

Health Consultation

ALL AMERICAN BARBER SHOP
DERRY, ROCKINGHAM COUNTY, NEW HAMPSHIRE
EPA FACILITY ID: NHD018905216

JUNE 20, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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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.

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HEALTH CONSULTATION

ALL AMERICAN BARBERSHOP

DERRY, ROCKINGHAM COUNTY, NEW HAMPSHIRE

EPA FACILITY ID: NHD018905216

Prepared by:

New Hampshire Department of Environmental Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

SUMMARY AND STATEMENT OF ISSUES

On February 27-28, 2006, the Environmental Protection Agency collected indoor air samples from the All American Barber Shop (AABS), located at 11A East Broadway in Derry, Rockingham County, New Hampshire. The building (Lot number 30117) consists of three discrete business units, one of which is occupied by the AABS. The building is adjacent to a nearby former dry cleaning establishment, Shamrock Cleaners. EPA New England's Office of Site Remediation and Restoration, Emergency Response and Removals Section excavated soils containing volatile organic compounds (VOCs) from Shamrock Cleaners in April -May 2007. The February EPA indoor air sampling event was conducted to determine whether VOCs below Shamrock Cleaners (in soils & groundwater) were volatilizing and migrating into the AABS. EPA specifically collected and analyzed one indoor air sample from the AABS first floor (1).

The DES Environmental Health Program used the air samples collected by EPA to complete this health consultation. The purpose of the health consultation is to determine if inhalation of indoor air inside the AABS presents a human health risk. After thorough analysis of all air data collected, EHP has concluded that adverse health effects are not expected to result from inhalation exposure to indoor air at the AABS.

PURPOSE

The Agency for Toxic Substances and Disease Registry (ATSDR) is a non-regulatory federal agency mandated by Congress to assess the public health impact of exposure to hazardous substances released to the environment. To fulfill its mandate, ATSDR enters into formal partnerships with state agencies to carry out site-related evaluations on environmental exposures and public health. For 18 years, ATSDR and the Environmental Health Program (EHP) have maintained a cooperative agreement to conduct these activities in the state. EHP is a non-regulatory program within the New Hampshire Department of Environmental Services (DES). It serves to assess the human health implications of hazardous chemical releases, and to make recommendations to protect the public health.

The purpose of this health consultation is to determine if inhalation of indoor air at the AABS presents a human health risk. It presents an evaluation of environmental data provided to EHP from an air sample collected at the All American Barber Shop (AABS) located at 11A East Broadway on February 27-28, 2007.

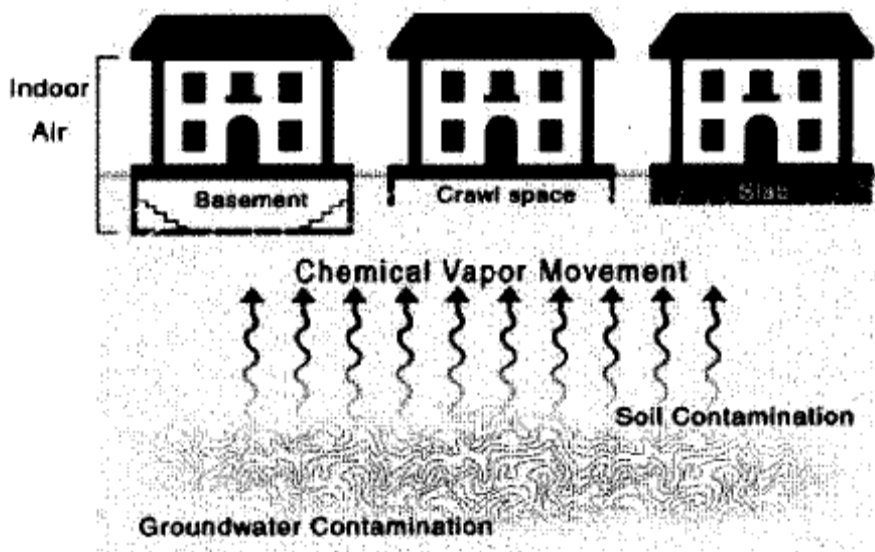
BACKGROUND

The Former Shamrock Cleaners (site) was a dry-cleaning establishment that operated from approximately 1950 until 2001. From about 1984 through 2001, tetrachloroethylene (also known as perchloroethylene, perc, or PCE) was used in dry-cleaning operations at the Site. Prior to 1984 "Stoddard Solvent" based cleaners were used for dry-cleaning. In August 2005 the former Shamrock Cleaners building (Lot No. 3017) and an adjacent unoccupied apartment building (Lot 3018) were demolished (2).

A DES contractor, Sanborn, Head & Associates (SHA), conducted a series of investigations to determine the extent of contamination at the site. These investigations identified contaminants in the groundwater, especially PCE, at levels that could impact the soil above the groundwater (2).

All soils contain gaps between their individual particles which are filled with either liquids (usually water) or gases. Soil gas is a term used to describe the gas that fills these voids. When VOCs contaminate and mix with groundwater, they tend to separate from a liquid phase into a soil gas phase. These soil gas contaminants can then migrate through the soil gaps and possibly enter confined building spaces (basements) through crawl spaces, plumbing holes, other floor holes (e.g., sumps) and foundation cracks. This could result in indoor air contamination. As a result of PCE contamination in site groundwater, SHA conducted soil gas testing at the site; commonly known as a soil-gas survey. This method is routinely used to determine the existence or extent of soil contamination (from a groundwater source in this case) (2, 3).

Figure 1 – Movement of contaminant vapors from groundwater into soil & indoor air (3).



The SHA soil-gas survey at the site identified PCE ranging from 17,000 $\mu\text{g}/\text{m}^3$ to 110,000 $\mu\text{g}/\text{m}^3$ (2). Due to these elevated soil-gas concentrations and historical groundwater contamination data detected at the Site, it was decided that indoor air quality sampling and analysis should be conducted by the Environmental Protection Agency (EPA) at the AABS. EPA also simultaneously collected an outdoor ambient air sample to be used for comparison purposes. This ambient air sample was later invalidated due to sample contamination and was omitted from consideration (1). EHP reviewed the EPA report and evaluated the potential for adverse health effects to occur from indoor air exposures to site-related compounds including PCE and its breakdown components. EHP utilized site-specific information collected during a May 2, 2007 visit for purposes of evaluating this indoor air exposure (4).

DISCUSSION

A. Exposure Pathways

Human exposure to environmental contamination occurs only when there is a completed pathway. A *completed* pathway exists when the following five critical elements are present: 1) a source of contamination or release (subsurface soil & groundwater); 2) environmental fate and transport (contaminated soil/groundwater to indoor air); 3) a point or area of exposure (AABS); 4) a route of human exposure (inhalation); and 5) a receptor population (workers at the AABS). These five elements determine the extent of past, present, or future site-related exposures. In a *potential* exposure pathway, one or more of the critical elements may not be present, but information is insufficient to eliminate or exclude it. For example, an exposure could have occurred in the past, could be occurring at present, or could occur in the future. An exposure pathway is *eliminated* if one or more of the critical elements are missing. Eliminated exposure pathways may also be referred to as incomplete (5).

Table 1 presents the onsite pathway for the AABS (indoor air in the primary work area). This pathway is evaluated and discussed in the remaining sections of this health consultation. Public water is provided to this complex. Groundwater contamination at this Site does not impact the quality of water supplied to residents. The drinking water, like all water supplied from public water sources, is considered safe for drinking, bathing, and other domestic uses.

Table 1. Potential Onsite Pathway for the All American Barbershop (Lot No. 30117) located in Derry, New Hampshire.

Source	Environmental Transport And Media	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Contaminated Soil & Groundwater (Site)	Subsurface soil & Groundwater to Indoor Air through foundation	Indoor Air Onsite	Inhalation	Workers	Past	Completed
					Present	Completed
					Future	Potential

Contaminants are migrating from the Site through subsurface soil and groundwater via a groundwater contaminant plume. Vapors emanating from the plume may penetrate the AABS building foundation and mix with indoor air. Workers could be exposed by breathing contaminated indoor air.

B. Environmental Contamination Data

An integral element of every health consultation is a review of site-related environmental contamination. In the preceding section, one pathway for possible human exposure was identified (indoor air). This section examines indoor air contaminants that may pose a hazard to the AABS workers. Environmental sampling preparation, procedures, and results provided in the report prepared by EPA dated April 16, 2007 are summarized below for this potential pathway (1).

On February 27, 2007 EPA conducted a pre-sampling inspection, product inventory and physical layout/condition assessment of the AABS first floor work area. These steps are conducted to identify potential sources of volatile organic compounds (VOCs), and to minimize the contribution of VOCs from common indoor sources or activities. At approximately 1:00 PM, they began to collect the three indoor air samples over a 24-hour period from the first floor of the AABS. Samples were collected in accordance with the EPA Region 1 Standard Operating Procedure for the Sampling of Trace Volatile Organic Compounds using SUMMA Polished Stainless Steel Canisters EPA-REG1-ESD/CAN-SAM-SOP, March 2001, Revision 2. The pre-evacuated 6-liter Summa canisters were fitted with mechanical flow controllers calibrated to 3ml/min (1).

The Summa canisters were subsequently gathered by EPA at approximately 1:00 PM on February 28, 2007 and verified to be below atmospheric pressure, thus indicating that the sample was properly collected. The samples were then transported to the EPA Laboratory, properly logged in, and analyzed for volatile organic compounds (VOCs) using EPA Method TO-15. Table 2 lists the concentrations of Site-related VOCs that were detected in the indoor air sample (1).

Table 2: Concentration (ppbv) of site-related VOC contaminants detected at the All American Barbershop (Lot No. 30117) located in Derry, New Hampshire on February 27-28, 2007 (1).

Contaminant	First Floor -Canister #20854 (ppbv)
Tetrachloroethylene	0.29

“ppbv” - parts-per-billion volume

C. Environmental Data Evaluation & Contaminants of Concern

After exposure pathways are designated and environmental data are summarized, site-related indoor air contaminants are evaluated. EHP uses a conservative, protective approach to determine whether contaminant levels constitute a potential health hazard. Health-based comparison values (CVs) are used to identify pollutants unlikely to present a health concern. If a concentration is below the CV, the compound is eliminated from further analysis. The remaining contaminants are subjected to a thorough scientific literature review to determine whether or not their levels present a public health hazard (5).

CVs used in this report represent concentrations of contaminants that current scientific literature concludes are "harmless." CVs are conservative, represent "worst-case" exposure assumptions, and include ample safety factors in consideration of sensitive populations such as children, the elderly, and those with chronic respiratory disease. Therefore, CVs are protective of public health in most exposure situations. If a contaminant level is lower than its CV, it is unlikely that harmful effects will result. If a contaminant exceeds its CV, it is examined in greater detail. Because CVs are based on conservative assumptions, the presence of concentrations greater than a CV does not necessarily indicate that adverse health effects will occur among exposed populations (5).

Table 3 lists the highest measured VOC concentrations and their associated CVs used in this assessment. Table 3 also delineates the VOCs associated with Site (PCE and PCE-related contaminants), as well as additional contaminants that were detected but not Site-related. These concentrations represent the maximum level that an individual may be exposed to assuming a continuous 24-hour exposure. They also specifically represent levels collected in the first floor work area; where workers spend the bulk of their time. As a conservative measure, Site-related VOCs not detected during laboratory analysis were also included at one-half of their analytical detection limit (referred to as "estimated" in Table 3). For example, if the analytical device was unable to detect the target compound, EHP assigned a value on-half of the instrument's lowest measurable quantity. These VOC concentrations were then compared to relevant ATSDR and EPA cancer and non-cancer air CVs. Bolded font indicates that the CV was exceeded (1).

EHP compared the highest recorded or "estimated" contaminant concentration to its CV. The comparison revealed that Site-related concentrations of PCE, trichloroethylene (estimated), and vinyl chloride (estimated), exceeded their respective cancer CVs. EHP then conducted a site-specific risk assessment to determine if these concentrations represented a health concern to the barber shop workers and their children. The conservative exposure scenario employed by EHP was based on an adult worker breathing indoor air for 8 hours per day, 300 days per year (Monday through Saturday), over a twenty five-year duration of exposure. EHP also considered the following additive child exposure scenario: 1) a young child (1yr-5yrs) breathing indoor air 8 hours per day, 100 days per year (2 days per week), over a five-year duration of exposure; and 2) a child (6yrs-18yrs) breathing indoor air 3 hours per day (after school), 250 days per year (5 days per week), over a thirteen-year duration of exposure (4). The scenarios also assumed that the highest recorded or "estimated" contaminant concentrations were present throughout the building (1).

Table 3: Highest actual and estimated VOC concentrations (ppbv) and respective CVs detected in the All American Barbershop (Lot No. 30117) located in Derry, New Hampshire on February 27-28, 2007 (1, 6, 7, 8, 9).

Contaminant	First Floor #20854 (ppbv)	Non-cancer CV (ppbv)	Cancer CV (ppbv)
Site-Related			
1,1,1-Trichloroethane	0.08(estimated)	700 (c)	-
1,1-Dichloroethene	0.075 (estimated)	20 (c)	-
Chloroethane	0.75 (estimated)	4000 (a)	0.83 (f)
Tetrachloroethylene (PCE)	0.29	40 (b)	0.046 (f)
Trichloroethylene (TCE)	0.08 (estimated)	100 (c)	0.003 (f)
Vinyl Chloride	0.075 (estimated)	40 (a)	0.04 (d)
<i>cis</i> 1,2-Dichloroethene	0.075 (estimated)	9.3 (e)	-
<i>trans</i> -1,2-Dichloroethene	0.08 (estimated)	200 (c)	-
Non Site-Related			
1,2,4-Trimethylbenzene	0.46	*1.22 (a)	-
1,3,5-Trimethylbenzene	0.23	*1.22 (a)	-
1,3-Butadiene	0.26	0.9 (a)	0.01 (d)
4-Ethyltoluene	0.63	-	-
Benzene	0.76	3.0 (b)	0.03 (d)
Carbon Tetrachloride	0.07	30 (b)	0.01 (d)
Cyclohexane	0.15	1700 (a)	-
Dichlorodifluoromethane	0.73	-	-
Ethylbenzene	0.44	200 (a)	-
Hexane	0.53	200 (a)	-
m/p-Xylenes	1.08	23 (a)	-
Methyl Ethyl Ketone	0.85	1700 (a)	-
Methylene Chloride	0.17	300 (b)	1.09 (f)
o-Xylene	0.44	23 (a)	-
Styrene	0.12	60 (b)	-
Toluene	2.00	80 (b)	-
Trichlorofluoromethane	0.52	-	-
Trichlorotrifluoroethane	0.14	-	-

Comparison Value Sources

- (a) EPA RfC
- (b) ATSDR Chronic MRL/EMEG
- (c) ATSDR Intermediate MRL/EMEG
- (d) ATSDR CREG
- (e) EPA Region 9 PRG
- (f) EPA Region 3 RBC

“ppbv” - parts-per-billion volume

“-” - indicates that no comparison value has been established.

“estimated” – indicates the VOC was not detected by the laboratory, however EHP used ½ of the analytical detection limit as a conservative measure.

“*” – indicates the CV is provisional

D. Public Health Implications of Exposure (Site-Related)

This section evaluates the public health implications of site-related indoor air contaminants measured at the AABS. Available monitoring data indicate that of the eight site-related VOCs sampled, PCE, trichloroethylene (estimated), and vinyl chloride (estimated) were detected above their respective cancer CVs. Of these three, only PCE was measured above its analytical detection limit (1). Following is a review of the scientific literature on the health effects of PCE.

PCE is a liquid chemical used for dry cleaning, metal-degreasing, and for making ingredients used in consumer products (water repellents, silicone lubricants, fabric finishers, spot removers, adhesives, and wood cleaners). PCE evaporates easily into the air and has a sharp, sweet odor. The odor threshold for PCE in air is approximately 1000 parts in 1 billion parts of air (1000 ppb) or more. Common background levels of PCE are several thousand times lower than those in some workplaces. Background levels found in outside ambient air are usually less than 1 ppb (10).

PCE is normally emitted into air by evaporation from industrial or dry cleaning operations that use this chemical. Clothes brought home from the dry cleaners (using PCE as the solvent) may release small amounts of PCE into the air as well. PCE can also be found in soil at contaminated sites. When PCE is present in soil, it can migrate through soil pores and contaminate ground water; where it can persist for many months without being broken down. Under certain conditions, however, bacteria will break down PCE to form other additional chemicals. These specific chemicals were included in EHP's analysis and are listed as "Site-related" in Table 3 (10).

People can be exposed to PCE in air from environmental and occupational sources as well as consumer products. The amount of PCE entering your body depends on the level in air, how fast and deeply you are breathing, and how long you are exposed to it. The majority of inhaled PCE is immediately exhaled. The remainder is either metabolized (mostly by the liver) into other chemicals that leave your body within days, or is stored in body fat. PCE in fatty tissue remains in the body for several days or weeks before it is eliminated (10).

Exposure to PCE concentrations over 1000 times higher than those measured (or estimated) in the AABS indoor air can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. These symptoms occur almost entirely in occupational or hobby environments. The OSHA limits for PCE is 100 parts in 1 million parts of air (100 ppm) for an 8-hour workday over a 40-hour workweek. Health effects from breathing PCE at low levels are not entirely certain, however, the risk from ambient air levels (usually less than 1 ppb) is minimal. Animal studies have shown that PCE at high dosages can cause liver and kidney damage and liver and kidney cancers. The relevance of these studies to humans is unclear. PCE has not been shown to cause cancer in people, but the International Agency for Research on Cancer (IARC) has classified it as probably carcinogenic to humans (10).

EHP evaluated an exposure scenario for adults and children (1-18 yrs) exposed to site-related VOC indoor air contaminants at the AABS. Exposure to the maximum measured concentration of PCE, as well as estimated levels of trichloroethylene, and vinyl chloride, does not pose a significant increased cancer risk among the AABS workers or their children. The cumulative theoretical excess lifetime cancer risk for all recorded and estimated concentrations of carcinogenic, Site-related VOCs is also not significant.

Individual VOC contaminant levels measured in indoor air at the AABS were all below established non-cancer CVs. As an additional conservative measure, the potential for non-carcinogenic health effects was evaluated by a comparison with the calculated inhalation average daily dose. In all cases, each calculated inhalation average daily dose was below a level of concern for a lifetime of continuous exposure (5). The cumulative potential (all VOCs added) for non-cancer health effects also did not indicate that residents would experience adverse health effects from these exposures.

E. Non Site-Related VOCs

Available monitoring data indicate that three of the seventeen “non-site-related” VOCs detected in the AABS were above their respective cancer CVs – 1,3-butadiene, benzene, and carbon tetrachloride. This section explores the possible sources of non-site-related VOCs, and evaluates the specific levels measured in the AABS.

According to DES Vapor Intrusion Guidance, background sources should always be considered when interpreting indoor air data. Background information is assembled by surveying the indoor sampling area for potential VOC sources (i.e., consumer products, chemical containers, oil tanks, etc.), and by collecting an outside ambient air sample to be used for comparison purposes (3). Unfortunately, EPA’s ambient air background sample was contaminated during laboratory analysis (1). As an alternative, EHP utilized background ambient and indoor air levels published by NHDES, ATSDR and New York State for comparison purposes.

The EPA “Survey of Occupied Dwelling” form prepared for the AABS indicated that numerous hair care products, including hairspray, as well as cleaning disinfectants were identified in the first floor work area prior to sampling (3). These sources may account for portions of the non-site-related VOCs identified. Other possible underground VOC sources may include two nearby properties where leaking underground storage tanks were recently remediated – Cumberland Farms located on 22 East Broadway and D&J Automotive located on 1 West Broadway (11). Additional plausible sources of air contaminants are fugitive air emissions from the Cumberland Farms gasoline filling station (across the street) as well as vehicular traffic along Broadway.

The non-site-related VOCs 1,3-butadiene, benzene, and carbon tetrachloride were detected in the AABS at levels above their cancer CVs. All indoor air data results were, however, indicative of background concentrations normally found either in outside ambient air, or in common indoor air environments. Any risk associated with these VOC

contaminants would thus be experienced by the general population. The specific levels and respective background comparisons are listed below.

- The maximum indoor air level of 1,3-butadiene measured in the AABS (0.26 ppb) exceeded its cancer CV, but was nearly the same as average ambient background levels typically found in the ambient air of cities and suburbs in the US (0.30 ppb) (7, 12). The level was also almost identical to levels measured in nearby buildings near the Site (1).
- The maximum indoor air benzene level measured in the AABS (0.76 ppb) exceeded its cancer CV, and was higher than the average ambient background levels measured throughout New Hampshire (0.28 ppb) (7, 13). The level, however, was similar to indoor air levels measured in buildings that heat with fuel oil (50th percentile – 0.69 ppb) (14). The level was also almost identical to those measured in six other buildings near the Site (1). This suggests the existence of a more localized background level influenced possibly by the close proximity of a gasoline filling station (Cumberland Farms gasoline filling station is located approximately one block away) (4).
- The maximum indoor air level of carbon tetrachloride measured in the AABS (0.07 ppb) exceeded its cancer CV, but was nearly the same as average ambient background levels measured throughout New Hampshire (0.10 ppb) (7, 13). The level was also nearly identical to those measured in two other businesses located in the same building (1).

A review of the scientific literature on the specific health effects of 1,3-butadiene, benzene, and carbon tetrachloride is available in Appendix B.

CHILD HEALTH CONSIDERATIONS

Children are at greater risk than adults from exposure to indoor air contaminants for several reasons. Children are smaller than adults, resulting in higher doses of chemical exposure per body weight. Children are often more sensitive to the effects of chemical exposures than adults and can sustain permanent damage if toxic exposures occur during critical growing stages. Finally, children depend on adults for risk identification and avoidance. For these reasons, EHP considered a young child exposure scenario when completing this health consultation for the AABS.

CONCLUSIONS

After thorough analysis of all air data collected, EHP concludes that adverse health effects are not expected to result from inhalation exposure to indoor air at the AABS. Exposure to indoor air at the AABS therefore poses *no apparent public health hazard*.

RECOMMENDATIONS

Based on the conclusions of this report, EHP makes the following recommendations:

- EHP staff will evaluate any additional indoor air monitoring data that may become available.
- If additional samples are taken by EPA, collect the samples from the first floor using the analytical Method TO-15 with SIM analysis. This analysis is capable of detecting VOC contaminants at a much lower level than Method TO-15.
- If additional samples are taken by EPA, then simultaneously collect an ambient air sample for risk assessment comparison purposes.

PUBLIC HEALTH ACTION PLAN

Past Actions

- EPA collected environmental samples at the site on February 27-8, 2007.
- EPA conducted a removal action at Shamrock Cleaners property beginning in April, 2007.
- DES participated in an EPA Open House for the site on April 4, 2007 to discuss public health issues.

Present Actions

- EHP is continuing to evaluate indoor air quality data for other properties impacted by Shamrock Cleaners.

Future Actions

- EHP will distribute this health consultation to EPA and DES.
- EHP will evaluate any new environmental sampling data that becomes available.

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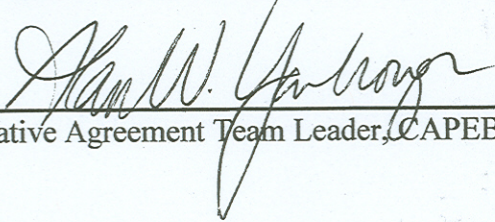
Certification

This health consultation on the evaluation of air data for the All American Barber Shop located at 11A East Broadway was prepared by the New Hampshire Department of Environmental Services, Environmental Health Program, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was prepared in accordance with methods and procedures approved at the time the consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.



Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

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



Cooperative Agreement Team Leader, CAPEB, DHAC, ATSDR

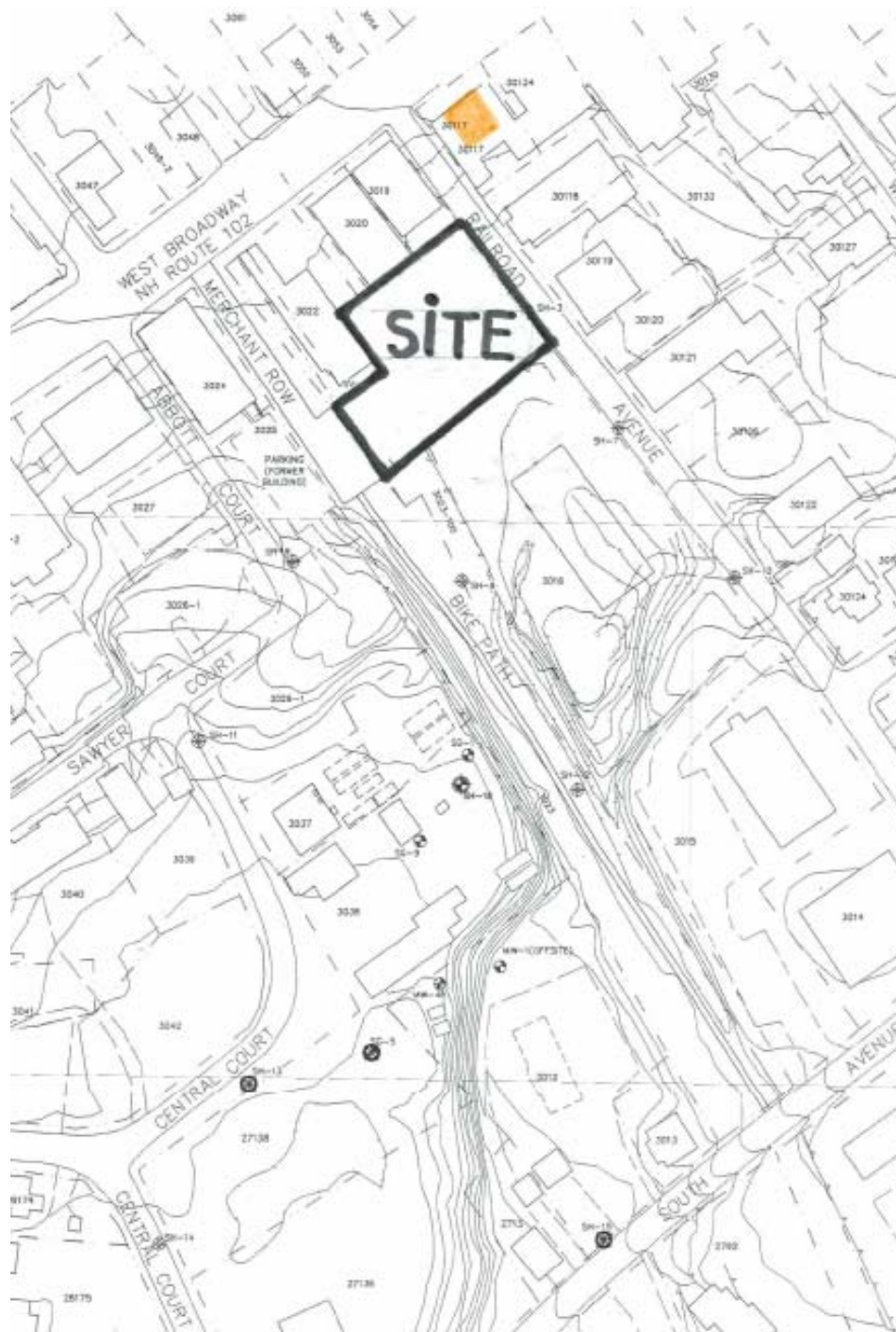
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APPENDIX A

Figure 1. Site Map - Derry, New Hampshire (2).



APPENDIX B

1. 1,3-Butadiene

1,3-butadiene is a colorless gas with a mild gasoline-like odor that breaks down quickly in the air. In fact, half of 1,3-butadiene goes away from the air in about 2 hours during sunny weather. 1,3-butadiene is produced from petroleum and is used to make man-made rubber (car and truck tires) and plastics. 1,3-butadiene is also found in gasoline, automobile exhaust, cigarette smoke, and wood fires. Thus, it is often present at very low levels in the air around cities and towns. (12).

Studies on workers have shown that heart disease, blood disease, lung disease, and certain cancers are the principal health effects resulting from long-term exposure to low levels of 1,3-butadiene. These workers, however, were also exposed to other chemicals combined with 1,3-butadiene. The exact composition and proportion of these chemical combinations is unknown, as is which specific chemical (or chemicals) caused these effects. Inhalation of 1,3-butadiene is mildly narcotic in humans at low concentrations and may result in a feeling of lethargy and drowsiness (12).

2. Benzene

Benzene is commonly found in the environment with industrial processes being the main source. The general population is mainly exposed to benzene through breathing air containing benzene. Benzene levels in the air can also be from industrial emissions, waste and storage operations, motor vehicle exhaust (about 20% of the total nationwide exposure), and evaporation from gasoline service stations. Tobacco smoke also contains benzene. About half of the entire nationwide exposure to benzene results from smoking tobacco or from exposure to environmental (“secondhand”) tobacco smoke (15).

Benzene causes problems in the blood. Human studies show that chronic inhalation exposure to benzene can result in harmful effects in the tissues that form blood cells, especially the bone marrow. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection and perhaps lowering the body’s defense against cancer of the blood-forming organs (leukemia). The U.S. Department of Health and Human Services (USDHHS) categorizes benzene as a known carcinogen (15).

3. Carbon Tetrachloride

Carbon tetrachloride is a clear liquid that evaporates into the air very easily. It has a sweet odor that most people can begin to smell at about 10 ppm. Carbon tetrachloride does not occur naturally in the environment. It has been used in the past as a cleaning fluid or degreasing agent, as a grain fumigant, and industrially in the synthesis of refrigeration fluid and propellants for aerosol cans. Most of these uses have been discontinued. Nevertheless, carbon tetrachloride releases still occur primarily from industrial processes, or older cleaning agents remaining in the home. Inhalation appears to be the major route of exposure for workers and also for the general population (16).

Carbon tetrachloride degrades very slowly in the environment. Very low background levels of carbon tetrachloride are found in water, soil, and consequently in air from past and present releases. Average outdoor air concentrations in several areas of the United States range between 0.1–0.16 ppb, with some values reaching 1.4 ppb. Indoor air concentrations can be higher than in outdoor air because of carbon tetrachloride in building materials or household products (16).

Carbon tetrachloride has depressant effects on the central nervous system. These effects are most significant at high exposure levels. Carbon tetrachloride also produces irritant effects on the gastrointestinal tract. The liver and kidneys are the target organs in exposed humans and animals. Studies of occupational and general population exposures have produced no conclusive evidence that carbon tetrachloride is carcinogenic in humans. Carbon tetrachloride, however, has been shown to be carcinogenic in animals following chronic inhalation. IARC has classified carbon tetrachloride as possibly carcinogenic to humans (16).