HEALTH CONSULTATION

"Armen Cleaners" Dry Cleaners

City of Ann Arbor, Washtenaw County, Michigan
EPA Site ID # MIN000508741

Prepared by

Michigan Department of Community Health
Under a Cooperative Agreement with
Agency for Toxic Substances and Disease Registry

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List of Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AIAC	Acceptable Indoor Air Concentration
AQD	Air Quality Division
ATSDR	Agency for Toxic Substances and Disease Registry
DNAPL	dense non-aqueous phase liquid
EPA	Environmental Protection Agency
HCBD	hexachlorobutadiene
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MIP	Membrane Interface Probe
MRL	Minimum Risk Level
LOAEL	low-observed adverse effects level
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAEL	no observed adverse effects level
NW	northwest
OSHA	Occupational Safety & Health Administration
PCE	perchloroethylene, tetrachloroethylene
ppb	parts per billion
ppm	parts per million
SE	southeast
SRSL	Secondary Risk Screening Level
START	Superfund Technical Assistance and Response Team
TAGA	Trace Atmospheric Gas Analyzer
TCE	trichloroethylene
TLV-TWA	Threshold Limit Value – Time Weighted Average
TT/EMI	Tetra Tech EM Inc.
ug/L	micrograms per liter
ug/m3	micrograms per cubic meter
VI	vapor intrusion
VOC	volatile organic chemical

EXECUTIVE SUMMARY

In 2002, the Michigan Department of Environmental Quality (MDEQ) requested that the Michigan Department of Community Health (MDCH) conduct a health consultation on a property adjacent to the Armen Cleaners facility, located at 630 S. Ashley Street in Ann Arbor. This smaller health consultation (MDCH 2002) was completed in the same year but the collection of additional environmental data from the area led to the present consultation, which is larger in scope than the original (as mandated by the additional data). Several residential buildings immediately surrounding the site in downtown Ann Arbor (Washtenaw County, Michigan) are being impacted by releases of the dry cleaning solvent perchloroethylene (PCE, perchloroethene, or "perc"). There is evidence presented within this health consultation that shows several possible exposure scenarios to the surrounding neighborhood, both currently and in the future. Figures 1 and 2 provide maps of the immediate and regional area.

Two houses immediately adjacent to Armen Cleaners (properties 28 and 29 from Figure 1) are physically close enough to the dry cleaning process that ambient PCE exposure concentrations actually exceed appropriate health-based standards. Outdoor (ambient) measurements from one of these homes (property 29 from Figure 1) exceeds the Agency for Toxic Substances and Disease Registry (ATSDR) inhalation "minimal risk level" (MRL). These ambient exposures represent an indeterminate health hazard as they are sporadic and seasonal in nature (for example, one would not expect outdoor concentrations to impact indoor concentrations during the winter months). It appears as if these concentrations are a result of cooling air containing PCE being vented from the dry cleaner building.

Indoor air measurements from the living space of these properties (as well as others in the surrounding neighborhood) generally do not exceed the appropriate health-based standards and also represent an indeterminate public health hazard. The rationale for characterizing the indoor exposures as "indeterminate" stems from the fact that several measurements (from the basement and/or living space) either exceed these standards or come very close to exceeding these standards. Due to uncertainty in the indoor air measurements (i.e., the process may not have accurately characterized the indoor air concentrations given that the empirical data are so close to the health-based standard) as well as uncertainty in the chronic toxicity of PCE at the exposure standard (i.e., chronic exposure at these concentrations may not translate to an actual health impact), the indoor air exposure pathway is considered indeterminate, given current conditions.

It appears that some of the measured indoor air concentrations of PCE at one of these homes (property 29) may be due to vapor intrusion (VI) of PCE from contaminated groundwater. A plume of dense non-aqueous phase liquid (DNAPL) composed of almost pure "product" (i.e., almost pure PCE) has been fairly well characterized in the soil gas and groundwater below the dry cleaning operation. In addition, there are significant sub-slab (beneath the house foundation) PCE soil gas measurements for those homes directly surrounding the dry cleaner facility. There could be continued concerns over contaminated groundwater and vapor intrusion of PCE (and related degradation products)

until this plume of PCE is remediated. In fact, this plume likely represents a future public health hazard should migration of the contaminants be allowed to continue.

It is suggested that measures to reduce exposure be implemented at the house immediately adjacent to the Armen Cleaners (property 29), which could include expanding the provision of activated charcoal air purifying units (such has been done in the past at property 28). In addition, reducing exposure to the ambient concentrations of PCE behind the facility also needs to be addressed, which could involve placement of activated charcoal filters on the exhaust pipes that vent out cooling fan exhaust from the dry cleaners. Despite the method employed to reduce exposures, some follow-up air sampling of both the indoor living space and backyard ambient air should be performed to gauge effectiveness of the method chosen. Finally, MDCH should collaborate with MDEQ, the city of Ann Arbor, and Washtenaw County to address the longer-term issues of remediation and potential future exposures (i.e., removal of the DNAPL PCE beneath the facility, removal of building materials impregnated with PCE, and/or emissions from the current operational set-up).

BACKGROUND AND STATEMENT OF ISSUES

Armen Cleaners is a dry cleaning establishment that opened in 1947 at its existing location on 630 S. Ashley Street in downtown Ann Arbor, Washtenaw County, Michigan. The business was initially identified in 1985 as a site of environmental concern by a neighbor, due west of Armen Cleaners, who complained of chemical odors in her backyard. The property has changed owners several times between its inception and today, with the current business owners having used the property since 1994.

The Michigan Department of Natural Resources (MDNR) investigated the 1985 complaint and found that dry-cleaning sludges and used filters had been stored and spilled on the site.[1] Subsequent investigation revealed the contaminant in question to be tetrachloroethylene, otherwise known as perchloroethylene ("perc," or PCE). With MDNR oversight, initial remediation undertaken by the owner involved removing contaminated soil adjacent to the northwest corner of the building and replacing it with clean soil. After this initial clean-up, there was an assessment of residual health risk by the state of Michigan, which categorized the site as posing "no imminent public health threat." At this time, relatively low levels of PCE in soil and groundwater were detected (Davis, 2003b).

In 2000, the MDEQ took more groundwater and soil samples from the area surrounding the dry cleaning business. PCE data from a monitoring well on the property 28 (see Figure 1) was found to exceed residential standards – as determined by the MDEQ "Part 201 Cleanup Criteria" guidance (MDEQ 2000) – for drinking water protection, direct contact with groundwater, and groundwater volatilization to indoor air (i.e., the "vapor intrusion [VI] pathway"). In addition, PCE groundwater data were found to exceed

[1] On October 1, 1995, the environmental protection and regulation functions of the Michigan Department of Natural Resources (MDNR) were transferred to the newly formed Michigan Department of Environmental Quality (MDEQ).

generic and industrial drinking water standards. In a memo between MDEQ offices, it was pointed out at this time that not only was there "free product (PCE) detected in the groundwater" beneath property 28, but it was "mentioned that the basement walls were wet in the residence and also the foundation was crumbling" (Inglis 2000). The implications of these last two facts are that VI of PCE into indoor air at property 28 could easily occur.

Between November 2000 and December 2001, the MDEQ conducted air sampling for volatile organic compounds (VOCs) using evacuated ("Summa") canisters at property 28. See Appendix 1 for the results of these multiple air sampling events. In general, measurements taken in the basement were higher than those taken from the apartments (e.g. "living space") on the upper floors during those months when one might expect the windows to be open; however, some significant concentrations of PCE in indoor air were detected in the living space of property 28. Measurements taken from December and February showed comparable concentrations between basement and upper floors, with the upper floors generally having slightly higher air concentrations. Maximum PCE air concentrations found in the living space during October to December 2001 were reported at 152 – 158 ug/m3; however, Katko (2002) reported a living space concentration of 337 ug/m3, which exceeded the MDEQ "acceptable indoor air concentration" of 42 ug/m3 by almost a full order of magnitude. Even though the data is limited, information presented in Appendix 1 appears to support the trend of slightly higher "living space" air concentrations during colder months when the windows are likely closed (which is additional anecdotal data supporting historic VI of PCE into the house at property 28).

In January 2002, MDEQ requested that MDCH assess the potential for adverse health effects resulting from PCE inhalation exposures in the indoor air at property 28 (Adelman 2002). Information presented to MDCH at that time included soil, groundwater and indoor air data for PCE, tricholorethylene (TCE), and methylene chloride. Since PCE breaks down in the absence of oxygen ("anaerobic degradation") to trichloroethylene, dichloroethylene compounds, and vinyl chloride, it appears that the free product and/or contaminants in this product under Armen Cleaners may be degrading over time (Ellis and Anderson 2003).

To fulfill the request from MDEQ, MDCH released a health consultation in March 2002 (MDCH 2002). This previous document concluded that VI from the contaminated groundwater plume was the likely source of PCE found in indoor air at property 28 and that these exposures to the residents of the apartments in this building constituted a public health hazard. During the month of June 2002, MDEQ placed activated-carbon air-purifying units within apartments located within the residence in an attempt to reduce indoor exposures to PCE. The rationale for declaring the site a public health hazard was based on significant exceedance of a cancer-based health endpoint (referred to in this report as the MDEQ "acceptable indoor air concentration," or AIAC). Advances in the knowledge of the toxicology of PCE have changed somewhat since this declaration and will be discussed in the Toxicological Evaluation section of this document.

In July 2002, DLZ Michigan Inc. provided MDEQ with a Supplemental Investigation Letter Report for the Armen Cleaners site; the purpose of this was to provide results of indoor air sampling that took place between February 2001 and June 2002 (DLZ 2002). A soil-gas survey was also conducted as part of this effort in June and July 2002 to determine presence, identity and relative strength of certain soil and/or groundwater contaminants. PCE concentrations in groundwater and soil gas were still found in exceedance of MDEQ Part 201 criteria, such as drinking water standards, direct contact standards, and volatilization to indoor air standards. Indoor air samples were taken from the living space of the house at property 28 after the installation of the air-purifying units (56 to 207 ug/m3 PCE) and still found to exceed the MDEQ AIAC of 42 ug/m3. Groundwater data identified additional degradation products (cis-1,2-dichloroethylene and vinyl chloride) and supports the idea that the free product is degrading within the contaminated plume. Finally, the DLZ report indicated the existence of a groundwater divide under the Armen Cleaners building that results in transport of this groundwater either to the northwest (roughly towards the intersection of S. First and Madison) or southeast (roughly towards the intersection of Mosely and S. Ashley Streets).

In March 2003, MDCH hosted a public meeting in Ann Arbor to discuss residents' concerns and present background information to the affected public. A survey administered after the meeting reported that MDCH met the expectations of the crowd with regard to providing the appropriate public health background information on the issue as well as informing the public as to the details of the impending environmental study.

Davis (2003a) reported in May 2003 that Armen Cleaners had partially converted from a PCE-based operation to an organic alternative (Rynex). Rynex is a biodegradable, azeotropic mix of substituted aliphatic glycol ethers that is promoted as an environmentally friendly alternative to traditional dry cleaner operations. The U.S. Environmental Protection Agency (EPA) has not classified Rynex as hazardous waste or a hazardous air pollutant.

During May and June 2003, the "Superfund Technical Assistance and Response Team (START) team of TetraTech EM Inc. (TT/EMI) collected over 50 air samples via Summa canister in conjunction with a removal site evaluation. [In the latter months of 2002, MDEQ and MDCH requested that the Environmental Protection Agency (EPA) assist in the acharacterization of the Armen Cleaners site and surrounding area.] In addition, soil gas and ambient air samples were taken at this time. See the next section for a more thorough description of this sampling event. For a partial listing of the data collected in 2003, see Table 1. As of March 2005, TT/EMI is still preparing a final report and all analysis and conclusions included here are based on raw data as received by TT/EMI. A description of this study for the public was provided on the web site for the City of Ann Arbor and can be found in Appendix 5.

DISCUSSION

Environmental Contamination

Sampling Events from 2000 through 2002

The highest concentrations of indoor airborne PCE were generally found in basements, which for the most part, are unoccupied and infrequently visited for short periods of time (for laundry and other chores). Consult Appendix 1 for measurements of PCE taken from basement and living space areas of property 28 during 2000 and 2001. Starting within February 2001, other residential properties (properties 6, 24, 26, and 27 from Figure 2) were also sampled. Indoor air data generated in 2002 indicated that PCE concentrations in excess of state health-based standards also existed at surrounding properties other than property 28 (particularly, properties 26 and 27). Additionally, the highest living space air concentration of PCE (337 ug/m3) was found during an MDEQ September 2002 sampling event at property 28 (Katko 2002).

DLZ (2002) presented data characterizing the extent of PCE contamination in soil gas and groundwater. A soil gas plume of PCE exceeding the MDEQ Part 201 drinking water criterion (100 ppb) not only existed under the dry cleaners property but enveloped the three residential properties immediately adjacent to the dry cleaning business (properties 27, 28, and 29). An extremely high concentration (510,000 ppb) was found directly under the north edge of the building and occurs at the top of the groundwater ridge, indicating it has potential to move both to the NW and SE. A plume of groundwater contaminated with PCE (as well as the degradation products) levels exceeding the volatilization to indoor air criterion (25,000 ug/L) was found directly under the north edge of the dry cleaning business as well as the south side of property 28.

Sampling Events from 2003

As mentioned earlier, the sampling efforts of 2003 were contracted out to TT/EMI, who took soil gas, indoor air (both basement and living space), and ambient air (outdoor air) samples from roughly May through June 2004. According to Sawicki (2004), no groundwater samples were taken to characterize the free product (DNAPL) under the site due to specific charges given to the TT/EMI. Likewise, soil gas was not sampled for anything but PCE and its degradation products.

Indoor air and ambient (outdoor) air samples were taken via Summa canister. Sample locations were either outside the main house (front and/or back porch), inside the main house (first or second floor generally), or in the basement and were taken for roughly 24 hours in length. Prior to any sampling, homeowners in the study area were asked to fill out a survey regarding the use of household cleaners and the frequency of carpet, furniture and garment dry-cleaning (as these products/processes contribute to total indoor air VOCs).

These indoor air samples were compared to several state and federal standards for chronic exposure, including the MDEQ secondary risk screening level (SRSL, 17 ug/m3), the MDEQ acceptable indoor air concentration (42 ug/m3, or 6.2 ppb), and the ATSDR chronic inhalation MRL (271 ug/m3, or 40 ppb). With the exception of two properties, every sampled property exceeded the SRSL, which, in this case, represents a threshold of risk (1 in 100,000 cancer risk value) and not an enforceable standard.[1] The vast majority of these exceedances are outside the living space (i.e. in the basement), with the exception of property 29 (41 ug/m3 from the living space). Additionally, the ambient air samples from this same property measured 330 and 480 ug/m3, which are above all applicable federal and state standards for chronic exposures. These ambient exposures do not necessarily translate to a "health hazard," since exposures to these concentrations would be sporadic and seasonal in nature. Attempts should still be made to reduce these ambient concentrations, however.

Table 1. Short list of detected PCE concentrations during the 2003 sampling event. See Figure 2 for key to properties listed in "Sample Property column."

Sample Property	*Sample Location*	*PCE Concentration*	*Comments*
Property 19	Basement	53	
	House	ND	
	Sub-Slab	ND	
	Outside	23	
Property 26	Sub-Slab	244	Only detect
Property 28	Basement	85, 170	2 samples taken per location, except sub-slab
	House	ND, 5	
	Sub-Slab	17,600; 17,000; 18,300	
	Outside	ND, 10	
Property 27	Basement	ND	
	House	10	
	Sub-Slab	41	
	Outside	7	
Property 29	Basement	24, 100	2 samples taken per location, except sub-slab
	House	6, 41	
	Sub-Slab	251	
	Outside	330, 480	
Property 15	Sub-Slab	271	Only detect

All addresses are in the city of Ann Arbor. PCE = perchloroethylene; all concentrations reported in micrograms (µg) per cubic meter (m^3). Basement and other house samples are Summa canister data. Outside data is from Summa canister and sub-slab data is from Membrane Interface Probe.

[1] According to MDEQ (Personal communication from M.L. Hultin, 7 September 2004), Armen Cleaners is exempt from state air toxic rules as they fall under the federal National Emission Standard for Hazardous Air Pollutants (NESHAPs). Additionally, they are not required to have a "New Source Review" permit and are technically not obligated to meet the SRSL exposure standard. Given the long-term existence of the groundwater and soil gas contamination, it is prudent to consider these long-term screening levels in the overall assessment of the health risks from Armen Cleaners PCE emissions.

Soil gas (soil vapor) monitoring was done via a Membrane Interface Probe (MIP) to produce real-time, continuous chemical and physical logs of the sub-surface underground environment. Measurements of soil gas below homes (sub-slab readings) were taken using the MIP technology by TT/EMI. The samples taken from underneath property 28 are the highest measured sub-slab samples (17,000 to 18,300 ug/m3), and even these do not exceed the MDEQ soil volatilization to indoor air criterion (74,626 ug/m3). This criterion defines a soil concentration (underneath a building foundation) below which vapor intrusion (VI) is not expected to be of health concern to those inside the dwelling. However, this comparison is problematic as the standard is for soil concentrations and the sub-slab readings are "soil gas" measurements. MDEQ has an interim screening value of 1,700 ug/m3 for PCE at industrial sites and the sub-slab samples from property 28 exceed this not-yet-finalized standard.

Table 1 consists of those properties sampled that actually had PCE detected ("detect," or a "positive hit") above the method detection limit. All the PCE hits for all properties are reported in Table 1, whether it was indoor air, outdoor air, or sub-slab data.

Lastly, the Trace Atmospheric Gas Analyzer (TAGA) was used to take ambient air samples from the neighborhood surrounding the Armen Cleaners Site, in addition to some indoor samples. The TAGA (provided by the EPA) unit is a self-contained mobile laboratory capable of real-time sampling and analysis from various environmental sources and concerns and was physically driven around the site while taking ambient air measurements. Samples were collected from June 2 through June 5, 2003. The only residence to show any appreciable detectable amounts of PCE was property 29, with basement readings ranging from 23-26 ug/m3, first floor readings ranging from 9.6-11 ug/m3, and second floor readings ranging from 27-29 ug/m3. All living space measurements exceed the MDEQ SRSL health benchmark, but again, this benchmark is a conservative screening level for cancer endpoints and not an enforceable standard for this site. Data recorded during several drives around the neighborhood were generally not of significance, with only one ambient air hit (26 ug/m3) exceeding the MDEQ SRSL. It is of interest to note that three (3) of the four (4) highest ambient concentrations as measured by the TAGA unit were found at the same intersection (where W. Mosely meets S. First, right next to property 29).

According to Sawicki (2004), the higher ambient concentrations seen on the back porches of immediately adjacent housing (especially property 29) occurred when cooling fans are running from the facility, and not process fans. This information was later corroborated by the MDEQ during routine inspection visits to the facility. During the most recent visit (early November 2004), maximum ambient concentrations of PCE were found to be 2,713 ug/m3 (400 ppb) at the larger of the two cooling fan exhaust outlets. Additional supporting evidence came from the TAGA unit data collected from an exterior sweep of the Armen Cleaners building, which measured non-roof vent concentrations ranging from 1,000-2,000 ug/m3. Roof vent concentrations were found to be 27,130 ug/m3 (4,000 ppb) during the MDEQ November 2004 site visit. Future efforts to reduce ambient concentrations in the area immediately surrounding the dry cleaners should consider reduction of emissions from these exhaust points.

It should be reiterated that these conclusions are based on raw data from TT/EMI and that the final report is still being created as of March 2005.

Other Potential Volatile Organic Chemical Exposures

There are some other possible VOC exposures to the residents of properties surrounding the dry cleaning site based on Summa canister data taken in 2003. Please consult Appendix 3 for the non-PCE data from the properties surrounding the Armen Cleaners site. Soil gas or groundwater measurements have not been performed for the following chemicals to verify the original source in indoor air.

The data taken from property 34 revealed that basement air concentrations exceeded the acceptable indoor air concentration (AIAC) for benzene, styrene, *trans*-1,3,-dichloropropene as well as several breakdown products of PCE (including vinyl chloride, *trans*-1,2-dichloroethylene, and trichloroethylene). Furthermore, since all these measurements were equivalent to the method reporting limit, it appears data from this property is of unacceptable quality and should be re-sampled as the detection method was not sensitive enough to measure quantities of airborne contaminants that could cause health effects upon chronic exposure.

All measurements taken for hexachlorobutadiene (HCBD) exceeded the AIAC (1.1 ug/m3) at all properties sampled. Similar to what was seen with the data from the basement of property 34, it appears data from this property is of unacceptable quality and should be re-sampled as the detection method was not sensitive enough to measure quantities of airborne contaminants that could cause health effects upon chronic exposure. All "hits" for hexachlorobutadiene were considered "non-detects" as they were at the reporting limit; however, this reporting limit ranged from 29 to 580 ug/m3. The source of HCBD is unknown as is the method by which it is entering the house.

Nine (9) properties were found to equal or exceed the benzene AIAC (2.9 ug/m3) for data taken from the living space of the house. Fifteen (15) properties were found to have an exceedance of this standard from a sample taken from any part of the house (including basement and front/back porches).

Data taken from the living space of property 14 (63 ug/m3) exceeded the AIAC for methylene chloride (52 ug/m3); however, the basement measurement (33 ug/m3) did not exceed the AIAC. The source of the methylene chloride is unknown as is the method by which it is entering the house.

Data taken from the living space of property 18 (9.3 ug/m3) exceeded the AIAC for *trans*-1,3-dichloropropene (6.1 ug/m3). Likewise, data from the basement of this property (6.6 ug/m3) and from the basement of property 27 (6.2 ug/m3) also exceeded the AIAC. The source of this contaminant is unknown; however, there is the possibility that there may be some VI of *trans*-1,3,-dichloropropene at property 18.

Human Exposure Pathways

To determine whether nearby residents are, have been, or are likely to be exposed to contaminants associated with a property, ATSDR and MDCH evaluate the environmental and human components that lead to human exposure. An exposure pathway contains five major elements: 1) a source of contamination, 2) contaminant transport through an environmental medium, 3) a point of exposure, 4) a route of human exposure, and 5) an exposed population. An exposure pathway is considered a complete pathway if there is evidence that all five of these elements are, have been, or will be present at the property. Alternatively, an exposure pathway is considered complete if there is a high probability of exposure. It is considered a potential pathway if there is no evidence that at least one of the elements above are, have been, or will be present at the property, or that there is a lower probability of exposure. The table below lists the complete and potential pathways for human exposure to the chemicals of interest at the "Armen Cleaners" site.

Table 2. List of potential and complete exposure pathways at the Armen Cleaners site.

Source	Environmental Transport and Media	Chemicals of Interest	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Stack emissions	Air	PCE, other VOCs	Ambient air and indoor air	Inhalation	Residents of area surrounding Armen Cleaners, employees of facility and neighboring businesses	Past Present Future	Complete Complete Potential
Runoff from site	Soil gas	PCE, other VOCs	Nearby residential soils, vapor intrusion into indoor air	Direct contact, incidental ingestion, inhalation	Residents of area surrounding Armen Cleaners	Past Present Future	Complete Complete Potential
Runoff from site	Groundwater	PCE, other VOCs	Vapor intrusion into indoor air	Direct contact with groundwater, inhalation of indoor air	Residents of area surrounding Armen Cleaners, employees of facility and neighboring businesses	Past Present Future	Complete Complete Potential

NOTE: THE PRESENCE OF AN EXPOSURE PATHWAY IN THIS TABLE DOES NOT IMPLY THAT AN EXPOSURE WOULD BE SUBSTANTIVE OR THAT AN ADVERSE HEALTH EFFECT WOULD OCCUR

Generally, levels of PCE in air are higher in cities and/or industrial areas and higher still in areas immediately surrounding dry cleaning businesses and chemical waste sites. In addition, water (both above and below ground) near the site may contain PCE. In the specific case of Armen Cleaners, a plume of PCE has been characterized on the property via soil gas investigation (DLZ 2002). Due to the proximity of the groundwater table to the characterized plume, there is a high likelihood that the groundwater under the site is contaminated with PCE and its breakdown products. Not only does the groundwater under this neighborhood come into contact with residential home foundations, but it also is moving to the northwest and southeast (away from the original source on Armen Cleaner property). There have also been reports of basement flooding in the neighborhood and PCE (and other products) may be found in the floodwaters in residential basements. Furthermore, as the migration of contaminated groundwater continues, additional cases of residential VI may occur in areas NW and SE from the site.

VOCs (like PCE) from contaminated soil and groundwater can infiltrate a building through the foundation or other openings. These vapors can then be distributed throughout the structure via natural forces of ventilation that determine the course of indoor air, such as stack effect, passive/active ventilation, wind, preferential pathways, etc. This process is referred to as "vapor intrusion" (or VI, as defined earlier).

In those homes where VI of PCE is occurring, the obvious pathway of exposure is inhalation. In those homes that flood, there are other pathways of exposure, including direct contact with the contaminated water (dermal exposure) as well as potential hand-to-mouth activity following bare skin exposure to contaminated water (oral exposure). Finally, it is possible for small amounts of PCE to be taken up across moist membranes (eye, nose, etc.) and/or skin; however, the vapor must be trapped against skin as very little airborne PCE can pass through intact skin.

Two lesser known but possible pathways of exposure include contaminated food (previous studies have found PCE in small quantities in food prepared near dry cleaner businesses) and contaminated breast milk (as PCE has been found in the breast milk of exposed mothers) (EPA 2003).

Residential indoor air investigations can be confounded by the fact that PCE can be found in many consumer products, including water repellents, fabric finishers, spot removers, adhesives, and wood cleaners. Many similar VOCs can be found in various domestic formulations, including household cleaning products, automotive products, etc. The prevalence of these compounds in households makes it difficult sometimes to pinpoint sources of potential cases of VI without conducting a survey of household-specific sources of volatile air compounds. The specific sampling event conducted in from May-June 2003 was prefaced by a household VOC survey so it is thought that data collected during this time reflects actual contribution from the original source (and not household-specific contributions to overall VOC air concentrations within a particular dwelling).

Toxicological Evaluation

PCE is a non-flammable, colorless, dense liquid at room temperature that is relatively insoluble in water. Although insoluble, it will decompose slowly in water to yield certain breakdown products (or degradants). In air, it is sufficiently persistent to be transported through air before being degraded. Although it is primarily used in dry cleaning operations, it is also used in degreasing operations, as a laboratory solvent, in rug shampoos, and in the production of specialty chemicals (OEHHA 1997). The largest sources of PCE in indoor air are from dry cleaning operations, brake cleaning compounds, water repellent compounds, and fabric finishing products.

Most of the PCE released into water or soil will volatilize into the air, where it can reside for several months before breaking down into other chemicals or returned to the soil and water through the action of precipitation. PCE can move rapidly through soils and can get into groundwater, where again, it can reside for many months without breaking down. Under the right circumstances, PCE can be broken down in groundwater via bacterial action into trichloroethylene, dichloroethylene compounds, and vinyl chloride.

Starting in the 1970s, PCE was widely used in the dry cleaning and apparel industries to clean garments and remove stains. In fact, some estimates place the number of existing dry cleaners using PCE as high as 90% (Davis, 2003a). PCE is a volatile organic compound that easily volatilizes into gas form from water contamination and is a very common pollutant, found at over 50% of EPA "Superfund" sites. Most people can detect airborne PCE concentrations greater than 1 ppm from its characteristic sharp, sweet odor.

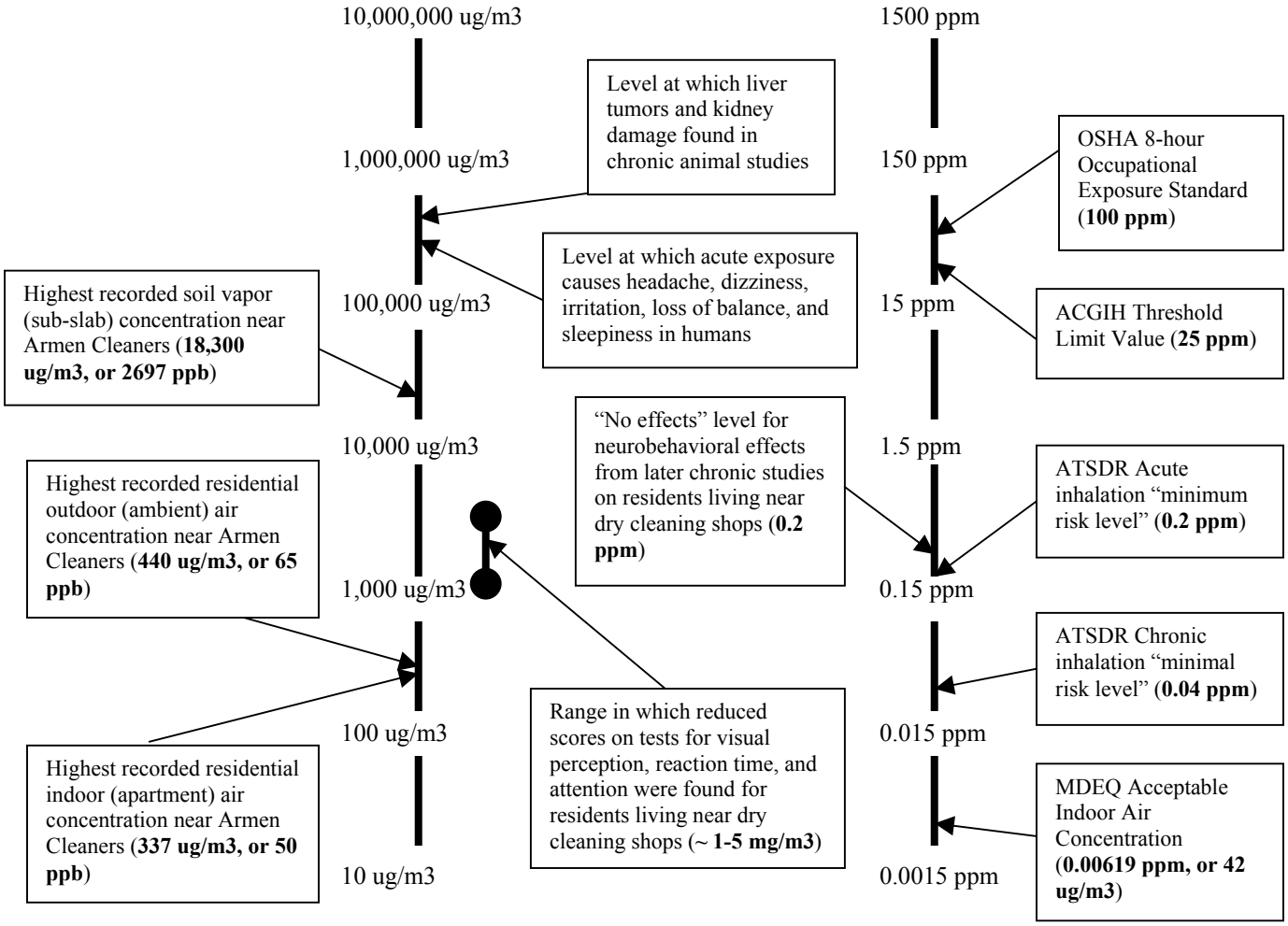
Generally, the non-cancer effects of exposure to PCE vapor (i.e., inhalation pathway) include irritation of the eyes and respiratory tract as well as depression of the central nervous system. PCE may make heart muscle more sensitive to the effects of epinephrine (which may induce irregular heartbeat) (OEHHA 1997). In addition, effects to the liver and kidney have been observed in animal studies following chronic inhalation exposure.

Short (acute) exposures to high concentrations of PCE in poorly ventilated areas can lead to dizziness, headaches, sleepiness, confusion, nausea, unconsciousness, difficulty in speaking or walking, and, ultimately, death. Repeated or prolonged skin contact with PCE can lead to irritation effects. ATSDR has derived an acute inhalation MRL for PCE of 1357 ug/m3 (or 200 ppb). An MRL is the concentration of a compound that is expected to cause no adverse, non-cancer health effects upon a brief exposure in a sensitive individual. The acute inhalation MRL is based on increased visual pattern recognition latencies and eye-hand coordination deficits observed in human volunteers (ATSDR 1997). The acute inhalation MRL specifically addresses short-term, or acute, exposures of 14 days or less.

Chronic effects of PCE exposure as determined by animal studies include effects on the liver, kidney, and central nervous system. Epidemiologic studies on dry cleaning workers have implicated some possible reproductive effects (including menstrual disorders, spontaneous abortions) while animal studies have reported some possible

developmental effects (developmental delays as measured by neurobehavioral testing performed on offspring born to exposed mothers) (OEHHA 1997). Other epidemiology studies performed on people living in proximity to dry cleaning operations have provided evidence that chronic exposure to low levels of PCE can affect visual spatial function (Altmann et al 1995, Schrieber et al 2002). More importantly, these studies further indicate that tasks requiring the processing of visual information (such as color vision, reaction time, visual memory, and visual contrast perception) can be affected by PCE exposure (EPA 2003). From these studies, a "low-observed adverse effect level" (LOAEL) of 300 ppb (2,035 ug/m3) was identified by EPA (2003), based on the aforementioned nervous system effects in human subjects. Furthermore, a "no observed effect level" (NOAEL) of 200 ppb (or 1,357 ug/m3) was identified in this same paper. (Again, this magnitude of exposure has not been seen in any indoor air measurements, but may be possible on/near the roof of the dry cleaners.)

Figure 3. Relative comparison of tetrachloroethylene (PCE) exposure levels, regulatory levels, and health effects. The values listed side-by-side in ug/m3 and ppm (connected by solid black lines) are equal (i.e., 1,000,000 ug/m3 is equivalent to 150 ppm).



ATSDR has established a chronic-duration inhalation MRL for PCE of 271 ug/m3 (40 ppb). The chronic inhalation MRL was based on increased reaction times (length of time between stimulus and response) among dry cleaning workers (ATSDR 1997). The EPA has not established a reference concentration for PCE (EPA 1998). A reference concentration is the daily inhalation exposure in humans, including sensitive subgroups, that is likely to be without appreciable risk of non-cancer, adverse health effects during a lifetime of exposure.

The MDEQ Air Quality Division (AQD) derived a residential screening concentration ("acceptable indoor air concentration," or AIAC) based on MDEQ's secondary risk screening level (SRSL) for PCE of 42 $\mu g/m^3$. This is the concentration of PCE in air estimated to cause 1 increased cancer risk in 100,000 people that are assumed to be exposed to this concentration for 24-hours a day, 350-days-per-year, for 30 years (MDEQ 2000). The SRSL is 17 ug/m3, which is based on 70 years of exposure of 365 days per year. The SRSL is used as a surrogate health benchmark indicating excess cancer risk of 1 in 100,000 from exposure to pollutants in ambient air. The AIAC is intended for application to indoor exposures.

Recent evidence presented by the EPA indicates that humans may be more sensitive to neurotoxic effects than the cancer effects these standards are designed to protect against (EPA 2003). Information presented in this report show that there have been some human studies on the non-cancer effects of low-level chronic exposure to PCE that identify a potential "no observed effect level" (NOAEL) of 200 ppb, or 1,357 ug/m3 (which is equivalent to the ATSDR acute inhalation MRL). It may, in fact, be more appropriate to compare the air data to these nervous system health benchmarks in order to comment on potential non-cancer health effects of exposure, which again, appears to be the most sensitive effect in humans. In addition, there appears to be a possible disconnect between the most sensitive endpoints and the corresponding standards: the EPA NOAEL of 200 ppb supposedly represents the most sensitive endpoint (neurological endpoint) yet the MDEQ AIAC of 6 ppb is much lower than this (and is for a cancer endpoint).

Animal studies performed with high concentrations and chronic exposures show that PCE can lead to liver and kidney damage (and cancers of the same organs). Additionally, epidemiologic studies on humans have provided some indication that PCE can pose an increased risk of cancer to exposed workers. As such, both the US Department of Health and Human Services and the International Agency for Research on Cancer have classified PCE as a probable human carcinogen (cancer-causing agent). Again, it appears to be prudent to compare the current exposure concentrations to these nervous system benchmarks to comment on possible health effects to residents that are likely not to inhabit a residence for 70 years, in addition to any cancer-based exposure standards. In fact, review of the existing data to identify the most sensitive and most appropriate health-based endpoint for PCE exposure may be in order, based on the findings of EPA (2003).

Occupational standards for PCE concentrations in air vary. The Occupational Safety and Health Administration's (OSHA) permissible exposure level for PCE is 100,000 ppbv

(ATSDR 1997). The American Council of Government Industrial Hygienists' (ACGIH) threshold limit value, 8-hour time weighted average (TLV-TWA) for PCE in an occupational setting is 25,000 ppbv. This is the 8-hour average concentration that that the ACGIH recommends not be exceeded to protect worker health. Occupational limits are not recognized, enforceable standards in residential settings as the exposure assumptions vary greatly. They are presented in Figure 1 as a reference.

To summarize the implications of PCE exposures at Armen Cleaners:

- The maximal ambient (outdoor) exposures level (65 ppb) exceeds the ATSDR MRL for chronic inhalation exposure (40 ppb) but does not exceed what EPA defined as a NOAEL and what ATSDR uses as an MRL for acute inhalation exposure (200 ppb). Both the ATSDR and EPA standards are based on neurological endpoints. Chronic exposures to concentrations greater than 40 ppb could result in increased reaction times to visual stimuli.
- The maximal indoor exposure level (50 ppb) at property 28 exceeds the aforementioned ATSDR chronic MRL. Although these levels are rarely found the living space of tested residences, chronic exposure to concentrations greater than 40 ppb could result in increased reaction times to visual stimuli.
- Both outdoor and indoor exposure levels have been found to exceed the SRSL (17 ug/m3, or about 2 ppb). This implies that chronic long-term exposure at these levels indicates an excess cancer risk of 1 in 100,000, although the SRSL is intended to be applied against ambient exposures. The corresponding indoor standard is the MDEQ AIAC (6 ppb).

Other Volatile Organic Compounds of Concern

Hexochlorobutadiene (HCBD): All "non-detect hits" for HCBD ranged from 29 to 580 ug/m3 and represent the limit of detection for all properties sampled. HCBD is normally found as a by-product during chlorinated solvent manufacturing (including PCE) and related products; it is also used in some industrial processes (OEHHA 2000). Although little is known about how it moves through air and water, it has been found in tissues of fish, shellfish, cow's milk, and human fat tissue (OEHHA 2000). Some volatilization from soil can be expected to occur with HCBD, so there could be potential for VI; however, the source mechanism by which it is entering indoor air is unknown at this point. Two possible sources could be the creation of HCBD during the use of PCE in a dry cleaning machine and the existence of HCBD as a contaminant within the PCE. Confirmation of the presence of HCBD in soil gas or groundwater would be useful data.

Brief inhalation exposures can cause nose irritation but the effects of chronic low-level exposure in humans is unknown. It has been classified a potential human carcinogen by EPA, has been shown to cause kidney and lung cancer effects in animal studies, and is implicated as being genotoxic (able to cause mutations or other damage to DNA) (ATSDR 1994). Both ATSDR and EPA have identified oral exposure standards for HCBD, but identified no standards for inhalation. The MDEQ AIAC for HCBD is set at 1.1 ug/m3 and the MDEQ SRSL is 0.5 ug/m3, which are well exceeded even at a "non detect" concentrations as high as 580 ug/m3.

Benzene: Nine (9) properties were found to equal or exceed the benzene AIAC (2.9 ug/m3) for data taken from the living space of the house. Given that the measured concentrations were all very close to the AIAC (ranging from 2.9 to 14 ug/m3 if you rule out the "bad data" at property 34) and that exposure to small amounts of benzene occur daily in ambient air, indoor air, and in the workplace, it is very likely consistent with background exposure. In fact, ATSDR (1997b) reports the background level to be 2.8 to 20 ppb (or about 8 to 60 ug/m3).

Methylene Chloride: Data taken from the living space of property 14 (63 ug/m3) exceeded the AIAC for methylene chloride (52 ug/m3), otherwise known as dichloromethane. This compound is not readily soluble in water and therefore, would not be an expected indoor air contaminant via the VI pathway. This is corroborated by the occurrence of a single detect in only one household's sample and by the fact that the basement reading is actually lower in concentration than the living space measurement. It is more likely that the occurrence of methylene chloride in indoor air is due to the storage of aerosol products, paint removers, automotive cleaners, or other household products (ATSDR 2000).

Dichloropropenes: Data taken from the living space of property 18 (9.3 ug/m3) exceeded the AIAC for *trans*-1,3-dichloropropene (6.1 ug/m3). The effects of breathing 1,3-dichloropropene in humans are nausea, vomiting, irritation of the skin, eyes, nose and throat, coughing, headache, fatigue and difficulty breathing (ATSDR 1992). Chronic low-level exposure has been found to cause nose and lung tissue damage in animal studies. The EPA classifies 1,3-dichloropropene as a probable human carcinogen due to lack of data in humans and sufficient evidence of carcinogenicity in animals. Similar to methylene chloride, the concentration in the living space was higher than the basement concentration, so VI may not necessarily be the pathway through which it enters these dwellings. 1,3-Dichloropropene is usually associated with treated farm fields and lesser amounts can be generated by sewage treatment facilities, electrical power stations, and industrial facilities that use cooling water in their processes (ATSDR 1992). It does not appear likely that the source of the dichloropropene is emissions from Armen Cleaners, but rather, could be a historic contaminant from past agricultural activity or from some other local source (such as a power station). Confirmation of the presence of dichloropropenes in soil gas or groundwater would be useful data.

Addressing the Unique Vulnerabilities of Children

In general, children may be at greater risk than adults from certain kinds of exposure to hazardous substances at sites of environmental contamination. They engage in activities such as playing outdoors and hand-to-mouth behaviors that increase their exposure to hazardous substances. They are shorter than adults, which means they breathe dust, soil, and vapors close to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages. Finally, genetic differences, health and nutritional status,

and exposure to other chemicals may lead to differences in childrens' (and adults') vulnerability.

The developing fetus, children, and the developing nervous system may have particular sensitivity to PCE exposure. Furthermore, animal studies report that PCE may be able to cross the placenta and that unmetabolized PCE has been found in breast milk (ATSDR 1997). However, it should be noted that effects of PCE exposure to young children via breast milk is unknown. For these reasons, it is important to identify young children, pregnant women, and women of childbearing age who may be exposed to PCE in the vicinity of the Armen Cleaners property.

CONCLUSIONS

The residential buildings immediately surrounding the Armen Cleaners Site in downtown Ann Arbor (Washtenaw County, Michigan) are being impacted by releases of the dry cleaning solvent perchloroethylene. In addition, there is still a well-defined plume of DNAPL (probably composed of PCE and its degradants) under the Armen Cleaners building as well as under property 28.

The most recent sampling at the Armen Cleaners site in 2003 included soil vapor, indoor air, and outdoor air measurements. Summa canisters were used to measure air at the properties surrounding the site in various locations, mainly basements, first floor rooms, and front/back porches. Sub-slab samples were taken using MIP technology to measure soil vapor concentrations. Finally, the TAGA unit was employed to measure ambient outdoor air samples in the area surrounding the site.

There are two main inhalation exposure pathways: exposure to ambient air and exposure to indoor air. The ambient exposures represent an indeterminate health hazard as they are sporadic and seasonal in nature (one would not expect outdoor concentrations to impact indoor concentrations during the winter months). Due to uncertainty in the indoor air measurements (i.e., the process may not have accurately characterized the indoor air concentrations given that the empirical data are so close to the health-based standard) as well as uncertainty in the chronic toxicity of PCE at the exposure standard (i.e., chronic exposure at these concentrations may not translate to an actual health impact), the indoor air exposure pathway is also considered an indeterminate public health hazard, given current conditions.

The data indicate that the properties immediately adjacent to Armen Cleaners are the most impacted by airborne PCE; however, there is potential for other more distant properties to be impacted as long as there is a mobile PCE plume migrating away from the Armen Cleaners property. There are likely be continued concerns over contaminated groundwater and vapor intrusion of PCE (and related degradation products) until this plume of PCE is remediated. Continued degradation of PCE in this plume to more carcinogenic breakdown products (such as vinyl chloride) will also occur until the plume is remediated. In fact, this plume represents a future public health hazard should migration of the contaminants be allowed to continue to the northwest and southeast and

come into contact with residential home foundations, potentially allowing additional cases of vapor intrusion.

As such, MDCH concludes the following for this site:

- Property 29 appears to be impacted by VI from contaminated groundwater as well as from cooling exhaust pipes removing PCE-contaminated air from inside the dry cleaning facility. Airborne PCE concentrations in the basement of this property (100 ug/m3) exceed the MDEQ AIAC value of 42 ug/m3 while first floor concentrations (41 ug/m3) essentially equal this standard. Ambient concentrations (380, 440 ug/m3) exceed ATSDR's chronic inhalation MRL for PCE.
- Property 27 has no detectable PCE in the basement and measurements of indoor (10 ug/m3) and outdoor air (7 ug/m3) by Summa canister reveal no exceedances of the AIAC. There is no proof of VI at the property and it appears as if indoor concentrations are originating from outdoor ambient levels of PCE; however, there is potential for soil vapor and groundwater contaminant migration from the site under this property and this should be followed over time.
- Property 28 has PCE airborne concentrations above the AIAC for all samples taken in the basement (85 and 170 ug/m3). While there may be some VI of PCE at this property, it is not currently leading to levels of concern within the living space of the house. Of greater concern is the concentrations of PCE under the home, which could lead to high levels of PCE in the basement air should the home be subject to flooding.
- Property 19 had PCE detected in the basement (23 ug/m3) and outside air (53 ug/m3), but not in the living space of the house nor underneath the house. There is no proof of VI at this property; however, outdoor concentrations could contribute to unhealthy indoor concentrations under the right conditions (like during summer, when doors and windows may be kept open for long periods of time).
- Properties 15 and 26 both had detectable PCE concentrations in the sub-slab readings (271 and 244 ug/m3, respectively) but no detectable quantities in the basement or living space air.
- It appears fairly evident that there will be continued possibility of VI into surrounding properties as long as the DNAPL exists. The likelihood of VI is much greater where the groundwater is close to the foundation of the home and where there may be cracks in the foundation, allowing vapor to enter the basement area from the sub-slab area.

There are some other possible VOC exposures to the properties surrounding the dry cleaning site based on Summa canister data:

- Of all the non-PCE volatile compounds that were detected in air, the compound of greatest concern is HCBD due to the lack of accurate characterization in indoor air and the possible synergistic effects on kidney tumor induction.

RECOMMENDATIONS

The following recommendations are being made by MDCH:

- MDCH recommends that re-sampling of the DNAPL plume and/or surrounding soil gas for hexachlorobutadiene and dichloropropenes be done to determine if this is the source of this contaminant. If it is detected, then indoor air concentrations of hexachlorobutadiene and dichloropropenes should be re-evaluated using a more sensitive method (i.e., using a method that can capture concentrations at or below the MDEQ recommended indoor air concentration).
- MDCH recommends that residents surrounding the Armen Cleaners property are provided with basic information on the site as well as health education materials for the contaminants and pathway(s) involved, including sensitive sub-populations in the area (pregnant women, breast-feeding infants, etc.)
- MDCH recommends that method(s) of reducing exposure to PCE (and other compounds of concern as discussed within this consultation) be implemented in the houses immediately adjacent to the site (properties 27, 28, and 29). These methods could include anything from basic home maintenance (sealing foundation cracks, etc.) to installation of air purifying devices. It is further recommended that follow-up indoor air testing be done to measure success of any exposure reduction method that is implemented. This is to prevent frequent exposure to ambient concentrations of PCE above the chronic MRL.
- MDCH recommends that some measure be implemented to reduce PCE emissions from the two cooling air exhaust pipes at the rear of the Armen Cleaner facility. Furthermore, MDCH recommends that these measures include the roof vent as well. This is to prevent frequent exposure to ambient concentrations of PCE above the chronic MRL.
- MDCH recommends that efforts to characterize the underground contaminant fingerprint, concentrations, and movement be continued so that residents may be updated as necessary. (In addition, this can help direct future health education measures.)
- MDCH recommends that planning for remediation of the DNAPL plume under the site begin as soon as possible.
- MDCH recommends that MDEQ review the existing database and monitor new information for human health effects of PCE exposure and revise the acceptable indoor air concentration, if necessary (as well as other PCE standards where appropriate). MDCH is available to assist in this effort, if necessary.

PUBLIC HEALTH ACTION PLAN

The following actions are proposed by the MDCH:

- MDCH will continue to be available to Ann Arbor residents as well as the city of Ann Arbor and Washtenaw County officials in order to address health concerns and other toxicological matters.
- MDCH will collaborate with MDEQ, the city of Ann Arbor, and Washtenaw County officials to discuss the re-sampling of the DNAPL plume (and the possibility of re-evaluating indoor air) for concentrations of hexachlorobutadiene, dichloropropenes, and other PCE degradants (if necessary).

- MDCH, in conjunction with the city of Ann Arbor, will provide basic information and appropriate health education materials to the residents surrounding the site.
- MDCH will collaborate with staff from the city of Ann Arbor to identify sensitive sub-populations (particularly young children, pregnant women and women of child-bearing age). MDCH, in conjunction with the city of Ann Arbor, will then provide health education materials to these sub-populations.
- MDCH will collaborate with MDEQ, the city of Ann Arbor, and Washtenaw County officials to ensure that some type of exposure reduction method be implemented in residential buildings where appropriate. This could take the form of providing activated carbon air-purifying devices similar to what was done in 2002.
- MDCH will collaborate with MDEQ, the city of Ann Arbor, and Washtenaw County officials to discuss the use of follow-up indoor air monitoring to determine effectiveness and/or outcome of implementing exposure reduction method(s).
- MDCH will collaborate with MDEQ, the city of Ann Arbor, and Washtenaw County officials to discuss the possibility of reducing ambient emissions from the Armen Cleaner facility. In particular, the two cooling air exhaust pipes at the back of the facility will be addressed.
- MDEQ (along with whatever support MDCH can provide) shall start planning for the remediation of the DNAPL plume under the site to prevent any future potential exposures due to plume migration.
- MDCH will be available for consultation to all affected parties and to review technical documents related to sampling and/or remediation of the site as it pertains to removal of the DNAPL plume under the site.
- MDCH will monitor new scientific information regarding neurological effects of low-level exposures to PCE in order to be aware and utilize the most accurate and most sensitive health-based exposure level.

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CERTIFICATION

This Armen Cleaners Health Consultation was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial Review was completed by the Cooperative Agreement Partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Leader, Cooperative Agreement Team, SPAB, DHAC, ATSDR

ARMEN CLEANERS

Washtenaw County, Michigan

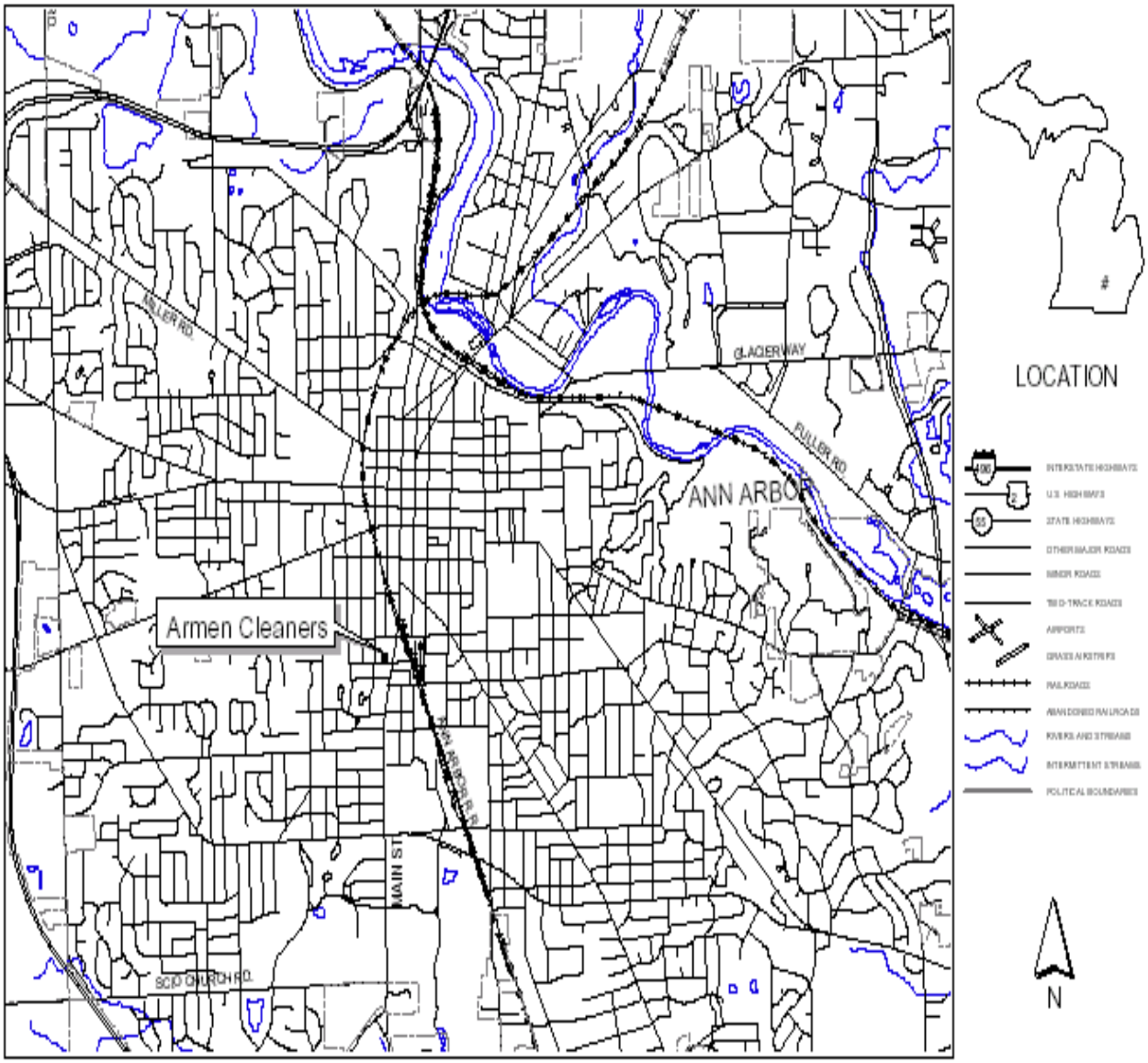
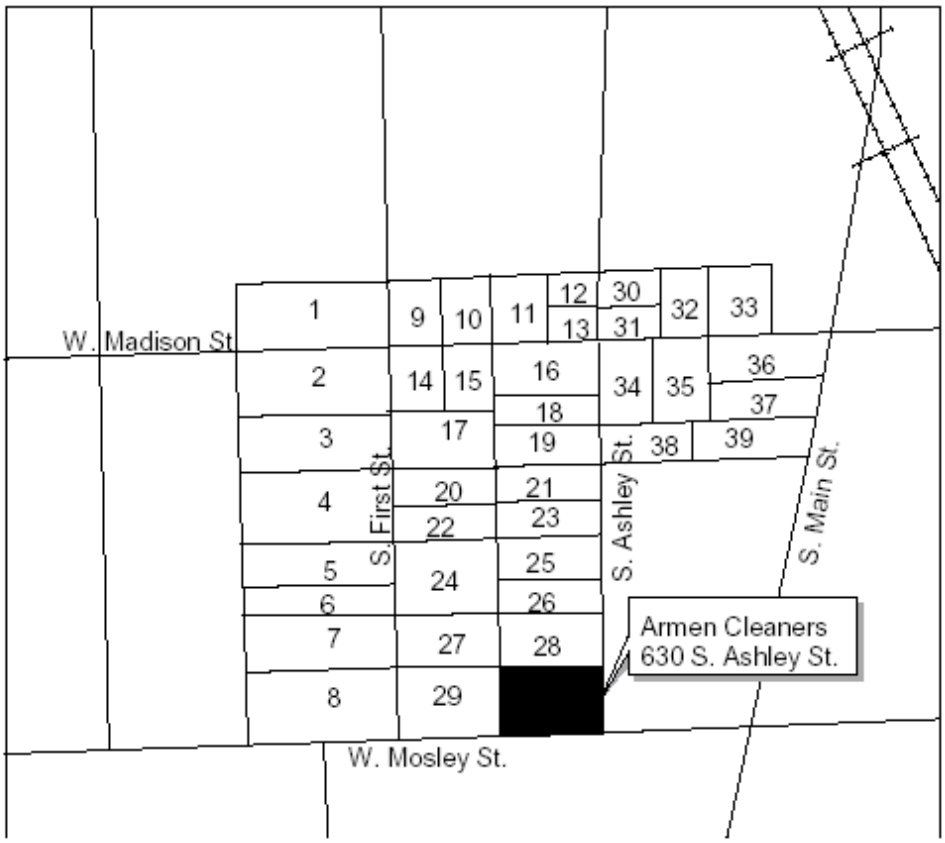


Figure 1.

Figure 2.

ARMEN CLEANERS NEIGHBORHOOD



Appendix 1 – Summa canister data included in previous MDCH health consultation (released March 2002). Indoor air concentrations of tetrachloroethlyene (PCE) at Property 28 in the text of the health consultation report), Ann Arbor, Michigan over 5 sampling events from November 2000 through December 2001.

Date	Sample Location	Tetrachloroethene concentrations*		Comparison Values		
		ppbv (vol./vol.)	ug/m^3	MDEQ residential screening criteria† (ppbv)	ATSDR Acute Inhalation MRL‡ (ppbv)	ATSDR Chronic Inhalation MRL (ppbv)
11/30/00	Basement SW	18.89	130.15	6.2	200	40
	First Floor SW	5.57	38.38	6.2	200	40
02/27/01	Basement 24 hr. (composite)	5.2	35.83	6.2	200	40
	Basement	<2.0	<13.78	6.2	200	40
	Apartment 1	2.7	18.6	6.2	200	40
	Apartment 2	<2.0	<13.78	6.2	200	40
	Apartment 3	6.0	41.34	6.2	200	40
	Apartment 4	<2.0	<13.78	6.2	200	40
07/25/01	Basement 24 hr. (composite)	23	158.47	6.2	200	40
	Basement	31	213.59	6.2	200	40
	Apartment 2	<0.38	<2.62	6.2	200	40
10/25/01	Basement 24 hr. (composite)	16	110.24	6.2	200	40
	Basement	20	137.8	6.2	200	40
	Apartment 2	22	151.58	6.2	200	40
12/19/01	Basement 24 hr. (composite)	8.4	57.88	6.2	200	40
	Basement	3.7	25.49	6.2	200	40
	Apartment 2	23	158.47	6.2	200	40

* Based on NIOSH: 1 ppbv PCE = 6.89 ug/m^3 PCE
† Cancer-based endpoint derived from MDEQ's Secondary Risk Screening Level
‡ ATSDR's Minimum Risk Level

Appendix 2 – Conclusions, Recommendations, and Public Health Action Plan from the former (March 2002) MDCH health consultation done for Property 28.

Excerpts from "Tetrachloroethene contamination in the indoor air of an apartment building near a dry cleaners – Ann Arbor, Washtenaw County, Michigan. March 6, 2002":

CONCLUSIONS

Chronic, low-level concentrations of PCE are found in the indoor air at the South Ashley apartments. The likely source is vapor infiltration through the building foundation from a highly contaminated groundwater plume under the structure.

Indoor air concentrations detected in one apartment and the basement exceed levels calculated by MDEQ's AQD to cause 1 excess cancer risk per 100,000 people. Based on the exceedence of MDEQ's residential screening criteria and reasonable certainty of eventual increase, MDCH has determined that the concentration of PCE in the indoor air at the South Ashley apartments constitutes a public health hazard.

RECOMMENDATIONS

The following recommendations were made in the course of the investigation by MDCH:

1. Investigate and implement abatement options that will reduce the concentration of PCE in the indoor air.

2. Continue monitoring the indoor air at the building for PCE to quantify exposures and gauge the effectiveness of abatement efforts.

3. Educate present and future tenants on pertinent health risks.

PUBLIC HEALTH ACTION PLAN

The following steps are proposed:

1. MDCH will work with MDEQ to continue monitoring for PCE in the indoor air at the South Ashley apartments.

2. MDEQ will work with its engineers and contractors to propose abatement options for reducing the indoor air concentrations of PCE.

3. MDCH's Health Educator will stay in communication with the tenants to answer any health related questions.

Appendix 3 – Other VOCs detected during 2003 sampling event. Data generated via Summa canister. Only those data hits that equal or exceed the MDEQ "acceptable indoor air concentration" (AIAC) are listed here. Hexachlorobutadiene exceeded the AIAC at all properties as the limit of detection for all hits was higher than the AIAC.

VOC of concern	*Sampling Site*	*Sampling location*	*Measured concentration (ug/m3)*	*Acceptable Indoor air concentration (ug/m3)*
Benzene	Property 19	Front Porch	2.9, 3.3	2.9
	Property 28	Basement	3.3, 3.4	
		Kitchen	3.1	
		Front Porch	3.4	
	Property 26	Basement	3.0	
	Property 21	Basement	3.0	
	Property 29	Basement	3.0	
		Back Porch	3.3	
	Property 18	Kitchen	3.0	
	Property 15	Front Porch	3.0	
	Property 23	Basement	3.0	
		Living Room	2.9	
		Front Porch	3.0	
	Property 35	Basement	3.0	
		Living Room	3.7	
		Front Porch	3.1	
	Property 34	Basement	44.0	
	Property 27	Basement	4.4	
		Kitchen	3.1	
	Property 14	Basement	2.9	
		Dining Room	2.9	
		Front Porch	3.6	
	Property 3	Basement	4.6	
		Kitchen	6.5	
	Property 22	Dining Room	3.2	
		Front Porch	3.0	
	Property 24	Basement	14	
		Den	2.9	
Methylene Chloride	Property 34	Basement	47	52
	Property 14	Basement	33	
		Dining Room	63	
Styrene	Property 34	Basement	58	43
Trans-1,2-dichloroethylene	Property 34	Basement	220	73
Trans-1,3-dichloropropene	Property 34	Basement	62	6.1
	Property 27	Basement	6.2	
	Property 3	Basement	6.6	
		Kitchen	9.3	
Trichloroethylene	Property 34	Basement	73	14
Vinyl Chloride	Property 34	Basement	35	5.5

Appendix 4 – Details of the "perc" study done in 2003 (as taken from City of Ann Arbor web site, see http://www.ci.ann-arbor.mi.us/EnvironmentalCoordination/Perc.html for more details).

Homeowner Survey

Prior to any sampling, homeowners in the study area will be asked to fill out a survey regarding the use of household cleaners and the frequency of carpet, furniture and garment dry-cleaning. In addition to the survey, homeowners will be asked to sign site access agreements for the soil, water and air sampling, and will be requested to remove certain cleaning products and dry-cleaned garments from their homes a minimum of 48 hours prior to the air sampling. Homeowners will also be asked to refrain from having carpets and furniture cleaned or pesticides applied during the study period. These initial steps must be accomplished prior to the sampling if the air quality testing is to provide a reliable indicator of chronic Perc exposures.

Soil vapor monitoring installations with Geoprobes

With the aid of a piece of equipment called a Geoprobe®, the Technicians are able to drill a hole in the ground approximately 2 inches in diameter and advance a Membrane Interface Probe (MIP) to depths up to 50 feet. The MIP is a tool that produces real-time, continuous chemical and physical logs of this underground environment called the subsurface. Data from these analyses can be used to determine if a pollutant has migrated down through the soil and possibly into the groundwater aquifer and to assist in identifying areas in need of additional study. The purpose of this segment of the study is to evaluate the subsurface for the presence of Perc and other solvents. Results from these tests will provide the Task Force with real-time data and a 3-dimensional picture of the soil and groundwater characteristics, including the location of contaminants as well as potential and existing pathways for the contaminants to travel.

While the sampling equipment used with the Geoprobe is very small in diameter, about the size of a can of soda, it is a very sensitive piece of equipment and installation requires truck or all-terrain vehicle access at the site. Technicians will repair any damage to lawns or landscaping as a result of this work.

Shortly after installation of these soil gas monitoring points, a mobile laboratory called TAGA (Trace Atmospheric Gas Analyzer) will be on hand to collect and provide analysis of the soil vapor samples. The TAGA mobile laboratory is used primarily for analyzing volatile organic compounds in soil vapor and air. The information generated is screening data that provides analytical results to on-site project managers within hours. This rapid turn-around-time is invaluable when one of the data quality objectives is to define the levels of pollution at various points at a given site.

As standard procedure, the workers will be wearing special clothing and hoods. On a daily basis, these workers directly handle contaminants in the soil and groundwater that homeowners never access because they are underground. The workers are required to

wear protective clothing as a precaution against potential risks. This sampling poses no foreseeable health risk to homeowners, neighbors or pets.

Soil gas probes installations in basements

Based upon the information gained from the MIP, the study team will identify houses that have a potential for intrusion of vapors from the ground. Permission will be sought from selected homeowners for installation of gas probes in basements to allow soil gas samples to be collected from below the floor of their basement or crawl space slab.

These probes will be semi permanent installations allowing ongoing monitoring of the contaminant plume and assessment of soil gas concentrations during remediation efforts if those become necessary.

Soil vapor monitoring and indoor air sampling with TAGA unit

The Trace Atmospheric Gas Analyzer (TAGA) is a self-contained mobile laboratory capable of real-time sampling and analysis from various environmental sources and concerns. In addition, the TAGA has specialized sampling equipment for measuring indoor air and at remote locations. More information about the TAGA can be found at:

http://www.epa.gov/earth1r6/6lab/taga.htm

The air monitoring and analysis instruments aboard the TAGA ensure that such site assessments and investigations are done in a safe manner and that airborne contamination from sites is identified and tracked.

Once the house has been screened for VOCs using the TAGA, samples will be collected for fixed laboratory analysis. Samples will be collected using Summa Canisters, which are about the size of a basketball and are specially designed containers. Samples will be collected over a 24-hour period from the basement and the main living area.