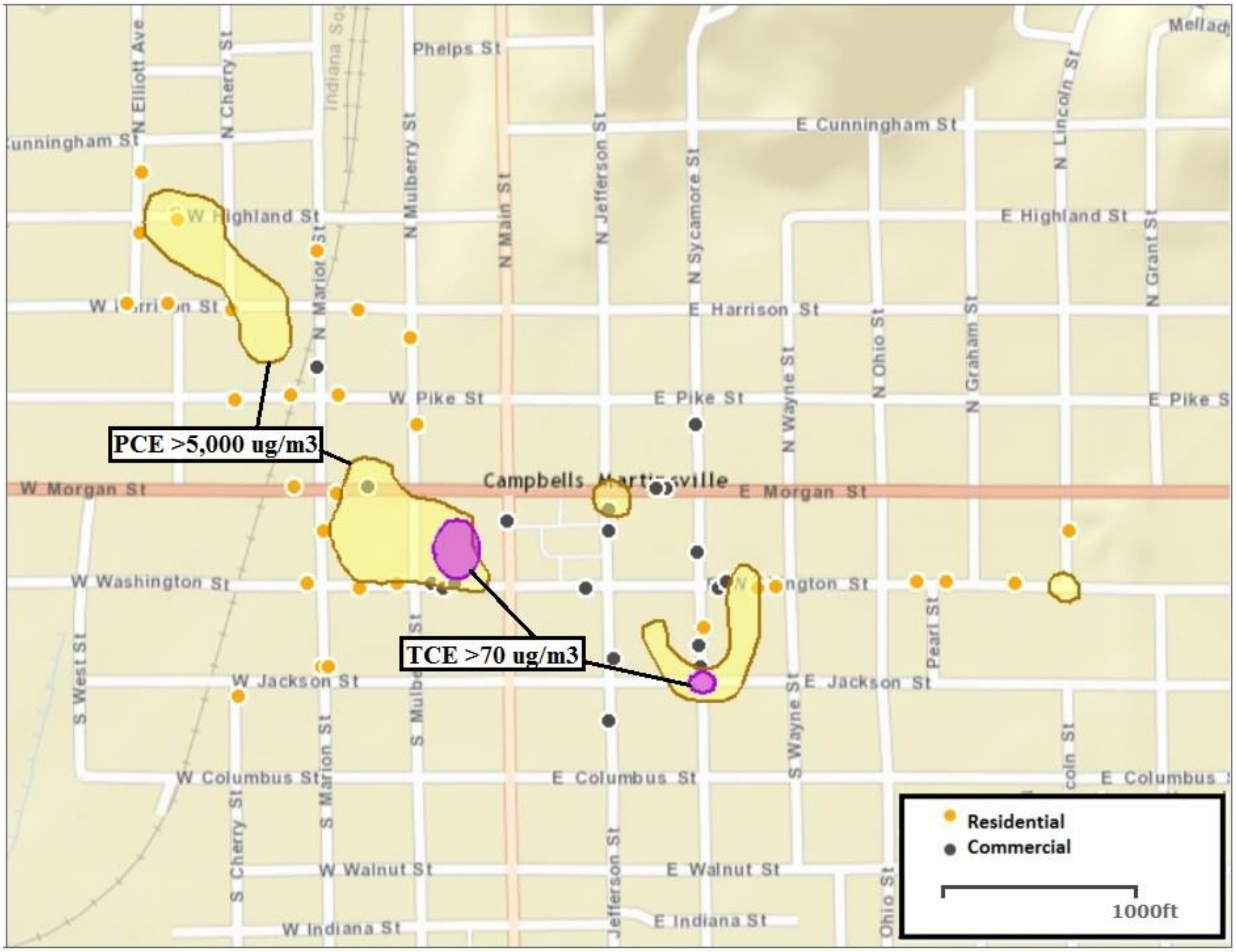
ATSDR recommends that homes should be tested more than once to characterize seasonal differences and to identify any potential health hazards based on the additional sampling data. In the Midwest, wintertime testing represents a worst-case scenario because people tend to have their windows closed and harmful gases are not diluted by outdoor air. If a home was sampled only once in summer, then retesting in the winter is advisable.

ATSDR evaluated the sampling results, for the immediate vicinity of the former Masterwear site and toward the northwest, along the direction of groundwater flow, where EPA has confirmed PCE contamination in groundwater and soil vapor. Air samples were also collected near other historic dry cleaners where EPA has found contaminated groundwater. Figure 4 shows the approximate location of all tested residential and commercial properties, including those where VOCs were below laboratory detection limits. Figure 4 also displays the outline of zones where PCE and TCE exceeds EPA's action levels in soil vapor, as depicted in EPA's draft RI [EPA 2017c].

Soil gas VOC concentrations in Martinsville tend to be greater at a depth of 5 to 15 feet as compared with surface (1-3 foot) concentrations. This profile is consistent with solvents evaporating from contaminated groundwater as opposed to VOCs emanating from contaminated soils near the ground surface. The exception is the immediate vicinity of Masterwear, where the surface soils were grossly contaminated and soil gases contain VOCs in both the surface and sub-surface layers. Although the soil was remediated in the 2004-08 Removal Action, surface soils still have higher VOCs near the Masterwear site than elsewhere in Martinsville. Soil gas concentrations do not always follow the outline of the groundwater plume. In fact, the EPA data provides evidence for another dispersion mechanism being the potential spread of VOCs through storm sewers.

ATSDR evaluated indoor air data from residences and commercial properties as a measure of current levels of inhalation exposure. However, the sub-slab data is informative for two important reasons. First, a high solvent concentration in the sub-slab can indicate future potential risks even in a home that has solvents measured in indoor air below HBCVs. Over time the concrete foundation may crack, or other conditions may change in the structure that would allow vapors to evaporate into the home. Conversely, solvent levels in indoor air may be higher than those measured in sub-slab air, indicating that they do not originate from the underground PCE plume. In this scenario, there is likely an indoor source of potentially unhealthy levels of chemicals in indoor air. When indoor air solvents are above HBCVs, it is important to determine whether they are caused by the PCE plume, and thus may be addressed by the EPA cleanup process, or alternatively whether there is a different indoor source that the property owner will need to eliminate. If the indoor contamination may be attributed to an underground source, then soil vapor intrusion is confirmed.

Figure 4. Buildings Tested for Vapor Intrusion and Areas of Exterior Soil Gas Contamination with Tetrachloroethylene (PCE) and Trichloroethylene (TCE) [1], micrograms per cubic meter (μg/m^3)



1. Data source: Environmental Protection Agency (EPA). Draft Remedial Investigation Report – Revision 1. Pike and Mulberry Streets PCE Plume Site. June 2017.

ATSDR compared the highest indoor air, crawlspace air, and sub-slab gas PCE and TCE concentrations by address for all sampling events with their respective HBCVs to determine which properties needed further evaluation.

Of the 33 residential properties tested, 7 had maximum PCE and TCE concentrations below HBCVs which required no further evaluation. The 26 homes with indoor air, crawlspace air, and sub-slab soil gas concentrations above HBCVs are shown in Table 1.

In the case of buildings without a concrete slab, sub-slab soil gas cannot be collected. Soil gas concentrations previously collected by EPA at properties adjacent to such buildings (not on-site) is shown in brackets. Complete indoor air and sub-slab results are in Appendix D.

Table 1. Residential Properties: Tetrachloroethylene (PCE)[1] and Trichloroethylene (TCE)[2] in Indoor Air, Crawlspace Air, and Sub-slab Soil Gas, micrograms per cubic meter (μg/m³)

Site Code	PCE in Indoor Air[3]	PCE in Crawlspace Air[3]	PCE in Sub-slab Gas[4]	TCE in Indoor Air[3]	TCE in Crawlspace Air[3]	TCE in Sub-slab Gas[4]	Vapor Intrusion[7]
RP-005	**3.9**	3.7	**[685-4,604][5]**	**0.28**	**5.7**	[ND][6]	n/a
RP-021	**164**		**7,000**	**<0.27**		**33**	yes
RP-022	**14**		**16,408**	**1.4**		2.4	yes
RP-027	**4.8**		**[314-1,254]**	**<1.2**		[ND]	yes
RP-028	0.52	1.4	**[314-773]**	**3.4**	**<0.27**	[ND]	No
RP-038	2.8		**3,900**	**<0.27**		**<54**	n/a
RP-045	< 0.88		**177**	**< 0.70**		< 0.75	n/a
RP-047	1.0		**3,500**	**3.7**		**< 110**	No
RP-083	0.85	0.97	**210**	**0.29**	**0.24**	<5.4	n/a
RP-095		**4.0**	**2,700**		**<0.27**	**<54**	n/a
RP-121	3.2	2.7	**740**	**<0.27**	0.18	<5.4	n/a
RP-131	0.20		4.3	**0.40**		<5.4	n/a
RP-133	**239**	**18**	**700**	**<0.27**	**<0.27**	4.3	potential
RP-135	< 0.34	0.45	4.9	**0.35**	**<0.27**	<5.4	n/a
RP-156	**5.5**		5.4	**<0.97**		<1.1	No
RP-157	**4.4**		**4,200**	**<0.27**		**160**	yes
RP-160	2.9	**6.6**	**7,300**	**0.57**	**0.81**	**<54**	n/a
RP-189	0.71	**6.2**	**[139-518]**	**1.2**	**<0.27**	[ND]	n/a
RP-193	**5.8**	**18**	**270**	**<0.27**	**<0.27**	<5.4	No
RP-200	0.73	**10**	**[23,870]**	**<0.27**	**< 2.7**	[ND]	n/a
RP-201	**29**	3.6	**6,500**	**<2.7**	**<0.27**	**<110**	yes
RP-210	0.23	0.86	**[297-1,844]**	**<0.27**	**0.32**	[ND]	n/a
RP-223	1.7	1.8	**910**	**<0.27**	**0.26**	**<54**	n/a
RP-224	1.4		**1,700**	0.12		**<54**	n/a
RP-229	**6.2**	**6.9**	**[692-2,238]**	**16**	**<0.27**	[ND-5.4]	potential
RP-232	2.4	**4.0**	**[8,693]**	0.15	0.17	[ND]	n/a

1. For PCE, the ATSDR cancer risk evaluation guide (CREG) is 3.8 μg/m³. When adjusted for sub-slab and soil gas by dividing by 0.03, the CREG is 127 μg/m³. [ATSDR 2016b]
2. For TCE, the CREG is 0.22 μg/m³; the adjusted subsurface CREG is 7.3 μg/m³.
3. Indoor and crawlspace air concentrations above CREG bolded.
4. Sub-slab gas above adjusted CREG bolded.
5. Property does not have a concrete slab; range of soil gas from adjacent properties shown in brackets.
6. Nondetect (ND): concentration below laboratory detection limit
7. A complete vapor intrusion pathway may be confirmed (“yes”), suspected (“potential”), unlikely (“no”), or not assessed by ATSDR (n/a). A complete pathway does not prove elevated health risk.

A detailed map of EPA’s soil gas measurements is shown in Appendix E. The highest soil gas VOC concentrations are near the Masterwear site and extending several city blocks northwest toward the municipal drinking water wellfield. There is another area of high VOCs to the southeast of Masterwear, around Jefferson Street and Sycamore Street, near Central Dry Cleaners. There are additional zones of VOC soil gas contamination east of the Masterwear site. These areas may be due to other contamination sources and/or VOC migration from Masterwear along "preferential pathways" such as sewer lines or other underground channels that allow VOCs to spread laterally.

There were 26 homes that exceeded the CREG for PCE, TCE, or both pollutants in indoor air, crawlspace air, and/or sub-slab gas. The non-cancer health effects associated with these exposures are evaluated in detail in Section 5.1. Cancer risk estimates are discussed in Section 5.2.

The ratio of a pollutant concentration in the sub-slab or soil vapor to the indoor air is indicative of whether vapor intrusion is occurring. EPA research shows that when vapor intrusion is occurring, then indoor gas concentrations are up to about 0.03 times the level in the sub-slab or soil vapor [EPA 2015]. The inverse of this "attenuation factor", i.e. 33, may be used as evidence of vapor intrusion. This ratio should be considered together with subsurface-adjusted health screening levels: in this investigation, ATSDR divided HBCVs by 0.03 to derive health-protective subsurface screening levels.

The home on Table 1 with the highest PCE in indoor air (RP-133) may potentially have a vapor intrusion pathway causing solvents to evaporate from the PCE plume into indoor air. The concentration on the ground floor was higher than what was reported in the partial basement and crawlspace, which is not typical for a classic vapor intrusion scenario. The ratio of sub-slab to indoor air concentration is 2.9, substantially lower than the 33-ratio indicative of vapor intrusion. However, it is possible that PCE is migrating into the home along a plumbing conduit connected to the building's sewer line [Pennell]. More investigation is needed to assess this property. In contrast, the data show clear evidence of vapor intrusion at RP-021, where two rounds of sampling showed extremely high PCE levels in the sub-slab and a sub-slab-to-indoor ratio of 43. EPA contractors noted that there are cracks in the basement floor and a sump is present, so the vapors have multiple routes to enter the building.

Evidence for soil vapor intrusion is mixed for the home with the highest indoor TCE (RP-229). The property has a partial basement and crawlspace; it is located several blocks east of the Masterwear site. The maximum TCE level was in the basement, higher than the adjacent crawlspace, and household chemicals were observed in the basement. RP-229 is adjacent to a building that overlays EPA's estimated location of a small PCE soil vapor plume, thus vapor intrusion may be occurring now and could in the future. RP-047 had TCE above the HBCVs and degreasing chemicals are known to be used indoors. RP-047 is located over the soil vapor and groundwater plume, indicating that vapor intrusion may occur in the future. Indoor PCE was below the HBCV at RP-047, however sub-slab PCE levels were more than 10 times the adjusted CREG at this property; sub-slab TCE may also be quite high, given the detection limit in one sampling round was 110 $\mu g/m^3$. RP-028 is a small building with a crawlspace throughout. In three rounds of sampling it had one high measurement of TCE; the chemical was a nondetect in the crawlspace, however, suggesting that vapor intrusion is not likely occurring. The home is near the edge of the PCE groundwater plume and may experience vapor intrusion in the future; soil gas at an adjacent property exceeded the adjusted CREG for TCE.

The 5 homes described above (RP-021, RP-028, RP-047, RP-133, and RP-229) had indoor VOC concentrations above EPA's action levels. EPA confirmed a direct connection (i.e. completed exposure pathway) between vapors from the plume and indoor concentrations at RP-021 and is acting to mitigate exposures [EPA 2018b]. EPA and ATSDR followed up with the other property owners to advise them that they should increase ventilation in their homes and remove household or industrial chemicals from their living spaces. ATSDR conducted further evaluation of exposures and their likelihood to result in health effects at all sites above HBCVs, presented in Sections 5.1 and 5.2. In its draft site remedial investigation, EPA characterizes properties RP-133 and RP-229 are described as "possibly currently" having a complete vapor intrusion pathway and having "potential for this in the future". RP-047 is noted as "unlikely currently" having vapor intrusion "but has potential for this in the future", whereas RP-028 "unlikely currently" has vapor intrusion and "unlikely has potential for this in the future." [EPA 2017c]

Of the 7 homes below HBCVs, 2 were tested only once in July or September 2016; these properties should be resampled in the winter to clarify whether a health hazard exists. Low confidence is generally attributed to decisions based on one sampling event, unless there is clear evidence that this will result in a health protective decision. Indoor air monitoring that reflects seasonal variations for the site should provide a better basis for an exposure estimate. All properties below HBCVs should be evaluated to determine whether high levels of chlorinated solvents are found in the sub-slab that could pose an indoor air risk in the future. The 26 properties that exceeded HBCVs were sampled in the winter and it may be assumed that the reported concentrations are at the high end of potential exposures. However, these structures may also change over time and more solvents may enter the indoor environment, so they too should be tested again in future years if there is sub-slab contamination.

ATSDR evaluated indoor air at 19 commercial properties in Martinsville. The results of the screening showed that 4 properties had PCE and TCE concentrations below HBCVs in indoor air and sub-slab gas; these buildings are not listed on Table 2. There are 15 properties that exceeded the CREG for PCE, TCE, or both solvents. Non-cancer health effects associated with TCE are evaluated in Section 5.1. Cancer risk estimates are discussed in Section 5.2. Complete indoor air and sub-slab results are in Appendix D. A detailed map of EPA's soil gas measurements is shown in Appendix E.

The commercial property with the highest TCE and PCE concentrations, CP-099, is located within the former Masterwear building; vapor intrusion has been confirmed, as sub-slab and soil vapor concentrations are extremely high. This is the one commercial property with indoor air above EPA's action levels and a completed exposure pathway, prompting EPA to initiate a time-critical removal action [EPA 2018b]. Other properties with PCE above the CREG should be retested again in future years, to determine whether structural degradation may cause more vapors to enter the indoor air.

Of the 10 properties that exceeded the CREG for PCE, 3 of them also exceeded the CREG for TCE: CP-073, CP-074, and CP-099. One other property (CP-146) exceeded the CREG for TCE and not PCE. CP-146 is difficult to evaluate, because there is no sub-slab sample and the nearby soil vapor (collected between 1-15 feet) is below the detection limit for TCE. However, the building is over the PCE groundwater plume and in between contaminated soil plumes and should be monitored in the future. The indoor air result at CP-110 was below the detection limit, which itself is higher than the CREG. The highest sub-slab samples at this property are also below their respective detection limits. Resampling and analysis with appropriately low detection limits would be needed to properly evaluate this location.

Table 2. Commercial Properties: Tetrachloroethylene (PCE)[1] and Trichloroethylene (TCE)[2] in Indoor Air, Crawlspace Air, and Sub-slab Soil Gas, micrograms per cubic meter (μg/m³)

Site Code	PCE in Indoor Air[3]	PCE in Crawlspace Air[3]	PCE in Sub-slab Gas[4]	TCE in Indoor Air[3]	TCE in Crawlspace Air[3]	TCE in Sub-slab Gas[4]	Vapor Intrusion[7]
CP-023	**12**	**6.8**	**2,100**	< 0.27	< 0.27	< 54	yes
CP-046	**57**		**20,000**	< 0.27		< 1,100	yes
CP-073	0.46		120	**0.94**		**14**	yes
CP-074	0.28		**270**	0.16		**690**	n/a
CP-099	**141**		**410,000**	**14**		**2,000**	yes
CP-110	**89**		**39,000**	**0.40**		**24**	yes
CP-112	1.8	3.6	[2,095-3,608][5]	**0.71**	0.11	[ND][6]	n/a
CP-119	**10**	**6.2**	**4,000**	< 0.27	0.19	< 54	yes
CP-140	2.9		**26,000**	< 0.27		**120**	n/a
CP-146	**6.7**	**4.8**	[311-1,266]	**2.0**	**2.4**	[ND]	n/a
CP-150	**18**	**63**	**16,000**	< 2.7	< 2.7	< 1,100	yes
CP-153	0.19		**160**	< 0.27		< 5.4	yes
CP-155	**14**	**21**	**250**	< 0.27	< 1.3	< 5.4	no
CP-168	**58**		**35,000**	< 0.27		**190**	yes
CP-169	**36**		**3,600**	< 0.27		< 54	yes

1. For PCE, the ATSDR cancer risk evaluation guide (CREG) is 3.8 μg/m³. When adjusted for sub-slab and soil gas by dividing by 0.03, the CREG is 127 μg/m³.
2. For TCE, the CREG is 0.22 μg/m³; subsurface CREG is 7.3 μg/m³.
3. Indoor and crawlspace air concentrations above CREG bolded.
4. Sub-slab gas above CREG bolded.
5. Property does not have a concrete slab; range of soil gas from adjacent properties shown in brackets.
6. Nondetect (ND): concentration below laboratory detection limit
7. A complete vapor intrusion pathway may be confirmed ("yes"), suspected ("potential"), unlikely ("no"), or not assessed by ATSDR (n/a). A complete pathway does not prove elevated health risk.

Of the 9 commercial properties that were a part of IDEM's 2004-08 removal action, not all allowed access during EPA's recent air testing efforts. There were some previously cleaned-up properties that EPA re-evaluated between January 2016 and January 2017 (CP-46, CP-98, CP-99, and RP-95). However, there are multiple other buildings that have not been tested for about 15 years and they are within the zone most impacted by the PCE groundwater plume and PCE/TCE contaminated soils.

5. ENVIRONMENTAL HEALTH EVALUATION

5.1 Non-cancer Health Effects

As detailed in Section 4.1, ATSDR determined that TCE in untreated municipal drinking water may pose a non-cancer health risk. However, no one is currently drinking this untreated water as the municipal water in Martinsville goes through an activated carbon filtration system that removes VOCs. Residential drinking water does not contain detectable levels of TCE. The health risks associated with drinking untreated water from the contaminated well, in a hypothetical scenario where the treatment system goes offline, are discussed in Appendix C. Screening for non-cancer health risks from chlorination byproducts and PCE did not reveal potential health concerns. Long-term PCE data were provided by the MPWD.

As noted in Section 4.2, there was one private residential well that exceeded noncancer HBCVs for PCE. ATSDR followed the methods detailed in Appendix B to calculate an age-specific exposure dose based on drinking well water with a PCE concentration of 87 µg/L. The reasonable maximum exposure (RME) is 12 µg/kg/day for babies from birth to one year of age. ATSDR's oral MRL is derived from the inhalation MRL. The inhalation MRL for PCE is based on an occupational epidemiology study which found that dry-cleaning workers acquired decrements in color vision with a lowest observed adverse effect level (LOAEL) of 1.7 parts per million (ppm). This inhalation exposure is equivalent to an oral dose of 2,300 µg/mg/day [ATSDR 2014a]. The calculated RME of 12 µg/kg/day is two orders of magnitude lower than the LOAEL. **ATSDR does not expect that non-cancer health effects from PCE exposure would occur at these measured concentrations.**

A review of indoor air and sub-slab gas data in Section 4.3 revealed that there are 23 residences and 11 commercial properties that exceeded HBCVs for PCE and/or TCE. To evaluate the potential for people in these structures to experience negative health effects, ATSDR directly compared the indoor VOC concentrations with the air levels that are associated with adverse effects in human and animal studies.

ATSDR evaluated PCE based on the above-referenced occupational epidemiology study, which found a LOAEL of 1.7 ppm (11,544 µg/m^3) [ATSDR 2014a]. The highest indoor air PCE concentrations (239 µg/m^3 at RP-133 and 164 µg/m^3 at RP-021) are two orders of magnitude lower than the LOAEL. ATSDR does not expect that non-cancer health effects from PCE exposure would occur at these concentrations.

ATSDR also evaluated inhalation exposures to TCE in residences and commercial properties. ATSDR screens TCE using EPA's reference dose (RfD) of 0.0005 milligrams per kilogram per day (mg/kg/day) as the chronic oral MRL. The RfD was derived from the most sensitive observed adverse effects, as documented in three separate oral studies: 1) increased rates of heart defects in newborn rats whose mothers were exposed to TCE in drinking water during gestation; 2) adult female mice showed immune system effects (decreased thymus weight) after exposure to TCE in drinking water; and 3) mice exposed to TCE in drinking water during gestation and following birth showed problems with immune system development. EPA applied Physiologically Based Pharmacokinetics (PBPK) models of TCE metabolism in rats and humans to the heart defect study results to obtain a 99th percentile human equivalent dose (HED_{99}) of 0.0051 mg/kg/day. At this exposure level, there is an expected 1% response rate of fetal heart defects in humans. [ATSDR 2014b]

Indoor air TCE concentrations in buildings tested in Martinsville ranged from 0.06 to 16 µg/m^3. The human equivalent concentration (HEC) to the rat LOAEL in the fetal heart study noted above was 21 µg/m^3. While the highest measured TCE concentrations in indoor air were not as high as the HEC, the home with 16 µg/m^3 (RP-229) approaches the level that could result in harmful effects to the fetus from maternal exposure. Specifically, pregnant women who breathe TCE in indoor air are at increased risk of having their fetus develop with a heart defect. This health effect could occur during the 3-week period early in the first trimester when the fetal heart forms and begins to function.

5.2 Cancer Risk Assessment

As explained in Section 4.1, solvents in untreated municipal drinking water and indoor air were above their respective cancer risk screening levels and warranted a more detailed evaluation. PCE exposure has been linked in human studies to a higher risk of developing bladder cancer, multiple myeloma, or non-Hodgkin's lymphoma. Research on animals shows strong evidence that PCE causes cancers of the liver, kidney, and blood system. TCE is believed to cause kidney, liver, and esophageal cancers and non-Hodgkin's lymphoma in people. The risk of developing these cancers is increased with early life exposures. Additional evidence from occupational studies points to possible relationships between TCE exposure and increased risk of Hodgkin's disease, cervical cancer, multiple myeloma, bladder cancer, female breast cancer, and prostate cancer. However, many of these studies have strong limitations including unknown exposure level, small sample size, and inability to separate effects of TCE from other solvents present in the workplace.

To estimate cancer risks associated with water and air exposures, ATSDR derived cancer risk estimates for ingestion of drinking water using the chemical-specific oral CSF for PCE and TCE, which is multiplied by the age-specific exposure dose and duration of exposure. For indoor air exposures, concentrations measured in air are multiplied by the IUR for PCE and TCE to calculate cancer risk. The PCE IUR is 2.6E-07 $(ug/m^3)^{-1}$and the Oral CSF is 2.1E-03 mg/kg/day. For TCE, cancer risk is based on three separate target tissue sites – kidney, lymphoid tissue, and liver. The CSFs for the three individual cancer types are summed, resulting in a total CSF of 4.6E-02 mg/kg/day. The corresponding IUR is 4.1E-06. [EPA 2011] For TCE, the appropriate age-dependent adjustment factors (ADAFs) are also incorporated to address early-life kidney cancer susceptibility as TCE has been designated as a mutagen. This approach is described in more detail in Appendix B.

For drinking water and indoor air exposures, ATSDR considered residential exposures to occur for 33 years, the 95^{th} percentile residential occupancy default. Specifically, cancer risk was summed from birth to age 21 plus 12 addition years during adulthood for a total of 33 years. To consider exposures to both PCE and TCE, the individual cancer risks were added.

For cancer risk related to drinking water, ATSDR considered a hypothetical situation where the municipal treatment system failed to remove PCE from Well #3. This scenario is detailed in Appendix C. ATSDR calculated cancer risk from drinking untreated municipal water contaminated with the highest annual average PCE and TCE concentration. The resulting total cancer risk is 2 excess cases per million, **which ATSDR considers to be low**. Martinsville residents are not exposed to PCE and TCE in municipal water – ATSDR calculated this hypothetical risk to illustrate the potential risk if the treatment system failed.

ATSDR calculated the estimated cancer risk associated with drinking private well water from one residential property where historical PCE results were above screening levels. Following the procedures noted above for the municipal water system, drinking water from the private well was estimated to pose a cancer risk of 4 excess cases per million. **ATSDR considers this to be a low risk**.

ATSDR evaluated cancer risk from breathing PCE and TCE in the 26 residential properties where one or both chemicals exceeded the CREG. The highest indoor air concentration at each home was multiplied by the IUR for PCE and three organ-specific IURs with early-life adjustments for TCE to calculate the predicted number of excess cancer cases per million people over a lifetime of exposure. ATSDR substituted half of the detection limit for samples where one of the compounds was below detection. Results are summarized on Table 3.

Table 3. Residential Property Indoor Air Concentrations and Cancer Risk Estimates for Tetrachloroethylene (PCE) and Trichloroethylene (TCE)

Site Code	PCE Concentration, micrograms per cubic meter	TCE Concentration, micrograms per cubic meter	PCE Cancer Risk per Million People	TCE Cancer Risk per Million People	Total Cancer Risk per Million People
RP-005	3.9	5.7	0.4	13	13
RP-021	164	0.14	18	0.3	18
RP-022	14	1.4	2	3	5
RP-027	4.8	0.60	0.5	1	2
RP-028	1.4	3.4	0.2	8	8
RP-038	2.8	0.14	0.3	0.3	1
RP-045	0.44	0.35	0.05	0.8	1
RP-047	1.0	3.7	0.1	9	9
RP-083	0.97	0.29	0.1	0.7	1
RP-095	4.0	0.14	0.4	0.3	1
RP-121	3.2	0.18	0.4	0.4	1
RP-131	0.15	0.40	0.02	0.9	1
RP-133	239	0.14	26	0.3	27
RP-135	0.45	0.35	0.05	0.8	1
RP-156	5.5	0.48	0.6	1	2
RP-157	4.4	0.14	0.5	0.3	1
RP-160	6.6	0.81	0.7	2	3
RP-189	6.2	1.2	0.7	3	4
RP-193	18	0.14	2	0.3	2
RP-200	10	1.4	1	3	4
RP-201	29	1.4	3	3	7
RP-210	0.86	0.32	0.1	0.7	1
RP-223	1.8	0.26	0.2	0.6	1
RP-224	1.4	0.12	0.2	0.3	0.4
RP-229	6.9	16	0.8	37	38
RP-232	4.0	0.17	0.4	0.4	1

The highest residential property cancer risk from PCE is 26 excess cases per million people at RP-133 and the highest TCE risk is 37 per million at RP-229. The sum of PCE and TCE cancer risk at these two properties is 27 and 38 per million, respectively. ATSDR does not consider this an elevated cancer risk.

ATSDR also estimated cancer risk from breathing PCE and TCE in the 15 commercial properties where one or both chemicals exceeded the CREG. For cancer risk assessment, ATSDR's exposure estimates reflect the fact that workers and customers do not spend all their time (24 hours per day) at the workplace as they might at a residential location. ATSDR conservatively assumed that people had a 10-hour workday and were onsite six days a week. ATSDR also assumed a person works 25 years of their lifetime (25/78). These factors are multiplied together (10/24 x 6/7 x 25/78) to produce an adjustment factor of 0.12.

The indoor air and crawlspace concentrations shown on Table 4 are the result of the measured concentrations being multiplied by the adjustment factor in keeping with a commercial exposure scenario.

Table 4. Commercial Properties: Adjusted Indoor Air Concentrations and Cancer Risk Estimates for Tetrachloroethylene (PCE) and Trichloroethylene (TCE)[1]

Site Code	PCE Concentration, micrograms per cubic meter	TCE Concentration, micrograms per cubic meter	PCE Cancer Risk per Million	TCE Cancer Risk per Million	Total Cancer Risk per Million
CP-023	1.4	0.016	0.4	0.07	0.4
CP-046	6.8	0.016	2	0.07	2
CP-073	0.05	0.11	0.01	0.5	0.5
CP-074	0.033	0.019	0.01	0.1	0.1
CP-099	17	1.7	4	7	11
CP-110	11	0.048	3	0.2	3
CP-112	0.43	0.085	0.1	0.3	0.5
CP-119	1.2	0.023	0.3	0.1	0.4
CP-140	0.34	0.016	0.1	0.07	0.2
CP-146	0.80	0.29	0.2	1	1
CP-150	7.6	0.16	2	0.7	3
CP-153	0.022	0.016	0.01	0.07	0.07
CP-155	2.5	0.078	1	0.3	1
CP-168	6.9	0.016	2	0.07	2
CP-169	4.3	0.016	1	0.07	1

1. Air concentrations from Table 2 were adjusted by a factor of 0.12 to reflect workplace exposure conditions, as explained above.

The highest indoor air concentration at each property was multiplied by EPA's chemical-specific IUR for PCE and TCE to calculate the excess cancer cases per million people occurring over 25 years averaged over a lifetime of exposure. ATSDR substituted half of the respective detection limit for samples where either of the compounds was below detection. The highest cancer risk was at CP-099: 4 excess cases per million people for PCE, 7 per million from TCE, and a total cancer risk of 11 excess cases per million. **ATSDR does not consider this to be an elevated cancer risk**.

6. COMMUNITY CONCERNS

EPA conducted community interviews in 2015 to assess people's familiarity with the PCE plume and to solicit their questions and concerns about the site and how it may affect them. All the interviewed people knew about the groundwater contamination.

Concern 1: Residents' primary concern was the quality of their drinking water and health impacts. During ATSDR and EPA's January 2016 site visit for indoor air sampling, some residents had concerns about the safety of their drinking water and one stated that many community members are drinking bottled water for this reason. One resident is providing bottled water to the family dog to avoid any possible exposures.

> *Response 1: Information that MPWD provided to ATSDR demonstrates that the carbon filtration system is effectively removing PCE from well water. MPWD is routinely testing untreated and treated water to ensure that the system is working. ATSDR has concluded that people's health is not expected to be affected by contaminants in their drinking water.*
>
> *In response to a resident's request, EPA collected a single sample of kitchen tap water on January 28th, 2016. The results were below detection limits for PCE, TCE, and all other regulated VOCs. Four nonregulated VOCs – common disinfection byproducts – were found at low concentrations. Bromoform (0.69 µg/L) and chloroform (0.60 µg/L) were below ATSDR's HBCVs. Bromodichloromethane (1.4 µg/L) and dibromochloromethane (1.7 µg/L) exceeded their CREG levels (0.39 and 0.29, respectively). Bromodichloromethane and dibromochloromethane are commonly found in chlorinated drinking water, typically between 1-10 µg/L. Chlorine is added to drinking water to kill disease-causing bacteria, but it can react with naturally occurring materials, such as decaying leaves, to produce chlorinated chemicals. ATSDR calculated cancer risk estimates using the CSF of 6.2E-02 (mg/kg/day)-1 for bromodichloromethane and 8.4E-02 (mg/kg/day)-1 for dibromochloromethane [ATSDR 2017b]. The total lifetime cancer risk from these compounds in drinking water is 4.3E-06, which ATSDR does not consider to be an elevated cancer risk.*

Concern 2: In the 2015 EPA interviews, a few people asked about the safety of residents who use private wells to water their lawns and gardens.

> *Response 2: Martinsville residents should not drink untreated well water as it may contain harmful levels of dry-cleaning chemicals. However, using this water for landscaping purposes is not expected to harm people's health. The solvents that may be present in well water evaporate quickly and will disperse into the ambient air – residents' exposure through skin contact and inhalation will be minimal. Residents should not use well water for a prolonged period in an enclosed space, such as a greenhouse. If well water is used in an enclosed structure, then contaminants may evaporate into the air and not be diluted by mixing with outdoor air. Residents' exposure to air contaminants would increase the more time they spend in the enclosure and the greater amount of water is used. These exposures may be lessened by ventilating the structure to remove VOCs and introduce fresh air. Vegetables watered with solvent-containing well water do not accumulate*

these chemicals and are safe to eat. ISDH and ATSDR have not confirmed that there are any private residential wells potentially impacted by the PCE plume that are still in use.

Concern 3: Residents asked whether there is an immediate threat to their health and what specific symptoms they should be on the lookout for.

Response 3: There is an ongoing risk of health effects from breathing chemicals that evaporate from the groundwater plume into indoor air in homes and workplaces. Some property owners have allowed EPA to conduct indoor and underground vapor testing. There are many other buildings on or near the PCE plume that have not been sampled and where health risks cannot be evaluated by ATSDR. However, contaminants in groundwater are not expected to affect people's health by way of drinking exposures, because Martinsville's municipal drinking water is treated to remove solvents.

The most substantial health concern to people in Martinsville is that, if pregnant women breathe TCE at elevated concentrations in indoor air, their fetus could develop a heart defect. The risk to the fetal heart is greatest early in the first trimester, at a time when the women may not even be aware of the pregnancy. For this reason, testing the air in homes with a potential for vapor intrusion is critical.

7. CONCLUSIONS

Following its review of drinking water and indoor air quality data, ATSDR reached three health-based conclusions.

Conclusion 1

For people on the public drinking water supply, ATSDR concludes that people's health is not likely to be harmed by contaminants from the Pike and Mulberry Streets PCE Plume.

Basis for Conclusion 1

- MPWD discovered in 2002 that one of its wells was contaminated due to migration of the PCE plume to the northwest from the Masterwear site to the municipal drinking water wellfield.
- Residents are not exposed to PCE and TCE through their municipal drinking water since these chemicals are effectively removed by the treatment system that was installed in early 2005. Additionally, MPWD reports that their finished drinking water meets EPA standards for disinfectants and disinfection by-products, inorganic contaminants, and lead and copper.
- MPWD is maintaining and monitoring the treatment system to ensure that it continues to remove organic solvents and residents are not exposed to these contaminants in their drinking water. If the treatment system were to fail or be discontinued, residents could potentially be exposed to PCE and TCE at levels that would require further evaluation to determine whether they could harm people's health.
- Mn in drinking water exceeds EPA's non-enforceable SDWR level. SDWRs are limits for non-health threatening or "nuisance" water contaminants. Elevated Mn levels may give drinking water a black or brown discoloration, cause staining of fixtures, and cause a bitter metallic taste that some customers

may find objectionable. Mn is unrelated to the PCE plume and is not removed by the carbon filtration system.

Conclusion 2

For people on private residential wells, ATSDR cannot determine whether people's health could be harmed by drinking the water currently or in the past. ATSDR does not have adequate information to evaluate the PCE contamination in private residential wells.

Basis for Conclusion 2

- There are a small number of private water wells in Martinsville that may be affected by the PCE plume. ATSDR does not have a verified inventory of all private residential wells currently in use or used in the past for residential purposes.
- Limited VOC testing of private water wells by IDEM and EPA indicate that TCE and PCE were detected and that PCE was above health screening levels in some samples. It is unknown whether any of these wells are currently being used for residential purposes. If residents are using well water for drinking, they could potentially be exposed to PCE and TCE above levels that would require further evaluation to determine whether they could harm people's health. All properties in the PCE plume area have access to treated municipal water.

Conclusion 3

For some homes and businesses, ATSDR concludes that people's health may be harmed by breathing TCE and PCE that has evaporated into their indoor air from the Pike and Mulberry Streets PCE Plume. In addition, some homes and businesses that overlie the contaminant plume have not been sampled at all and other properties require more sampling to ensure that harmful exposures can be identified and stopped, if they are occurring.

Basis for Conclusion 3

- Indoor air may be contaminated through a process called soil vapor intrusion – the movement of gaseous contaminants from contaminated groundwater and subsurface soil into buildings above the plume. EPA tested indoor air concentrations of PCE, TCE, and other gases in January, July, and September 2016, and January 2017 at a total of 33 residential and 19 commercial properties above and near the PCE plume. In addition to indoor air, EPA also sampled "sub-slab" soil vapor beneath buildings (or portions of buildings) with a concrete slab; where a slab was not present, EPA sampled air in the crawlspace or dirt floor basement area. ATSDR identified 23 residences and 11 commercial properties with indoor concentrations of PCE and/or TCE higher than health screening levels and evaluated them more extensively.
- Further evaluation indicates there are several homes and commercial properties with TCE in indoor air at a level that could potentially harm health. For the properties that exceeded the PCE screening level, ATSDR reviewed PCE research and concluded that health effects are not expected to occur at the measured concentrations.
- At two properties, EPA confirmed a link between indoor air contaminants and an underground source and is acting to mitigate the exposures [EPA 2018b]. In other cases, the contribution of sub-surface gas to indoor air, if any, could not be determined due to the possible presence of indoor

sources. EPA and ATSDR have spoken to these homeowners, informing them of potential health risks and advising them to remove any solvents from their homes.

- EPA made indoor air testing available to many property owners with homes and businesses above or adjacent to the PCE plume. Some property owners denied entry, thus there are people living and working in these buildings where the exposures to the occupants cannot be evaluated. Several of the untested homes were a part of IDEM's 2004-08 removal action, indicating a history of vapor intrusion.

8. RECOMMENDATIONS

Following its review of available information, ATSDR recommends that:

1) EPA install vapor mitigation systems in homes and businesses where vapor intrusion could harm people's health, in order to reduce levels of PCE and TCE in indoor air. EPA establish plans for operation and maintenance of the systems and monitoring to ensure continued performance until the source is remediated and indoor air concentrations are below levels of concern.
2) EPA again offer air sampling to untested homes and businesses that are above or near the groundwater plume, where the potential exists for people to be exposed to PCE and TCE. Per EPA and ATSDR guidance, concurrent samples of indoor air, ambient air, and subsurface air (sub-slab or crawlspace) should be collected.
3) EPA conduct wintertime testing at properties that were previously only sampled in the summer. EPA retest buildings where findings were inconclusive due to high detection limits or other reasons.
4) EPA develop a long-term monitoring plan to check for vapor intrusion in properties that have high levels of solvents in soil vapor and future potential for vapors to migrate indoors. The plan should account for the plume's possible movement and changing shape over time. EPA consider installing preemptive mitigation systems in buildings with high risk of vapor intrusion in the future. EPA prioritize air sampling and mitigation at properties where TCE risks may be elevated, due to potential health effects even at relatively low concentrations and short duration of exposure, i.e. developmental health effects associated with a 3-week TCE exposure.
5) In the case of residences where health risks were identified but VOCs were not definitively linked to underground contamination, EPA offer follow-up testing after the homeowner has removed all solvents to determine whether indoor exposures have been eliminated. Note that some of these properties were described by EPA as having "possible" current and "potential" for future vapor intrusion.
6) MPWD continue routine testing and ensure that actions are taken if solvent levels in treated drinking water begin to increase. MPWD continue to share testing results in its routine customer water quality reports so the public is aware of the situation and the measures that MPWD is taking to protect their health.
7) EPA work with IDEM, ISDH, and MCHD to determine whether any of the private residential water wells in Martinsville potentially impacted by the PCE plume are currently being used. For affected wells, residents should be advised of the potential health impacts and told to only drink treated municipal water. City water is available within the affected areas of Martinsville and residents should request service if they are not already receiving it.

9. NEXT STEPS

To achieve the above recommendations, the following actions will be implemented:

1) ATSDR will assist EPA in communicating the potential health risks to property owners who previously denied access for indoor air testing or for those who may not have been contacted in the past. ATSDR will assist EPA with interpreting results and deciding on next steps once further testing is conducted.
2) ATSDR will work with EPA, IDEM, ISDH, and MCHD to determine whether private residential water wells are still in use that could be impacted by the PCE plume. ATSDR and MCHD will send a letter to these well owners advising them to stop using their well water for any household purposes.

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Appendix A

EPA EJScreen Report

Population (2010)*	3,135
Population density (per square mile)	4,325
Minority population	68
Percent minority	2%
Households	1,287
Housing Units	1,477
Land Area (square miles)	0.72
Percent land area	100%
Water area (square miles)	0
Percent water area	0%
POPULATION BY RACE	PERCENT
White	98%
Black	0%
American Indian	0%
Asian	0%
Pacific Islander	0%
Two or more races	1%
Hispanic population	1%
POPULATION BY SEX	PERCENT
Male	49%
Female	51%
POPULATION BY AGE	PERCENT
Age 0-4	7%
Age 0-17	26%
Age 18+	74%
Age 65+	13%
HOUSEHOLDS BY TENURE	PERCENT
Owner occupied	48%
Renter occupied	52%

*Source: US Census 2010

Appendix B

Health Evaluation Methods

Drinking Water: Exposure dose is calculated using the formula shown below. Note that only drinking exposures were evaluated in this assessment for presentation purposes. Exposures to VOCs during showering and bathing (inhalation and dermal contact) would increase the total dose. ATSDR calculated exposure doses for both central tendency exposure (CTE), which refers to persons who have an average or typical soil intake rate, and RME, which refers to persons who are at the upper end of the exposure distribution (approximately the 95th percentile). The RME scenario assesses exposures that are higher than average but still within a realistic exposure range.

Exposure Dose Equation:

$$D = (C * IR * EF)/ BW$$

Where:
D = exposure dose (milligram/kilogram-day)
C = contaminant concentration (milligram/liter)
IR = ingestion rate of contaminated water (liter/day)
$EF_{chronic}$ = exposure factor (unitless) = (F x ED)/AT

- F = exposure frequency (days/week x weeks/year = days/year)
- ED = exposure duration (years)
- AT = averaging time (days)
    - Noncancer = ED (years) x F (days/week x weeks/year)
    - Cancer: 78 year x F (7 days/week x 52.14 weeks/year)

BW = body weight (kilograms)

Source: The Public Health Assessment Guidance Manual, Appendix G, Exhibit 3 (ATSDR 2005)

The below table shows the age group specific water ingestion rates used by ATSDR. For a residential exposure scenario, ATSDR assumes 33 years: 21 years of childhood exposures plus 12 years as an adult.

ATSDR Recommended Age-Specific Water Ingestion Rates[a]

Age Range	**Mean, milliliters per day**	**95th Percentile, milliliters per day**	**Body Weight, kilograms**
Birth to <1 year	504[b]	1,113	7.8
1 to <2 year	308	893	11.4
2 to <6 year	376	977	17.4
6 to <11 year	511	1,404	31.8
11 to <16 year	637	1,976	56.8
16 to <21 year	770	2,444	71.6
Adults, ≥21 year	1,227	3,092	80

[a]Ingestion rates for combined direct and indirect water from community water supply
[b]Time-weighted average = [(470*1+552*2+556*3+467*6)/12] = 503.7 milliliters per day

The formula used for cancer calculations for drinking water is described below.

Age-specific Cancer Risk = D x CSF x (ED/78 years)

Where:

D = age-specific exposure dose in milligrams/kilogram/day
CSF = cancer slope factor in $(\text{milligrams/kilogram/day})^{-1}$
ED = age-specific exposure duration in years

For TCE, cancer risk is based on three separate target tissue sites – kidney, lymphoid tissue, and liver. The CSFs for the three individual cancer types (respectively, 9.33E-03, 2.16E-02, and 1.55E-02 micrograms/kilogram/day) are summed, resulting in a total CSF of 4.6E-02 micrograms/kilogram/day. ATSDR applies ADAF to TCE exposures to reflect a greater risk of kidney cancer with early life exposures. The kidney cancer component above formula is multiplied by a factor of 10 for ages birth to two years and a factor of 3 for ages 2 to 16.

Inhalation – ATSDR quantifies cancer risk from carcinogens in air by using EPA's IUR. The IUR is an estimate of increased cancer risk from inhalation exposure to a concentration of 1 microgram per cubic meter ($\mu g/m^3$) for a lifetime. The IUR is multiplied by an estimate of lifetime exposure to estimate the lifetime cancer risk.

The formula used for cancer calculations for inhalation is described below.

Age-specific Cancer Risk = D x IUR x (ED/78 years)

Where:

D = air concentration (ug/m^3)
IUR = inhalation unit risk $[(ug/m^3)^{-1}]$
ED = age-specific exposure duration in years

Similar to drinking water exposures, ATSDR assumes that residential inhalation exposures occur over a 33-year period. Worker exposures occur during a 25-year period. Further, TCE exposures in air are also adjusted with ADAFs to quantify additional kidney cancer risks with early-life exposures in the residential scenario.

Appendix C

Health Assessment of Untreated Water from Well #3

Non-cancer health effects

The highest TCE concentration in untreated water from Well #3 dating back to 2004 was 3.6 µg/L during February 7-20, 2007. The CTE and RME dose equivalent to the peak untreated TCE from Well #3 in Martinsville is 0.23 µg/kg-day and 0.51 µg/kg-day, respectively, for children from birth to 1 year of age. This dose is notably lower than the level where negative health effects are expected to be observed, i.e. the human equivalent dose of 5.1 µg/kg-day for fetal heart malformation, the most sensitive health endpoint. TCE non-cancer toxicology is discussed in greater detail in Section 5.1.

The peak PCE concentration in untreated water from Well #3 was an annual average of 38 µg/L in 2012. The CTE and RME dose equivalent to the peak untreated PCE is 2.5 and 5.4 µg/kg-day, respectively, for children from birth to 1 year of age. These dose levels are substantially below the LOAEL of 2,300 µg/kg-day shown to cause a loss of color vision in an occupational study of dry-cleaning workers. Given the relatively low PCE doses compared to effect levels, additional non-cancer health assessment for PCE in drinking water is not warranted.

Cancer health effects

In this hypothetical scenario where the municipal drinking water treatment system failed to remove PCE and TCE, we assumed the exposures were equivalent to the highest annual average in untreated water from Well #3, which was 38 µg/L of PCE (in 2012) and 0.45 µg/L of TCE (in 2007). ATSDR calculated cancer risk estimates for drinking municipal water without carbon filtration by using the CSF of 2.1E-03 $(mg/kg/day)^{-1}$ for PCE [ATSDR 2017b]. TCE cancer risks were calculated using its CSF of 4.6E-03 $(mg/kg/day)^{-1}$. The cancer risk is 1.5E-06 from PCE ingestion and 5.7E-07 from TCE ingestion. The resulting total cancer risk is 2 excess cases per million, which ATSDR considers to be low. TCE and PCE cancer toxicology is discussed in greater detail in Section 5.2 and Appendix B.

Appendix D

Indoor Air and Sub-slab Vapor Sampling Results

Residential Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
RP-004	Jul-16	IA-01	0.65	<0.27						
RP-005	Jul-16	IA-01	0.69	<0.27	CS-01	3.7	<0.27			
RP-005	Jul-16	IA-02	0.77	<0.27						
RP-005	Jan-17	IA-01	3.6	0.28	CS-01	3.0	5.7			
RP-005	Jan-17	IA-02	3.9	<0.27						
RP-021	Jul-16	IA-01 (1st floor)	3.2	<0.27				SS-01 (1st floor)	410	<5.4
RP-021	Jul-16	IA-02 (1st floor)	2.4	<0.27				SS-02 (basement)	7,000	33
RP-021	Jul-16	IA-03 (1st floor)	5.9	<0.27				SS-03 (1st floor)	970	3.2
RP-021	Jan-17	IA-01 (1st floor)	28	<0.27				SS-01 (1st floor)	310	1.4
RP-021	Jan-17	IA-02 (1st floor)	34	<0.27				SS-02 (basement)	5,100	<540
RP-021	Jan-17	IA-03 (1st floor)	164	<0.27				SS-03 (1st floor)	370	<5.4
RP-022	Jan-16	IA-01	14	< 0.86				SS-01	16,408	1.7
RP-022	Jan-16	IA-02	4.2	< 0.86				SS-02	3,254	< 0.75
RP-022	Jul-16	IA-01	0.52	<0.27				SS-01	62	<5.4
RP-022	Jul-16	IA-02	0.32	0.34				SS-02	12	<5.4
RP-022	Jul-16	IA-03	0.41	<0.27				SS-03	10,000	1.5
RP-022	Jul-16	IA-04	0.39	<0.27				SS-04	89	<5.4
RP-022	Jan-17	IA-01	2.1	<0.27				SS-01	43	<5.4
RP-022	Jan-17	IA-02	0.96	<0.27				SS-02	6.5	<5.4
RP-022	Jan-17	IA-03	1.4	1.4				SS-03	11,000	<540
RP-022	Jan-17	IA-04	1.3	0.96				SS-04	33	2.4
RP-027	Jan-16	IA-01	4.8	< 0.75						
RP-027	Jan-16	IA-02	2.0	< 1.2						
RP-028	Jan-16	IA-01 (1st floor)	< 0.88	< 0.75						
RP-028	Jan-16	IA-02 (1st floor)	< 0.88	< 0.70						
RP-028	Sep-16	IA-01 (1st floor)	0.31	0.12	CS-01	1.4	< 0.27			
RP-028	Sep-16	IA-02 (1st floor)	0.24	< 0.27						
RP-028	Feb-17	IA-01 (1st floor)	<0.34	<0.27	CS-01	<0.34	<0.27			
RP-028	Feb-17	IA-03 (1st floor)	0.52	3.4						
RP-031	Sep-16	IA-01	< 0.34	<0.27	CS-01	0.91	0.22			
RP-031	Sep-16	IA-02	< 0.34	<0.27						
RP-031	Jan-17	IA-01	<0.34	<0.27	CS-01	<0.34	<0.27			
RP-031	Jan-17	IA-02	<0.34	<0.27						

Residential Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter (continued)										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
RP-038	Jul-16	IA-01	0.69	<0.27				SS-01	1,900	<54
RP-038	Jul-16	IA-02	0.83	<0.27				SS-02	3,900	<54
RP-038	Jul-16	IA-03	0.60	<0.27				SS-03	420	<5.4
RP-038	Jan-17	IA-01	2.6	<0.27				SS-01	670	<5.4
RP-038	Jan-17	IA-02	2.8	<0.27				SS-02	2,700	<110
RP-038	Jan-17	IA-04	0.79	<0.27				SS-03	510	<5.4
RP-045	Jan-16	IA-01	< 0.88	< 0.70				SS-01	177	< 0.75
RP-047	Jul-16	IA-01 (1st floor)	<0.34	<0.27				SS-01 (1st floor)	92	<5.4
RP-047	Jul-16	IA-02 (1st floor)	<0.34	0.13						
RP-047	Jul-16	IA-03 (1st floor)	<0.34	<0.27						
RP-047	Feb-17	IA-01 (1st floor)	1.0	3.7				SS-01 (1st floor)	3,500	<110
RP-047	Feb-17	IA-02 (1st floor)	0.99	<0.27						
RP-047	Feb-17	IA-03 (1st floor)	1.0	<0.27						
RP-049	Jan-16	IA-01	< 0.88	< 0.75						
RP-049	Jan-16	IA-02	< 0.95	< 0.75						
RP-083	Jul-16	IA-01	0.85	0.29	CS-01	0.97	0.18	SS-01	210	<5.4
RP-083	Jul-16	IA-02	0.48	0.13	CS-02	0.75	0.12	SS-02	180	<5.4
RP-083	Jan-17	IA-01	0.34	<0.27	CS-01	0.45	0.20	SS-01	130	<5.4
RP-083	Jan-17	IA-02	0.19	<0.27	CS-02	0.44	0.24	SS-02	150	<5.4
RP-084	Jan-16	IA-01	2.2	< 0.70						
RP-084	Jan-16	IA-02	3.3	< 0.75						
RP-085	Jan-16	IA-01	1.6	< 0.75						
RP-085	Jan-16	IA-02	1.9	< 0.75						
RP-095	Jul-16							SS-01	2,700	<54
RP-095	Jan-17				CS-01	4.0	<0.27	SS-01	810	<5.4
RP-121	Jul-16	IA-01	0.31	<0.27	CS-01	1.0	<0.27	SS-01	350	<5.4
RP-121	Jul-16	IA-02	0.26	<0.27						
RP-121	Jan-17	IA-01	3.2	<0.27	CS-01	2.7	0.18	SS-01	740	<5.4
RP-121	Jan-17	IA-02	3.2	<0.27						
RP-131	Jul-16	IA-01	0.15	0.40				SS-01	3.6	<5.4
RP-131	Jul-16	IA-02	<0.34	<0.27				SS-02	4.3	<5.4
RP-131	Feb-17	IA-01	0.20	<0.27				SS-01	2.8	<5.4
RP-131	Feb-17	IA-02	<0.34	<0.27				SS-02	2.2	<5.4

Residential Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter (continued)										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
RP-133	Jul-16	IA-01 (1st floor)	0.19	<0.27				SS-01 (basement)	700	<54
RP-133	Jul-16	IA-02 (basement)	0.46	<0.27	CS-02	0.75	<0.27	SS-02 (basement)	320	<5.4
RP-133	Jan-17	IA-01 (1st floor)	239	<0.27	CS-01	18	<0.27	SS-01 (basement)	680	<5.4
RP-133	Jan-17	IA-02 (basement)	105	<0.27	CS-02	6.0	0.17	SS-02 (basement)	340	4.3
RP-135	Jul-16	IA-01	<0.34	<0.27	CS-01	0.45	<0.27	SS-01	4.9	<5.4
RP-135	Jul-16	IA-02	<0.34	0.20						
RP-135	Jan-17	IA-01	<0.34	<0.27	CS-01	0.32	0.20	SS-01	4.9	<5.4
RP-135	Jan-17	IA-02	<0.34	0.35						
RP-156	Jan-16	IA-01	5.5	< 0.97				SS-01	5.4	< 1.1
RP-157	Sep-16	IA-04	4.4	<0.27				SS-01	4,200	160
RP-157	Sep-16							SS-02	3,900	13
RP-157	Sep-16							SS-03	440	< 5.4
RP-157	Feb-17	IA-04	1.9	<0.27				SS-01	3,100	<110
RP-157	Feb-17							SS-02	2,400	<54
RP-157	Feb-17							SS-03	730	<54
RP-160	Jul-16	IA-01	1.4	0.57	CS-01	3.0	0.47	SS-01	7,300	5.9
RP-160	Jul-16	IA-02	1.3	0.54	CS-02	2.3	0.81	SS-02	3,900	<54
RP-160	Jul-16				CS-03	2.7	0.68			
RP-160	Jan-17	IA-01	2.3	<0.27	CS-01	6.6	0.14	SS-01	2,200	<54
RP-160	Jan-17	IA-02	2.9	<0.27	CS-02	3.8	0.23	SS-02	1,300	<54
RP-160	Jan-17				CS-03	3.0	<0.27			
RP-162	Jul-16	IA-01	0.30	<0.27						
RP-162	Jul-16	IA-02	0.64	<0.27						
RP-189	Jul-16	IA-01	0.15	<0.27	CS-01	6.2	<0.27			
RP-189	Jan-17	IA-01	0.67	1.2	CS-01	0.82	<0.27			
RP-189	Jan-17	IA-02	0.71	0.63						
RP-193	Sep-16							SS-01	270	<5.4
RP-193	Feb-17	IA-01	5.8	<0.27	CS-01	7.3	<0.27	SS-01	92	<5.4
RP-193	Feb-17				CS-02	18	<0.27			
RP-200	Jul-16	IA-01	0.73	<0.27	CS-01	10	<2.7			
RP-200	Jul-16	IA-02	0.70	<0.27						

Residential Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter (continued)										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
RP-201	Jul-16	IA-01	2.9	0.13	CS-01	3.6	<0.27	SS-01	6,500	<110
RP-201	Jul-16	IA-02	29	<2.7						
RP-201	Jan-17	IA-01	3.8	<0.27	CS-01	1.1	<0.27	SS-01	3,600	<54
RP-201	Jan-17	IA-02	14	<0.27						
RP-205	Jul-16	IA-01	0.28	<0.27	CS-01	0.92	0.18			
RP-205	Jul-16	IA-02	0.29	<0.27						
RP-205	Jan-17	IA-01	<0.34	<0.27	CS-01	0.19	0.13			
RP-205	Jan-17	IA-02	0.14	<0.27						
RP-210	Jul-16	IA-01	<0.34	<0.27	CS-01	0.86	<0.27			
RP-210	Jan-17	IA-01	0.23	<0.27	CS-01	0.29	0.32			
RP-223	Sep-16							SS-01	670	<54
RP-223	Jan-17	IA-01	1.7	<0.27	CS-01	1.8	0.26	SS-01	910	<5.4
RP-223	Jan-17	IA-02	0.87	<0.27						
RP-224	Sep-16							SS-01	1,300	<54
RP-224	Sep-16							SS-02	880	<54
RP-224	Jan-17	IA-01	0.77	0.12				SS-02	1,700	<54
RP-224	Jan-17	IA-03	1.4	<0.27						
RP-229	Jul-16	IA-01 (basement)	4.7	<0.27	CS-01	6.9	<0.27			
RP-229	Jul-16	IA-02 (1st floor)	6.2	<0.27						
RP-229	Feb-17	IA-01 (basement)	1.8	16	CS-01	1.8	<0.27			
RP-229	Feb-17	IA-02 (1st floor)	0.77	0.17						
RP-232	Jul-16	IA-02	2.4	<0.27	CS-01	4.0	<0.27			
RP-232	Jan-17	IA-01	1.4	0.15	CS-01	2.2	0.17			
RP-232	Jan-17	IA-02	2.2	<0.27						

Commercial Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
CP-023	Sep-16	IA-01	3.1	< 0.27	CS-01	4.2	< 0.27	SS-01	2,100	< 54
CP-023	Sep-16	IA-02	2.4	< 0.27						
CP-023	Jan-17	IA-01	10	< 0.27	CS-01	6.8	< 0.27			
CP-023	Jan-17	IA-02	8.8	< 0.27						
CP-023	Jan-17	IA-03	12	< 0.27						
CP-046	Sep-16	IA-01	12	< 2.7				SS-01	1,800	< 54
CP-046	Sep-16	IA-02	15	< 2.7				SS-02	20,000	< 1,100
CP-046	Sep-16							SS-03	2,700	< 54
CP-046	Jan-17	IA-01	46	< 0.27						
CP-046	Jan-17	IA-02	57	< 0.27						
CP-072	Sep-16	IA-01	0.37	0.16				SS-01	2.7	< 5.4
CP-072	Sep-16	IA-02	0.30	< 0.27				SS-02	1.9	< 5.4
CP-072	Sep-16	IA-04	0.36	0.19				SS-04	1.9	< 5.4
CP-072	Sep-16	IA-05	0.49	0.13						
CP-072	Sep-16	IA-06	0.28	< 0.27						
CP-072	Jan-17	IA-01	< 0.34	0.12						
CP-072	Jan-17	IA-02	0.20	< 0.27						
CP-072	Jan-17	IA-03	0.41	0.11						
CP-072	Jan-17	IA-04	0.34	< 0.27						
CP-072	Jan-17	IA-05	0.28	< 0.27						
CP-072	Jan-17	IA-06	0.24	0.14						
CP-073	Sep-16	IA-01	0.19	0.25				SS-01	16	14
CP-073	Sep-16	IA-02	< 0.34	< 0.27				SS-02	120	< 5.4
CP-073	Jan-17	IA-01	0.46	0.94						
CP-073	Jan-17	IA-02	0.19	0.31						
CP-074	Sep-16	IA-01	0.28	0.16				SS-01	48	< 5.4
CP-074	Sep-16	IA-02	0.20	< 0.27				SS-02	270	690
CP-074	Sep-16							SS-03	16	18
CP-074	Jan-17	IA-01	< 0.34	0.16						
CP-074	Jan-17	IA-02	< 0.34	0.16						
CP-098	Sep-16	IA-01	1.0	< 0.27				SS-01	21	4.4
CP-098	Jan-17	IA-01	2.4	< 0.27						
CP-099	Sep-16	IA-01	141	14				SS-02	31,000	140
CP-099	Sep-16	IA-02	24	2.4				SS-03	410,000	2,000
CP-099	Sep-16	IA-03	54	3.9						
CP-099	Jan-17	IA-01	96	5.3				SS-01	120	4.1
CP-099	Jan-17	IA-02	18	0.61				SS-02	34,000	< 1,100
CP-099	Jan-17	IA-03	81	2.8				SS-03	110,000	< 2,100
CP-099	Jan-17	IA-04	42	10						

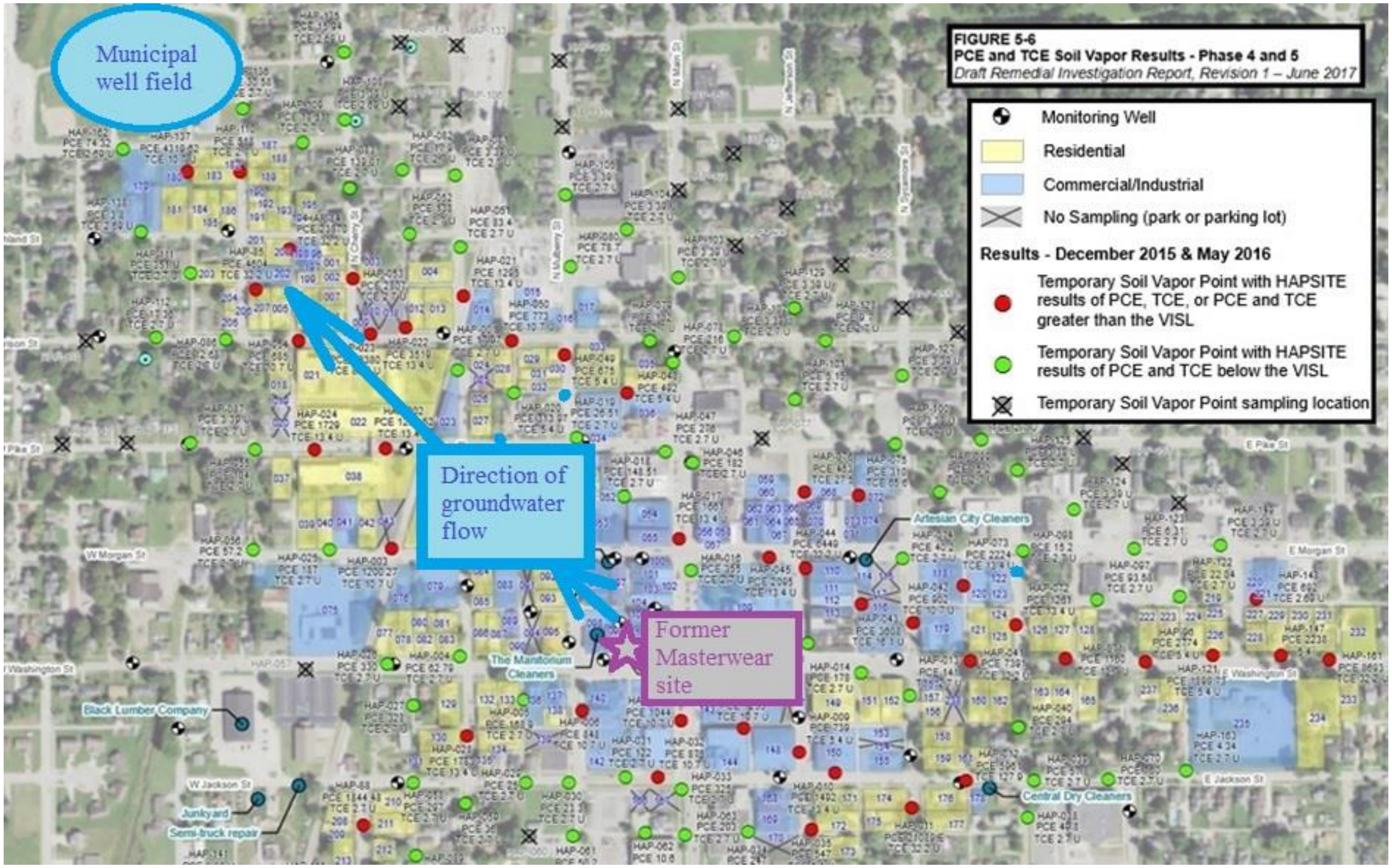
Commercial Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter (continued)										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
CP-103	Jul-16	IA-01	0.28	< 0.27				SS-01	12	< 5.4
CP-103	Jul-16	IA-02	0.25	< 0.27				SS-03	39	< 5.4
CP-103	Jul-16	IA-03	0.34	< 0.27						
CP-103	Jan-17	IA-01	0.48	< 0.27				SS-01	24	< 5.4
CP-103	Jan-17	IA-02	0.55	< 0.27				SS-02	97	< 5.4
CP-103	Jan-17	IA-03	0.19	< 0.27				SS-03	10	< 5.4
CP-110	Jul-16	IA-01	34	< 2.7				SS-01	12,000	< 540
CP-110	Jul-16	IA-02	34	< 2.7				SS-02	8,600	24
CP-110	Jul-16	IA-03	12	< 2.7				SS-03	29,000	< 540
CP-110	Jul-16	IA-05	16	< 2.7				SS-04	8,400	< 540
CP-110	Jan-17	IA-01	89	0.17				SS-01	13,000	6.3
CP-110	Jan-17	IA-02	61	0.12				SS-02	7,800	20
CP-110	Jan-17	IA-03	62	0.18				SS-03	39,000	4.7
CP-110	Jan-17	IA-04	35	0.40				SS-04	9,000	18
CP-110	Jan-17	IA-05	33	0.24						
CP-112	Jul-16	IA-01	0.40	0.71	CS-01	3.4	< 0.27			
CP-112	Jul-16	IA-02	0.87	< 0.27	CS-02	3.6	0.11			
CP-112	Jul-16	IA-03	1.2	< 0.27						
CP-112	Jan-17	IA-01	0.96	< 0.27	CS-01	1.4	< 0.27			
CP-112	Jan-17	IA-02	1.1	< 0.27	CS-02	1.8	< 0.27			
CP-112	Jan-17	IA-03	1.8	< 0.27						
CP-116	Sep-16	IA-01	0.56	0.14	CS-01	0.55	< 0.27	SS-01	1.8	< 5.4
CP-116	Jan-17	IA-01	0.81	< 0.27	CS-01	0.73	0.14	SS-01	3.1	< 5.4
CP-119	Sep-16	IA-01	0.34	< 0.27	CS-01	1.5	< 0.27	SS-01	1,300	< 54
CP-119	Sep-16	IA-02	2.3	< 0.27	CS-02	2.4	< 0.27	SS-02	1,300	< 54
CP-119	Sep-16	IA-03	0.32	< 0.27				SS-03	4,000	< 54
CP-119	Sep-16	IA-04	0.39	< 0.27						
CP-119	Sep-16	IA-05	0.95	< 0.27						
CP-119	Sep-16	IA-06	2.4	< 0.27						
CP-119	Jan-17	IA-01	2.4	< 0.27	CS-01	0.64	0.12	SS-01	760	< 5.4
CP-119	Jan-17	IA-02	7.5	< 0.27	CS-02	6.2	0.19	SS-02	750	< 5.4
CP-119	Jan-17	IA-03	3.4	< 0.27				SS-03	3,700	< 54
CP-119	Jan-17	IA-04	1.7	< 0.27						
CP-119	Jan-17	IA-05	3.7	< 0.27						
CP-119	Jan-17	IA-06	10	< 0.27						
CP-140	Sep-16	IA-01	0.99	< 0.27				SS-01	340	2.2
CP-140	Sep-16	IA-02	0.97	< 0.27				SS-02	26,000	120
CP-140	Sep-16	IA-03	0.92	< 0.27				SS-03	22	< 5.4
CP-140	Sep-16	IA-04	0.77	< 0.27						
CP-140	Feb-17	IA-01	2.0	< 0.27				SS-01	620	< 54
CP-140	Feb-17	IA-02	2.9	< 0.27				SS-02	16,000	< 540
CP-140	Feb-17	IA-03	1.6	< 0.27				SS-03	1,200	< 54
CP-140	Feb-17	IA-04	1.4	< 0.27						

Commercial Properties: Indoor Air and Sub-slab Vapor Sampling Results for Tetrachloroethylene (PCE) and Trichloroethylene (TCE), micrograms per cubic meter (continued)										
Site	**Date**	**Indoor**	**PCE**	**TCE**	**Crawlspace**	**PCE**	**TCE**	**Sub-slab**	**PCE**	**TCE**
CP-146	Jul-16	IA-03	2.6	0.43	CS-01	3.8	0.30			
CP-146	Jul-16	IA-04	6.7	2.0	CS-02	4.8	0.69			
CP-146	Jul-16				CS-03	4.8	1.7			
CP-146	Jul-16				CS-04	3.9	2.4			
CP-146	Feb-17	IA-01	0.52	< 0.27	CS-01	0.19	< 0.27			
CP-146	Feb-17	IA-02	0.76	< 0.27	CS-02	0.81	< 0.27			
CP-146	Feb-17	IA-03	< 0.34	< 0.27	CS-03	0.78	< 0.27			
CP-146	Feb-17	IA-04	0.45	< 0.27	CS-04	0.52	< 0.27			
CP-150	Jul-16	IA-01	15	< 2.7	CS-01	15	< 2.7	SS-01	16,000	< 1,100
CP-150	Jul-16	IA-02	2.9	< 0.27						
CP-150	Jul-16	IA-03	2.3	< 0.27						
CP-150	Jan-17	IA-01	18	< 0.27	CS-01	63	< 0.27	SS-01	13,000	1.1
CP-150	Jan-17	IA-02	9.5	< 0.27						
CP-150	Jan-17	IA-03	14	< 0.27						
CP-153	Sep-16							SS-01	160	< 5.4
CP-153	Jan-17	IA-01	0.19	< 0.27				SS-01	130	< 5.4
CP-155	Jul-16	IA-01	1.9	< 0.27	CS-01	3.0	< 0.27			
CP-155	Jul-16	IA-02	3.0	< 0.27						
CP-155	Jan-17	IA-01	12	< 0.27	CS-01	21	< 1.3	SS-01	250	< 5.4
CP-155	Jan-17	IA-02	8.2	< 0.54						
CP-155	Jan-17	IA-03	14	< 0.27						
CP-157	Sep-16	IA-01	7.3	< 2.7						
CP-157	Sep-16	IA-02	5.8	< 0.27						
CP-157	Sep-16	IA-03	3.8	< 0.27						
CP-157	Feb-17	IA-01	3.5	< 0.27						
CP-157	Feb-17	IA-02	1.2	0.60						
CP-157	Feb-17	IA-03	1.4	< 0.27						
CP-168	Sep-16	IA-01	2.3	< 0.27				SS-01	6,900	< 110
CP-168	Sep-16	IA-02	1.9	< 0.27				SS-02	5,200	190
CP-168	Jan-17	IA-01	58	< 0.27				SS-01	5,800	< 540
CP-168	Jan-17	IA-02	33	< 0.27				SS-02	35,000	< 1,100
CP-169	Sep-16	IA-01	2.4	< 0.27				SS-01	3,600	< 54
CP-169	Sep-16	IA-02	2.6	< 0.27						
CP-169	Sep-16	IA-03	2.4	< 0.27						
CP-169	Jan-17	IA-01	36	< 0.27				SS-01	1,100	< 54
CP-169	Jan-17	IA-02	29	< 0.27						
CP-169	Jan-17	IA-03	28	< 0.27						

Appendix E

Soil Vapor Map

U.S Environmental Protection Agency map showing soil vapor testing locations and screening results, modified by ATSDR to highlight location of former Masterwear site, municipal well field, and direction of groundwater flow.



Source: U.S. Environmental Protection Agency. Draft Remedial Investigation Report – Revision 1. Pike and Mulberry Streets PCE Plume Site. June 2017.

Appendix F

Public Comments on Health Consultation and ATSDR Responses

ATSDR received comments and questions from five entities during the 30-day public comment period from March 4th to April 3rd, 2019. Some issues were raised by multiple respondents. Other comments were lengthy and not directly relevant to ATSDR's work e.g. comments on remedies that EPA may be considering. ATSDR edited the public comments for brevity and clarity, grouped them by subject area, and has provided our responses below. In some instances, the public comment prompted a follow-up or addition to the main report, and we indicate the appropriate section to read for more detail.

HEALTH CONCERNS

Q1: What was the source of PCE health studies that ATSDR used to assess potential impacts on the Martinsville community? What assumptions were made about people's exposures and how did ATSDR address uncertainty?

> A1: PCE health effects are documented in the ATSDR Toxicological Profile [ATSDR 2014a] and our health assessment methods are detailed in ATSDR's Public Health Assessment Guidance Manual [ATSDR 2005], available here: https://www.atsdr.cdc.gov/hac/phamanual/toc.html. Refer to Section 5 Environmental Health Evaluation and Appendix B Health Evaluation Methods in this report. ATSDR's health consultations do not allow us to draw conclusions about the association between exposure to environmental contaminants and illnesses at an individual level.

Q2: Did ATSDR consider the health risks from a complex mixture of VOCs in Martinsville's water and indoor air? Is there a possible "cocktail effect" or synergistic effect from these exposures?

> A2: PCE and TCE are believed to have some of the same target organs for carcinogenicity. For example, both chemicals may contribute to non-Hodgkin's lymphoma and to kidney and liver cancer. ATSDR treated cancer risks from PCE and TCE as additive: we summed cancer risks across all chemicals and across all exposure routes. We do not have evidence of synergistic effects, i.e. total risks greater than the sum of PCE and TCE cancer risks.

Q3: Morgan County has the 2nd highest cancer rate in Indiana and there are many stories of people in Martinsville with cancer and poor health. My family member had a tumor which the doctor said can only be from an environmental cause. How can ATSDR say the cancer risk in Martinsville is low without studying the health of the community?

> A3: People in Martinsville are not exposed to chemicals from the PCE plume in their municipal drinking water. There is a limited number of homes and businesses above the PCE plume with a potential for vapor intrusion. The broader Martinsville and Morgan County community is not exposed to solvents from the Pike and Mulberry Streets PCE Plume site. However, there are likely other sources of environmental contaminants in the community, as is the case in any American urban area. There are also other potential causes of illness, other than chemical exposures.

People in the United States are exposed to environmental toxins from various sources, including vehicle emissions, household chemicals, and metals in soil. The health risks from these chemical exposures are in addition to the dominant cancer risk factors: age, genetics, behaviors (tobacco and alcohol use, poor diet, lack of exercise, and exposure to the sun), and exposure to viruses and bacteria, for example hepatitis B and C viruses that can cause liver cancer and Epstein-Barr virus which may cause a type of lymphoma [ATSDR 2009].

The U.S. National Cancer Institute's Surveillance Epidemiology and End Results Database estimates that about 40% (two out of five) men and women across the U.S. will develop some type of cancer in their lifetime [ACS 2020]. This baseline cancer risk is not widely known beyond the medical and public health community. Further, it is important to understand that the term "environmental" is used differently by clinicians than it is by environmental regulators and the public. As noted by researchers at Johns Hopkins University, "In cancer epidemiology, the term 'environmental' is generally used to denote anything not hereditary" [Tomasetti and Vogelstein, 2015]. Researchers have defined "environment" as "the sum total of all the conditions and elements that make up the surroundings and influence the development and actions of an individual", including lifestyle and viruses [IM 2002].

People can reduce their cancer risk by not smoking, avoiding smoke from others, maintaining a healthy weight, exercising, and being careful about the chemicals they use in their home [ATSDR 2009]. People may also purchase a test kit to find out whether radon gas is present in their home at levels that could potentially affect their health. Radon is a naturally-occuring gas that is known to increase the risk of developing lung cancer. More information about testing and how homes can be fixed to remove radon available here: https://www.atsdr.cdc.gov/docs/radoninthehome_508.pdf

EXPOSURE ISSUES

Q4: Indoor air contamination levels at vapor intrusion sites can vary daily, seasonally, and with weather. Annual or biannual sampling is not enough to capture TCE spikes that could trigger fetal heart defects, given the short-term (~3 week) window of exposure for this health endpoint. What can be done to increase frequency of indoor air testing in high risk areas, to require pre-emptive mitigation systems, and to notify building occupants of the potential risks?

A4: EPA is following its guidelines for vapor intrusion and Superfund site investigation. Within this framework, ATSDR recommends that EPA prioritize indoor air testing and consider preemptive mitigation of properties where TCE has the greatest potential for migrating to indoor living and work spaces. Recommendations are updated to include this issue.

Q5: What are the levels of PCE and TCE in municipal drinking water at Wells #4 and #5 before blending with treated water from Well #3? If the levels in Wells #4 and #5 are low, then why is there a need for carbon treatment which has been in place since 2005?

A5: Laboratory results for Wells #4 and 5 have been below detection limits (0.5 μg/L) for PCE and TCE since MPWD started routine testing in 2004. Water from Well #3 is treated to remove VOCs to below detection limits and then blended with water from Wells #4 and 5. Carbon treatment remains necessary because untreated water from Well #3 routinely exceeds EPA's MCL for PCE, which is 5 μg/L.

Q6: What assurances are there that drinking water was safe between 1992 and 2005 before carbon filters were installed?

A6: Analytical results for Well #3 show that PCE was detected, but below the MCL in 2004 and 2005. PCE levels gradually increased over the next few years, indicating that the groundwater plume was migrating downgradient toward the municipal well field. Data that may have been collected prior to 2004 were not made available to ATSDR. Of 46 samples collected in 2005, none exceeded the PCE MCL. Out of 45 samples in 2006, 28 exceeded the MCL and all 50 samples in 2007 exceeded the MCL. As described in Section 4.1, the data suggest PCE levels rose after 2005 and plateaued within a few years.

Q7: It would be health protective and cost-effective if the City of Martinsville would require mitigation (such as sub-slab depressurization) as part of all new construction and major remodeling in areas with known VOC contamination in the subsurface. Are there any "activity and use limitations" (institutional controls) in place at this site? What are the specific controls and how are they being applied and enforced? Does ATSDR believe there is a need for additional controls or public education?

A7: There are no institutional controls currently in place around the PCE plume. This step would be considered by EPA as part of the Superfund remedy selection process. More information about the steps in a Superfund cleanup are available at this website: https://www.epa.gov/superfund/cleaning-superfund-sites. In the meantime, ATSDR recommends that property owners near the PCE plume (i.e. those who have been offered indoor air testing) consult with EPA and the Martinsville Building Services about the potential value of pre-emptive vapor mitigation as part of construction and remodeling projects.

Q8: In the draft EPA Human Health Risk Assessment, these VOCs were identified as contaminants of potential concern in groundwater, but did not exceed their respective MCLs: Bromodichloromethane, carbon tetrachloride, chlorodibromomethane, and chloroform. Is EPA analyzing groundwater samples for these VOCs as part of the Superfund site investigation?

A8: EPA is reporting chemicals of concern associated with the NPL site and their breakdown products: PCE, TCE, cis-1,2-dichloroethene, and vinyl chloride. EPA is not analyzing groundwater for these additional VOCs listed. However, with the exception of carbon tetrachloride, these additional VOCs are disinfection by-products that are tested for in the finished drinking water by the municipal water system, and the results included in the Annual Water Quality report sent to residents.

COOPERATION WITH OTHER HEALTH AND REGULATORY AGENCIES

Q9: Did ATSDR consult MCHD regarding whether any residents over the plume are drinking water from private wells? Have you provided MCHD with information about people's exposures to solvents and potential health effects?

> A9: We have discussed our findings with MCHD and engaged them in our efforts to determine whether any residents within the groundwater plume area are using private well water for domestic purposes. Private well water is not regulated by MCHD, IDEM, or EPA. The ISDH offers recommendations on routine private well water testing and offers support in interpreting results [ISDH 2019]. MCHD is often the intermediary between residents and ISDH on well water issues. In the case of the Pike and Mulberry Streets PCE Plume site, MCHD, IDEM, ISDH, and EPA are aware of the potential risks and advise the public against the use of private well water for household purposes. Additional information and updates are provided in Section 4.2 Private Well Water.

Q10: Why are there several lulls in activity at the Masterwear site since IDEM and EPA first discovered the contamination? Why does ATSDR not offer an action plan to eliminate or mitigate the PCE plume itself? How confident are you that the highest plume concentration has been identified and that you know the characteristics of the plume?

> A10: The timeline of IDEM and EPA's engagement at the site is reflected in the Final RI Report posted here: https://semspub.epa.gov/work/05/941790.pdf. Regarding characteristics of the plume EPA states in the RI: "The PCE plume in groundwater is well-defined horizontally and vertically and consists of two "lobes" radiating from the former Master Wear facility. A third 'lobe' extends towards the former Master Wear facility from a potential upgradient source. Following approval of the RI report, a detailed analysis and evaluation of potential remedial action alternatives as part of a feasibility study is warranted for PCE due to its exceedance of its [screening levels] in groundwater and soil vapor, and TCE based on its exceedance of its [screening levels] in soil and soil vapor." ATSDR's advisory role in this process is to characterize any potential health hazard from the NPL site and to advise regulatory agencies on how to reduce people's exposures while EPA implements the Superfund process of site investigation and mitigation.

Q11: EPA's former Administrator Scott Pruitt has targeted certain Superfund sites for development once they are cleaned up. How can EPA allow development in Martinsville, given that the PCE plume has not been cleaned up?

> A11: Questions regarding redevelopment of properties should be directed to IDEM, EPA, and City of Martinsville. ATSDR has recommended that EPA continue investigating properties where indoor air exposures could occur and mitigating buildings where indoor VOC levels pose a health hazard. This effort is ongoing as a part of EPA's Superfund process to remediate the PCE plume.

Q12: People who move into the area or take jobs have a right to be informed, even if authorities are appropriately addressing risk. What is being done to ensure that the public at large knows what is going on at the Pike and Mulberry Streets Plume site?

A12: Since the Pike and Mulberry Streets PCE Plume site was listed on the NPL in 2013, EPA sent informational postcards and factsheets to approximately 1,000 addresses nearest the plume on multiple occasions. In 2015, EPA informed these residents and business-owners about plans for community interviews, soil and groundwater testing, and testing indoor air. In 2016, EPA reached out to owners of over 200 properties at greatest risk for vapor intrusion by sending letters and/or going door-to-door to explain the need for indoor air testing. Subsequently, EPA notified property owners of their sampling results. More recently, EPA sent about 1,000 postcards to invite community members to ATSDR's meeting on March 4th, 2019 where this draft report was presented to the public. EPA again sent these people postcards and placed a newspaper advertisement to announce their plans to hold community interviews regarding the NPL site [EPA, 2019b].

EPA is continuing their community involvement process for the Pike & Mulberry PCE Plume site which began in 2015. EPA interviewed residents from April 22-25, 2019, at the Morgan County Administration Building. EPA drafted a Community Involvement Plan in August 2019, which is posted at https://semspub.epa.gov/work/05/949417.pdf. The plan lays out a framework for continued community engagement, most notably EPA's intent to hold public meetings throughout the site cleanup process. The next project milestone will be when EPA drafts a proposed plan for site remediation and the agency engages the community for their comments and concerns [EPA, 2019a].

More recently, MCHD has compiled site-specific information and technical resources for the Pike & Mulberry PCE Plume site at this website: https://www.morgancountyhealth.com/environmental-health/pce-plume-pike-mulberry-street