Health Consultation

Environmental Data Evaluation

CHILLUM PERC
(a/k/a CHILLUM PERCHLOROETHYLENE)

CHILLUM, PRINCE GEORGE'S COUNTY, MARYLAND

EPA FACILITY ID: MDN000305887

NOVEMBER 24, 2004

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

Health Consultation: A Note of Explanation

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

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

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Prepared by:

Exposure Investigation and Consultation Branch
Division of Health Assessment and Consultation Branch
Agency for Toxic Substances and Disease Registry

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Summary and Statement of Issues

The U.S. Environmental Protection Agency (EPA) Region 3 office asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review indoor air, active soil vapor, ground water, and drinking water sampling data collected during summer 2003 for the Chillum, Maryland perc (perchloroethylene or PCE) site. A mixed gasoline and perc plume originated on the site. In January 2004, ATSDR released a health consultation that reviewed active soil gas data collected from January 2002 through December 2002, and reviewed preliminary indoor air data collected in April 2003. This health consultation analyzes additional environmental data collected from July 2003 through September 2003 and determines whether the on-site contamination poses a public health hazard through an inhalation pathway. Major findings of this health consultation include:

1. All indoor air volatile organic compound (VOC) concentrations detected at the site are at levels unlikely to cause adverse, noncancer health effects for acute, intermediate, and chronic exposures.
2. Conservative cancer risk assessment indicates that residents who have a continuous lifetime exposure to the highest levels of chemicals (most of them are not related to the gasoline or perc plumes) observed at this site may have a slight increase in the risk for developing cancer. Nevertheless, because very conservative assumptions were used for risk evaluation and because of the small population of the community (i.e., fewer than 500 people), any increase in the number of cancer cases in the community is unlikely.
3. There was no substantial correlation between soil vapor and indoor air concentration of perc. The limited available data indicated soil vapor intrusion is either not occurring, or occurring at de minimus rate that poses no adverse health effect in the community.
4. No site-related contaminants were detected in residential drinking water samples. All detected VOCs in drinking water are trihalomethanes (THMs). THMs are common by-products of the chlorination of public water supplies, and are not related to the gasoline or perc plumes. The total THM concentrations in the drinking water samples are below the maximum contamination level (MCL); therefore, exposures are not expected to result in adverse health effects in the community.

ATSDR categorizes this site as No Apparent Public Health Hazard, which indicates human exposure to contaminated indoor air could be occurring, could have occurred in the past, or could occur in the future. The exposure, however, is not expected to cause any adverse health effects.

To maintain exposures at safe levels, ATSDR made recommendations to verify high-VOC concentrations at one location, and to implement restrictions on future activities that may affect the subsurface contaminated areas (e.g., excavations related to basement or utility activities in the areas of known subsurface contamination).

Background

The Chillum perc site is located at the intersection of Riggs Road and Eastern Avenue in Chillum, Maryland. The plume, consisting of gasoline and perchloroethylene (perc), originated in Maryland and has since spread into the Lamond-Riggs Park community in Washington, D.C. The gasoline plume is a result of a gasoline release at a service station in Chillum. The origin of the perc plume is still under investigation.

Beginning in 1990, numerous environmental investigation, remediation, and assessment activities have been conducted at the site. In March 2003, the U.S. Environmental Protection Agency (EPA) Region III asked the Agency for Toxic Substances and Disease Registry (ATSDR) to review active soil vapor and preliminary indoor air sampling data. In January 2004, ATSDR released a health consultation that categorized the Chillum perc site as an Indeterminate Public Health Hazard because of limited indoor air data and a lack of environmental data for potentially affected locations. The major findings included

1. The perc soil vapor concentrations ranged from nondetect to 4,600 μg/ m^3. The average concentrations for shallow-soil vapor samples (samples with sampling depths of equal to or less than 5 feet below the bottom of the basement slab) and deep-soil vapor samples (samples with sampling depth of greater than 5 feet below the bottom of the basement slab) were 313 μg/ m^3 and 457 μg/ m^3, respectively. Five residences have perc soil vapor concentrations above 810 μg/m^3 that represent an estimated target indoor air concentration of 81 μg/ m^3 from modeling. This concentration indicates a low, theoretical increased risk for cancer.
2. Benzene soil vapor concentrations ranged from non-detect to 160 μg/m^3. The average concentrations for shallow- and deep-soil vapor samples were 21 μg/ m^3 and 53 μg/ m^3, respectively.
3. The methyl tertiary butyl ether (MTBE) soil vapor concentrations ranged from non-detect to 3,788 μg/ m^3. The average concentrations for shallow- and deep-soil vapor samples were 37 μg/ m^3 and 148 μg/ m^3, respectively.
4. Six volatile organic compounds (VOCs) were detected at very low levels and below their respective comparison values (CVs) in the initial indoor air samples. ATSDR recommended taking additional indoor air samples in the community to verify the indoor air contamination at the point of exposure [1].

From July 2003 through September 2003, EPA Region 3 collected additional indoor air, soil vapor, drinking water, and groundwater samples from around the Chillum perc site. In March 2004, the EPA Region 3 office requested that ATSDR review the sampling results and provide further recommendations based on this new data [2]. The purpose of this health consultation is to analyze the environmental data and determine whether contamination on the site poses a public health hazard through an inhalation pathway.

Discussion

For this health consultation, ATSDR reviewed indoor air, active soil gas, groundwater, and drinking water data collected by EPA contractors from July 2003 through September 2003. Figure 1 is a summary of all sampling locations for the site.

The primary route of potential human exposure is inhalation of indoor air potentially contaminated through vapor intrusion. As described in the previous health consultation for this site, ATSDR provides site-specific public health recommendations on the basis of

- toxicologic literature,
- levels of environmental contaminants detected at the site compared to accepted comparison values,
- an evaluation of potential exposure pathways and duration of exposure, and

- the characteristics of the exposed population.

ATSDR used the following comparison values for this health consultation

- ATSDR environmental media evaluation guides (EMEGs) for indoor air samples,
- ATSDR reference dose media evaluation guides (RMEGs) for indoor air samples,
- ATSDR cancer risk evaluation guides (CREGs) for indoor air samples,
- ATSDR minimal risk levels (MRLs) for indoor air samples,
- EPA draft guidance on indoor vapor intrusion for active soil vapor samples,
- EPA risk-based concentration (RBC) for indoor air samples for chemicals without ATSDR comparison values, and
- EPA drinking water maximum contamination levels (MCLs) for drinking water samples.

Indoor Air

From July 28, 2003 through July 31, 2003, representatives of Lockheed Martin/REAC and Tetra Tech EMI/START, under contract with EPA, conducted indoor air monitoring in the Lamond-Riggs Park community by using the trace atmospheric gas analyzer (TAGA) and Summa canisters.

TAGA Screening

The TAGA was used to screen residence indoor air before the placement of Summa canisters. Residents were asked to remove potential household VOCs sources such as paints, cleaners, kerosene heaters, gasoline, and glues. The EPA contractor screened 23 residences and analyzed seven VOCs: perc, trichloroethethene (TCE), dichloroethene (DCE), vinyl chloride (VC), benzene, toluene, and xylene. Five VOCs were detected slightly above their quanitation limit. All VOC concentrations were below their respective comparison values (Appendix A, Table 1).

Summa Canisters

The EPA contractor collected 46 indoor air samples in residences and 3 trip blanks at the site. All samples were collected in Summa canisters for 24 hours. The EPA contractor placed two Summa canisters — one in the basement and another on the first floor of each residence. Samples were analyzed for VOCs using EPA Method TO-15. Of the 69 VOCs analyzed, 22 were detected at very low levels (Appendix A, Table 2). Acetone was the most often-detected VOC with an average of 152 $\mu g/m^3$. Benzene was found in 9 samples with an average of 4.49 $\mu g/m^3$, perc in 5 samples with an average of 8.9 $\mu g/ m^3$, and MTBE in 15 samples with an average of 6.5 $\mu g/m^3$. All detected VOC concentrations fell below their health-based comparison values except for VOCs listed in Appendix A, Table 3. Those VOCs are discussed below.

Further examination of the sampling results indicated that carbon tetrachloride and trichloroethene (TCE) were found at one location (593-AS-200) only. The highest concentration of chloroform, methylene chloride, and 1,4-dichlorobenzene were found at the same location (593-AS-200).

1. Carbon tetrachloride is used widely to make refrigeration fluid (e.g., Freon 10), cleaning fluid (e.g., spot remover for clothing) and other substances (e.g., pesticide). Typical

concentrations in residential indoor air in several U.S. cities average about 1 $\mu g/m^3$, with highest values up to 9 $\mu g/m^3$ [3]. The principal adverse health effects associated with inhalation exposure to high concentrations (higher than 20,000 ppb or 128,000 $\mu g/m^3$) of carbon tetrachloride are central nervous system depression, liver damage, and kidney damage. ATSDR established a chronic EMEG of 191.7 $\mu g/m^3$ for carbon tetrachloride, based on the no observed adverse effect level (NOAEL) for human exposures with an uncertainty factor of 30. The concentration of carbon tetrachloride (2,370 $\mu g/m^3$) found at location 593-AS-200 is far below the NOAEL of 31,950 $\mu g/m^3$.

2. Trichloroethene (TCE) is used as a solvent to remove grease from metals, and in typewriter correction fluid, paint removers, adhesives, and spot removers. Indoor air concentrations of TCE in the United States range from 0.74 $\mu g/m^3$ to 27 $\mu g/m^3$ [4]. The maximum TCE concentration (160 $\mu g/m^3$) found at the site is less than the intermediate EMEG/MRL of 546 $\mu g/m^3$.
3. Chloroform was found in 15 samples. The highest concentration of chloroform (500 $\mu g/m^3$) was found at location 593-AS-200; the other 14 samples have chloroform concentrations ranging from 5 $\mu g/m^3$ to 20 $\mu g/m^3$. Chloroform is the most common chlorination byproduct formed in the drinking water disinfection process. One of the most significant indoor sources of chloroform is chlorinated tap water. Daily use of chlorinated tap water—such as taking showers—contributes substantially to indoor chloroform levels. Typical indoor air concentrations of chloroform range from 0.9 $\mu g/m^3$ to 19.8 $\mu g/m^3$ [5]. Breathing air, eating food, or drinking water containing very high levels of chloroform for long periods can damage the liver and kidneys. Short-term exposure to very high concentrations of chloroform can cause neurological effects such as dizziness, fatigue, headache, loss of consciousness, and death [5]. ATSDR established a chronic EMEG of 99.2 $\mu g/m^3$ for chloroform, based on the lowest observed adverse effect level (LOAEL) for human exposures with an uncertainty factor of 100. The LOAEL is approximately 9,920 $\mu g/m^3$, much higher than the levels associated with indoor air exposures in the Lamond-Riggs Park community. Chloroform is not likely to be carcinogenic to humans by any route of exposure under exposure conditions that do not cause cytotoxicity and cell regeneration [6]. Therefore, chloroform is not included in the cancer risk evaluation for the site.
4. Methylene chloride is a colorless liquid widely used as an industrial solvent and as a paint stripper. The chemical can be found in some spray paints, automotive cleaners, pesticide products and other household products [7]. The mean concentrations of methylene chloride in the vicinity of hazardous waste sites in the United States ranges from 0.3 $\mu g/m^3$ to 39 $\mu g/m^3$ [7]. Methylene chloride is the most common laboratory analysis artifact introduced in laboratory sample preparation [8]. The maximum concentration (52.5 $\mu g/m^3$) found at the site is less than the chronic EMEG/MRL of 1,059 $\mu g/m^3$.

5. A man-made chemical produced for home and industrial use, 1,4-dichlorobenzene is used, for example, in mothballs as a deodorizer and insect killer. Reported levels of 1,4-dichlorobenzene in some homes and public restrooms have ranged from 0.29 ppb to 272 ppb (1.7$\mu g/m^3$–1,635 $\mu g/m^3$) [9]. The maximum concentration of 1,4-dichlorobenzene (220 $\mu g/m^3$) found at the site is less than the chronic EMEG/MRL of 678 $\mu g/m^3$.

6. ATSDR discussed with sampling personnel the five detections found at the single location 593-AS-200. Sampling personnel did not observe any unusual activities or situations at this residence that would explain the presence of those chemicals during the sampling period. Carbon tetrachloride, TCE, chloroform, methylene chloride, and 1,4-dichlorobenzene are not associated with the gasoline and perc plumes. The VOC concentrations in this location could have come from household sources or could have been introduced during the laboratory analysis process [10]. All VOCs, with the exception of methylene chloride, have higher concentrations in indoor air as compared to the concentrations in the soil vapor under this residence (Figure 2). Further investigation is needed to verify the indoor air VOC concentrations for this location.
7. The highest concentrations of perc were found in the basement (133-AS-200) and on the first floor (133-AS-201) of one residence. The concentrations are in the range of the background concentration in residential indoor air, and are below levels that could cause any adverse health effects [1].
8. All VOCs detected at the site are at levels unlikely to cause adverse, noncancer health effects for acute, intermediate, and chronic exposures.
9. To evaluate the cancer risk, ATSDR used the EPA Region 3 inhalation cancer slope factors (CSFi) for inhalation exposures. Cumulative cancer risk assessment, assuming the addition of individual VOC risks is appropriate, indicates that indoor exposures slightly increase the risk for developing cancer for people living at the site. This is a conservative estimate; CSFi is based on conservative assumptions such as fixed level of risk (i.e., a 1-in-1 million cancer risk) and a lifetime exposure (i.e., 365 days per year for 70 years). Using these conservative assumptions plus a conservative assumption for dose calculation (Appendix A), ATSDR overestimates risk by factors ranging from 10 to 1,000. It should be noted that the slight increase in cancer risk is due, for the most part, to exposure to indoor air contaminants that not associated with the perc or gasoline plume.

Soil Vapor

From July 2003 through September 2003, EPA-contractor personnel collected 13 active soil vapor samples in 1-L Tedlar bags at 13 residential basements. For the 61 VOCs analyzed, sampling detected 17 different VOCs (28%). All detected VOC concentrations are below levels in the EPA draft guidance on indoor vapor intrusion except perc and chloroform (Appendix A, Table 3) [11]. Chloroform was found at one location (593-AS-200) with concentration lower than the correspondent indoor air concentration found at the same location. To understand the relation between soil vapor concentrations and indoor air concentrations, ATSDR prepared a chart (Figure 3) depicting concentrations of perc in the indoor air and in active soil vapor samples. There is no substantial correlation between soil vapor and indoor air concentrations of perc using a Spearman rank correlation coefficient. For example, perc was found in soil vapor samples at seven locations with an average concentration of 372 $\mu g/m^3$ and a median concentration of 14.3 $\mu g/m^3$. The maximum perc concentration was 2,110 $\mu g/m^3$ at location 042-SV-200. The correspondent indoor air perc concentration was 9.31 $\mu g/m^3$. The highest indoor air perc concentration was 41.4 $\mu g/m^3$ and the correspondent soil-vapor perc concentration was 13.6 $\mu g/m^3$. Not enough data are present, however, to test the correlations between the indoor air concentrations and the soil-vapor concentrations of benzene, MTBE, methylene chloride, and 1, 4-dichlorobenzene. The limited available data indicated soil vapor intrusion is either not occurring, or occurring at de minimus rate that poses no adverse health effect in the community.

The Lamond-Riggs Park community members expressed concerns about possible future exposure to contaminated air should activities (e.g., basement or utility work excavation) that could result in release of VOCs in the contaminated areas occur. ATSDR recommends that appropriate District of Columbia and Maryland authorities work with EPA to implement restrictions on future activities that may affect the subsurface contaminated areas.

Ground Water

Five chemicals were detected in the five groundwater samples collected in the summer sampling event (Appendix A, Table 4).

Because local groundwater is not the source of drinking water for the community, the groundwater exposure pathway is not completed for community members at this site.

In early 2003, community members expressed concerns about the possibility of contaminated groundwater infiltrating into drinking water pipes through damaged structures. EPA has conducted research on the issue and concluded that contaminants entering leaking pipes is unlikely because 1) the contaminated groundwater tables are located vertically and horizontally away from the water pipes, 2) the contaminant concentrations are diluted greatly as groundwater at the site moves away from the source, and 3) water pipes are pressurized so that water can only leak out if any minor leak exists [12].

Drinking Water

During the summer sampling event the EPA contractor took four drinking water samples from the public drinking water system — two from kitchen spigots, one trip blank, and one duplicate for quality control purposes. Tests detected the presence of five chemicals in the drinking water samples (Appendix A, Table 5).

All detected VOCs are trihalomethanes (THMs), formed in drinking water as chlorination disinfection byproducts. Chloroform, the most common chlorination byproduct, makes up approximately 90 percent of the mass of total THMs (TTHMs) [13–16]. Other THMs include bromodichloromethane, bromoform, and dibromochloromethane. Median chloroform concentrations in drinking water found in 35 sites across the country ranged from 9.6 μg/L to 15 μg/L, with most of the concentrations ranging between 22 μg/L and 68 μg/L [6]. EPA established a single MCL for TTHMs of 80 ppb. The MCL is a legally enforceable standard established to protect against possible cancer, liver, and kidney effects that could result from exposure to drinking water THMs [17]. The total THM concentrations in the drinking water samples are below the MCL; therefore, exposures are not expected to result in adverse health effects in the community.

In recent years, health concerns regarding exposures to THMs and other chlorination disinfection byproducts have been broadened to include cancer as well as adverse birth outcomes. Most studies were performed at THM levels below comparison values of health concern. Exposures to these levels, believed to be safe, would not be expected to result in adverse health effects, even for sensitive populations. Those epidemiologic studies suggested an association between multiroute drinking water exposures (i.e., ingestion, inhalation and dermal exposures) to a mixture of disinfection byproducts including THMs and adverse birth outcomes. The studies, however, showed uncertainties in low-dose exposures to THMs and other disinfection byproducts, maternal and prenatal pharmacokinetics, accurate exposure doses, and the level of maternal exposure at which adverse developmental or reproductive effects will occur [18–22].

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; they breathe dust, soil dust, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health. ATSDR has considered these factors in the development of conclusions and recommendations for this site.

Conclusions

1. All indoor air VOC concentrations detected at the site are at levels unlikely to cause adverse, noncancer health effects for acute, intermediate, and chronic exposures.
2. Conservative cancer risk assessment indicates that residents who have a continuous lifetime exposure to the highest levels of chemicals (most of them are not related to the gasoline or perc plumes) observed at this site may have a slight increase in the risk for developing cancer. Nevertheless, because conservative assumptions were used for risk evaluation and because the population of the community is small, any increase in the number of cancer cases in the community is unlikely.
3. Tests show no significant correlation between soil vapor and indoor air concentration of perc. The limited available data indicated soil vapor intrusion is not occurring, or occurring at de minimus rate that poses no adverse health effect in the community.
4. The groundwater exposure pathway (potable water) does not exist for community members because the community is serviced by a public water system.
5. No site-related contaminants were detected in residential drinking water samples. All detected VOCs in drinking water are trihalomethanes (THMs). THMs are common by-products of the chlorination of public water supplies, and are not related to the gasoline or perc plumes. The total THM concentrations in the drinking water samples are below the maximum contamination level (MCL); therefore, exposures are not expected to result in adverse health effects in the community.
6. ATSDR categorizes this site as No Apparent Public Health Hazard. This means human exposure to contaminated indoor air could be occurring, could have occurred in the past, or could occur in the future, but such exposure is not expected to cause any adverse health effects.

Recommendations

1. Verify the indoor air VOC (i.e., carbon tetrachloride, chloroform, 1,4-dichlorobenzene, and TCE) concentrations for location 593-AS-200 to insure the levels are below levels of health concern.

2. Appropriate District of Columbia and Maryland authorities should work with EPA to implement restrictions on future activities that may affect the subsurface contaminated areas (e.g., excavations related to basement or utility activities in the areas of known subsurface contamination).

Public Health Action Plan

Actions Taken:

1. During spring 2004, EPA collected additional indoor air, soil vapor, and ground water samples at selected residences in the community as well as at other potentially affected areas.
2. ATSDR released a site-specific fact sheet and a community health concern questionnaire in early December 2003.
3. In early 2004, ATSDR released a health consultation that reviewed and evaluated all available active soil gas data and a few initial indoor air data for the site.
4. ATSDR reviewed, compiled, and presented results of the community health concern questionnaire in spring 2004 at a public meeting hosted by EPA in La Salle Elementary School.

Actions Planned:

1. EPA or Chevron will continue to investigate selected residences in the community.
2. ATSDR will assist, as needed, in further evaluations of additional environmental data (e.g., data collected in spring 2004) to better characterize the exposure and the extent of vapor intrusion.
3. ATSDR will continue to work with EPA, the District of Columbia Department of Health, and Maryland Department of the Environment (MDE) to respond to public health questions and concerns.

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References

1. Agency for Toxic Substances and Disease Registry. Health consultation concerning active soil gas data review, Chillum Perc Site. Atlanta: US Department of Health and Human Services; 2003.

2. EPA Region 3. Technical assistance request. Atlanta. 2003.

3. Agency for Toxic Substances and Disease Registry. Toxicological profile for carbon tetrachloride (update). Atlanta: US Department of Health and Human Services; 2003.

4. Agency for Toxic Substances and Disease Registry. Toxicological profile for trichloroethene (TCE) (update). Atlanta: US Department of Health and Human Services; 1997.

5. Agency for Toxic Substances and Disease Registry. Toxicological profile for chloroform (update). Atlanta: US Department of Health and Human Services; 1998.

6. US Environmental Protection Agency. Toxicological review of chloroform. Washington, DC: EPA/635/R-01/001; 2001.

7. Agency for Toxic Substances and Disease Registry. Toxicological profile for methylene chloride (update). Atlanta: US Department of Health and Human Services; 2000.

8. Korte N. A guide for the technical evaluation of environmental data. Lancaster, Pennsylvania: Technomic Publishing Company, Inc. 1999. p. 147–64.

9. Agency for Toxic Substances and Disease Registry. Toxicological profile for 1, 4-dichlorobenzene (update). Atlanta: US Department of Health and Human Services; 1998.

10. Tetra Tech EM Inc. E-mail to Marcos Aquino from Christopher Sklaney. Boothwyn, PA. 2004.

11. US Environmental Protection Agency, Office of emergency and remedial response. User's Guide for evaluating subsurface vapor intrusion into buildings. Washington, DC: Environmental Protection Agency; 2003.

12. US Environmental Protection Agency, Question and answers regarding the Chillum/Lamond-Riggs park contamination. Philadelphia office. 2003.

13. Weisel CP et al. Ingestion, inhalation, and dermal exposures to chloroform and trichloroethene from tap water. Environ Health Perspect 1996; 104:48–51.

14. Wan KJo et al. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal 1990; 10(4):575–80.

15. Andelman J. Total exposure to volatile organic compounds in potable water. Significance and treatment of volatile organic compounds in water supplies. Chelsea, MI. Lewis Publishers; 1990. p. 485–504.

16. Maxwell N I et al. Trihalomethanes and maximum contaminant levels: the significance of inhalation and dermal exposures to chloroform in household water. Regul Toxicol Pharmacol 1991; 14:297–312.

17. National primary drinking water regulations: disinfectants and disinfection by products. Federal Register 1998 December 16; 63:68390–476.

18. Bove F, Shim Y, and Zeits P. Drinking water contaminants and adverse pregnancy outcomes: a review. Environ Health Perspect 2002; 110(1):61–74.

19. Nieuwenhuijsen MJ, Toledano MB, Eaton NE, Fawell J, and Elliott P. Chlorination disinfection byproducts in water and their association with adverse reproductive outcomes: a review. Occup Environ Med 2000; 57:73–85.

20. Gallagher MD, Nuckols JR, Stallones L, and Savitz DA. Exposure to trihalomethanes and adverse pregnancy outcomes. Epidemiology 1998; 9(5):484–89

21. Graves CG, Matanoski GM, and Tardiff RG. Weight of evidence for an association between adverse reproductive and developmental effects and exposure to disinfection by-products: a critical review. Regul Toxicol Pharmacol 2001; 34:103–24.

22. Bove FJ, Fulcomer MC, et al. Public drinking water contamination and birth outcomes. Am J Epidemiol 1995; 141(9);850–62.

Appendix A – Tables and Figures

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Table 1— Indoor Air Trace Atmospheric Gas Analyzer (TAGA) Data (μg/m3)

Location	***Vinyl Chloride***	***Benzene***	***Toluene***	***Dichloroethene***	***Xylenes***	***Trichloroethene***	***Tetrachloroethene***
002	ND (35.77)	ND (6.71)	NA	ND (10.30)	ND (16.93)	ND (2.47)	ND (7.46)
337	ND (38.33)	ND (8.30)	NA	ND (5.94)	15.62 J	ND (2.90)	ND (12.20)
122	ND (51.10)	5.11 J	NA	ND (11.49)	24.30 J	ND (3.49)	ND (10.85)
390	28.11 J	ND (5.11)	ND (60.27)	ND (2.38)	11.28 J	4.30	ND (4.34)
384	18.65 J	6.39 J	ND (71.57)	ND (2.85)	19.53 J	ND (0.91)	11.53 J
413	ND 25.55)	7.66 J	ND (64.04)	ND (2.46)	27.34	ND (1.13)	5.08 J
530	ND (30.66)	ND (5.11)	ND (37.67)	ND (2.77)	7.81 J	ND (1.72)	5.56 J
593	ND (5.88)	ND (5.43)	ND (90.41)	ND (1.62)	11.28 J	ND (1.07)	3.39 J
471	ND (28.11)	ND (4.15)	ND (146.91)	ND (2.26)	9.55 J	ND (1.24)	ND (3.80)
310	ND (9.45)	ND (4.79)	ND (60.27)	ND (1.59)	12.59 J	ND (1.07)	2.92 J
133	ND (13.54)	44.71 J	ND (113.01)	ND (1.70)	10.42 J	ND (0.86)	108.47
546	ND (8.18)	ND (4.79)	ND (116.78)	ND (1.19)	ND (8.68)	ND (0.59)	7.46 J
417	ND (38.22)	ND (4.79)	ND (75.34)	ND (3.73)	ND (5.64)	ND (0.52)	ND (2.17)
464	28.11 J	3.83 J	ND (64.04)	ND (2.38)	12.59	ND (0.70)	ND (5.76)
178	ND (16.35)	ND (3.16)	ND (67.81)	ND (1.82)	33.85	ND (0.27)	ND (1.36)
447	ND (13.29)	ND (5.11)	ND (101.71)	ND (2.42)	125.86	0.81 J	1.76 J
141	ND (10.22)	4.47 J	ND (45.20)	ND (2.38)	10.85 J	ND (0.34)	6.78
061	ND (16.86)	7.03 J	ND (79.11)	ND (2.81)	ND (5.64)	ND (0.49)	ND (3.32)
042	ND (51.10)	ND (3.19)	ND (67.81)	ND (3.53)	ND (6.51)	ND (0.54)	3.25 J
151	19.93 J	3.51 J	ND (82.87)	ND (3.61)	20.40 J	ND (0.40)	8.14 J
128	ND (25.55)	5.75	ND (56.50)	ND (1.59)	13.45 J	ND (0.64)	4.41 J
360	ND (18.14)	3.19 J	ND (82.87)	ND (2.10)	13.02 J	0.40 J	6.17 J
004	35.77 J	6.07 J	ND (90.41)	ND (1.94)	15.62 J	3.01	2.64 J
CV	100	30	80	200	434	537	271

CVs used are as follow:

Vinyl chloride: chronic inhal environmental media evaluation guide (EMEG)/minimal risk levels (MRL); benzene: chronic inhal EMEG; toluene: chronic inhal EMEG/minimal risk level(MRL); dichloroethene: chronic inhalation reference media evaluation guide (RMEG); xylens: chronic inhalation EMEG) / (MRL); trichloroethene: chronic inhalation EMEG) / (MRL); tetrachloroethene: chronic inhalation EMEG) / (MRL).

ND: not detected; associated values are detection limits.

J: compound was detected; quantification is approximate.

NA: not available

Table 2—Summary of Available Indoor Air Data Chillum perc site, Chillum, Maryland (μg/m3)

Substance	*Maximum*	*Mean*	*Median*	*Detects/samples*	*CV*	*cv_type*
carbon tetrachloride	2,370	2,370	2,370	1/46	0.07	CREG
acetone	552	152	131	46/46	30,886	CEMEG
chloroform	500	43.7	10	15/46	99.2	CEMEG
benzene	13.2	4.49	3.39	9/46	32	DHACGL
1,1,1-trichloroethane	414	126	78.4	17/46	2,300	RBC
bromomethane	NA	NA	NA	0/46	19.4	CEMEG
chloromethane	23.1	10.2	8.4	13/46	103	CEMEG
chloroethane	NA	NA	NA	0/46	10,000	RMEG
vinyl chloride	NA	NA	NA	0/46	0.1	CREG
methylene chloride	52.5	34.5	35	7/46	3	CREG
carbon disulfide	NA	NA	NA	0/46	934	CEMEG
1,1-dichloroethane	NA	NA	NA	0/46	519	RBC
1,1-dichloroethene	NA	NA	NA	0/46	220	RBC
trichlorofluoromethane	34.2	16.5	14.3	10/46	730	RBC
dichlorodifluoromethane	40	20.9	19.3	4/46	180	RBC
1,1,2-trichloro-1,2,2-trifluoroethane	NA	NA	NA	0/46	31,000	RBC
1,2-dichloro-1,1,2,2-tetrafluoroethane	NA	NA	NA	0/46	None	NA
1,2-dichloropropane	NA	NA	NA	0/46	4	RMEG
2-butanone	108	19	6	15/46	5,000	RMEG
1,1,2-trichloroethane	NA	NA	NA	0/46	0.06	CREG
trichloroethene	160	160	160	1/46	0.016	RBC
1,1,2,2-tetrachloroethane	NA	NA	NA	0/46	0.02	CREG
hexachlorobutadiene	NA	NA	NA	0/46	0.05	CREG
1,2-dichlorobenzene	NA	NA	NA	0/46	150	RBC

Substance	*Maximum*	*Mean*	*Median*	*Detects/samples*	*CV*	*cv_type*
1,2,4-trimethylbenzene	10	9	9	2/46	6.2	RBC
ethylbenzene	26.4	17.6	17.6	2/46	1,100	RBC
styrene	8.6	8.6	8.6	1/46	1,100	RBC
benzyl chloride	NA	NA	NA	0/46	0.037	RBC
1,4-dichlorobenzene	220	42.1	27.5	22/46	0.29	RBC
1,2-dibromoethane	NA	NA	NA	0/46	0.005	CREG
1,2-dichloroethane	NA	NA	NA	0/46	0.04	CREG
4-methyl-2-pentanone (mibk)	12.6	10.5	10.5	2/46	3,000	RMEG
1,3,5-trimethylbenzene	NA	NA	NA	0/46	6.2	RBC
toluene	45.6	19.8	15.2	39/46	302	CEMEG
chlorobenzene	NA	NA	NA	0/46	62	RBC
1,2,4-trichlorobenzene	NA	NA	NA	0/46	3.7	RBC
tetrachloroethene (perc)	41.4	22.1	13.8	5/46	0.31	RBC
cis-1,2-dichloroethene	NA	NA	NA	0/46	37	RBC
trans-1,2-dichloroethene	NA	NA	NA	0/46	73	RBC
1,3-dichlorobenzene	NA	NA	NA	0/46	110	RBC
2-hexanone	NA	NA	NA	0/46	None	NA
4-ethyltoluene	8.8	8.8	8.8	1/46	None	NA
m,p- xylene or total xylenes	83.6	19.5	13.2	11/46	434	CEMEG
methyl tert-butyl ether (mtbe)	25.2	11.5	7.2	15/46	2,519	CEMEG
cis-1,3-dichloropropene	NA	NA	NA	0/46	None	NA
trans-1,3-dichloropropene	NA	NA	NA	0/46	None	NA

Notes

Nondetects are not included in the statistics.

CV: comparison value.

Maximum: maximum concentration.

Mean: mean concentrations.

Median: median concentration.

Detects/samples: number of samples which the compound was detected/total number of samples.

NA: not applicable.

CEMEG: chronic environmental media evaluation guide.

RMEG: reference dose media evaluation guide.

CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk.

DHACGL: ATSDR Division of Health Assessment and Consultation Guideline for benzene.

RBC: EPA Region 3 risk based concentrations.

HHMSSL: EPA Region 6 human health medium-specific screening level.

Table 3— Chemicals of Concern for Indoor Air Samples, Summer 2003, Chillum Perc Site (μg/ m^3)

VOCs	*Maximum*	*Mean*	*Median*	*Detects/samples*	*CV*
Carbon tetrachloride	2,370	2,370	2,370	1/46	0.07 (CREG) 191.7(CEMEG/MRL)
Chloroform	500	43.7	10	15/46	99.2 (CEMEG/MRL)
Methylene chloride	52.5	34.5	35	7/46	3 (CREG) 1059(CEMEG/MRL)
Trichloroethene	160	160	160	1/46	0.016(RBC) 546 (IEMEG/MRL)
1,4-dichlorobenzene	220	42.1	27.5	22/46	0.29 (RBC) 678 (CEMEG/MRL)
Perc	41.4	22.1	13.8	5/46	0.31(RBC) 271 (CEMEG/MRL)

CV: comparison value
CREG: cancer risk evaluation guide for $1\times10^{-}6$ excess cancer risk
CRMEG: chronic reference dose media evaluation guide
CEMEG: chronic environmental media evaluation guide
IEMEG: intermediate environmental media evaluation guide
MRL : minimal risk level
RBC: EPA Region 3 risk-based concentrations
Nondetects not included in the statistics
Detects/samples: number of samples which the compound was detected/total number of samples

Table 4— Summary of Active Soil Vapor Data

Chillum Perc Site, Summer 2003, Chillum, Maryland ($\mu g/m^3$)

Substance	*Maximum*	*Mean*	*Median*	*Detects/ samples*	*CV*
carbon tetrachloride	NA	NA	NA	0/13	1.6
ethanol	47.5	31.3	31.3	2/2	None
2-propanol	32.6	32.6	32.6	2/13	None
acetone	42	24.8	21.4	13/13	3,500
chloroform	181	181	181	1/13	1.1
benzene	NA	NA	NA	0/13	3.1
1,1,1-trichloroethane	23.7	23.7	23.7	1/13	22,000
bromomethane	21.8	21.8	21.8	1/13	50
chloromethane	NA	NA	NA	0/13	24
chloroethane	NA	NA	NA	0/13	100,000
vinyl chloride	NA	NA	NA	0/13	2.8
methylene chloride	70	41	41	2/13	52
carbon disulfide	40.3	35.7	35.7	2/2	7,000
bromoform	NA	NA	NA	0/13	22
bromodichloromethane	NA	NA	NA	0/13	1.4
1,1-dichloroethane	NA	NA	NA	0/13	5,000
1,1-dichloroethene	NA	NA	NA	0/13	2,000
trichlorofluoromethane	NA	NA	NA	0/13	7,000
dichlorodifluoromethane	NA	NA	NA	0/13	2,000
1,1,2-trichloro-1,2,2-trifluoroethane	NA	NA	NA	0/13	300,000
1,2-dichloro-1,1,2,2-tetrafluoroethane	NA	NA	NA	0/13	None
1,2-dichloropropane	NA	NA	NA	0/13	40

Substance	***Maximum***	***Mean***	***Median***	***Detects/ samples***	***CV***
2-butanone	NA	NA	NA	0/13	10,000
1,1,2-trichloroethane	NA	NA	NA	0/13	1.5
trichloroethene	NA	NA	NA	0/13	0.22
1,1,2,2-tetrachloroethane	NA	NA	NA	0/13	0.42
hexachlorobutadiene	NA	NA	NA	0/2	1.1
o-xylene	12.5	9.69	9.69	2/13	70,000
1,2-dichlorobenzene	NA	NA	NA	0/13	2,000
1,2,4-trimethylbenzene	34.8	19.6	17.4	4/13	60
ethylbenzene	10.5	8.4	8.4	2/13	22
styrene	NA	NA	NA	0/13	10,000
benzyl chloride	NA	NA	NA	0/2	0.5
1,4-dichlorobenzene	NA	NA	NA	0/13	8,000
1,2-dibromoethane	NA	NA	NA	0/13	0.11
1,3-butadiene	NA	NA	NA	0/13	0.087
1,2-dichloroethane	NA	NA	NA	0/13	0.94
vinyl acetate	NA	NA	NA	0/2	2,000
4-methyl-2-pentanone (mibk)	NA	NA	NA	0/13	800
1,3,5-trimethylbenzene	NA	NA	NA	0/13	60
toluene	60.8	38.5	32.7	3/13	4,000
chlorobenzene	NA	NA	NA	0/13	60
tetrahydrofuran	NA	NA	NA	0/13	None
hexane	6.3	5.78	5.78	2/13	2,000
cyclohexane	NA	NA	NA	0/13	None

Substance	Maximum	Mean	Median	Detects/ samples	CV
propylene	NA	NA	NA	0/13	None
1,2,4-trichlorobenzene	NA	NA	NA	0/2	2,000
1,4-dioxane	NA	NA	NA	0/13	None
dibromochloromethane	NA	NA	NA	0/13	1
tetrachloroethene (perc)	2110	680	435	7/13	8.1
ethyl acetate	NA	NA	NA	0/13	32,000
heptane	NA	NA	NA	0/13	None
cis-1,2-dichloroethene	NA	NA	NA	0/13	None
trans-1,2-dichloroethene	NA	NA	NA	0/13	None
1,3-dichlorobenzene	NA	NA	NA	0/13	1,100
2-hexanone	NA	NA	NA	0/13	None
4-ethyltoluene	21.6	13.3	12.3	3/13	None
m,p- xylene or total xylenes	34.3	25.3	22	5/13	70,000
methyl tert-butyl ether (mtbe)	3.96	3.96	3.96	1/13	30,000
cis-1,3-dichloropropene	NA	NA	NA	0/13	None
trans-1,3-dichloropropene	NA	NA	NA	0/13	None

Note:
Nondetects are not included in the statistics

CV: comparison value. All values adopted from the EPA Subsurface Vapor Intrusion Guidance, Table 2c: Question 4 generic screening levels and summary sheet.

NA: not applicable.

Detects/samples: number of samples which the compound was detected/total number of samples

Table 5— Groundwater Sampling Results, Chillum Perc Site, Summer 2003

Chemical	*Concentration(μg/L)*	*Location*	*Sampling date*	*Detects/samples*
benzene	26	102-GW-201	9/15/2003	1/5
bromodichloromethane	50	104-GW-200	9/15/2003	1/5
chloroform	8	104-GW-200	9/15/2003	1/5
MTBE	840	102-GW-201	9/15/2003	1/5
Perc	17 1	101-GW-201 104-GW-201	9/15/2003 9/15/2003	2/5

Table 6— Drinking Water Sampling Results, Chillum Perc Site, Summer 2003

Chemical	*Concentrations(μg/L)*	*Location*	*Sampling date*
bromodichloromethane	15 15	0630 0771	9/15/2003 9/15/2003
chloroform	58 55	0630 0771	9/15/2003 9/15/2003
dibromochloromethane	1.7	0630	9/15/2003

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Figure 1. Indoor Air and Soil Vapor Sampling Locations, Summer 2003

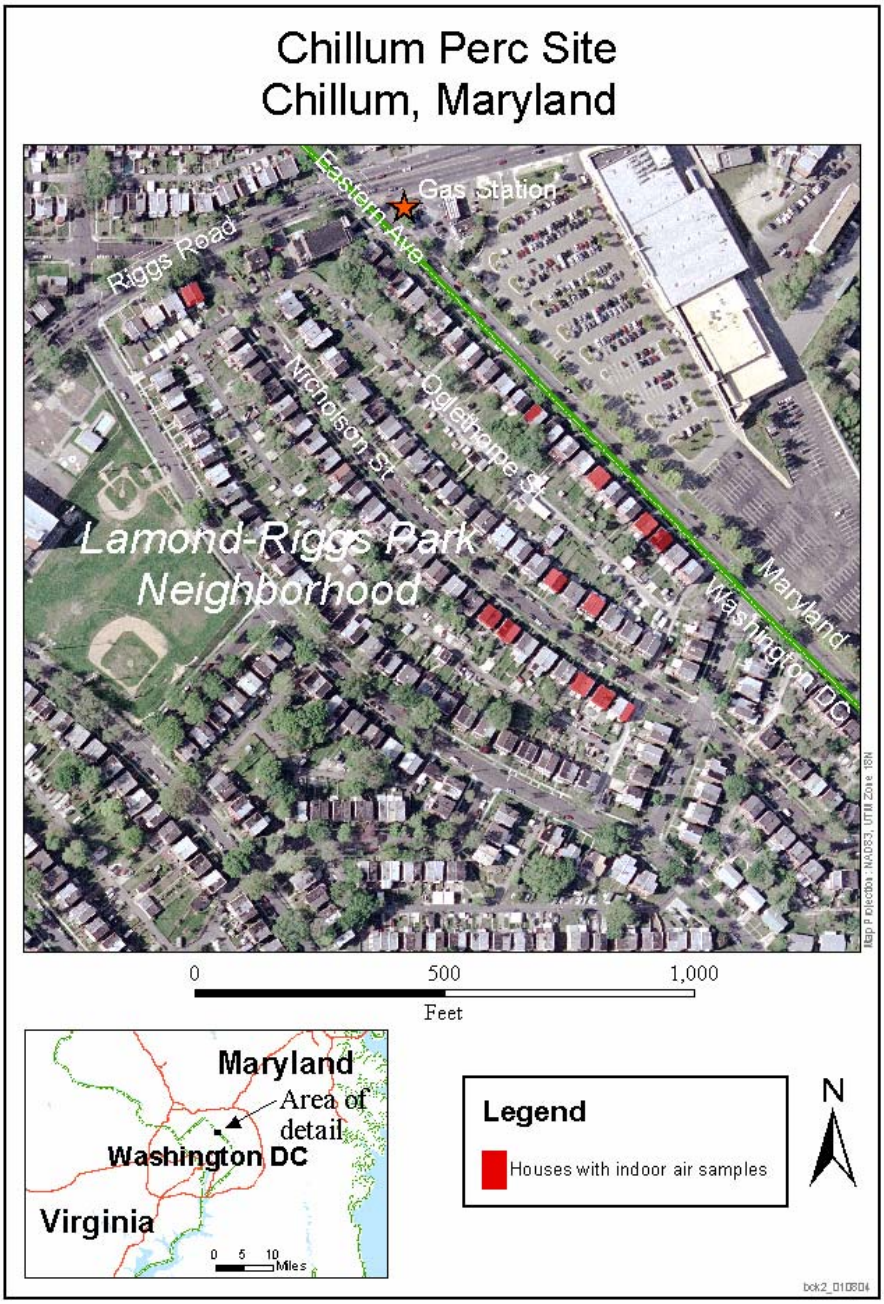

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Figure 2. Concentrations of Soil Vapor and Indoor Air For Location 593-AS-200 (μg/ m^3)

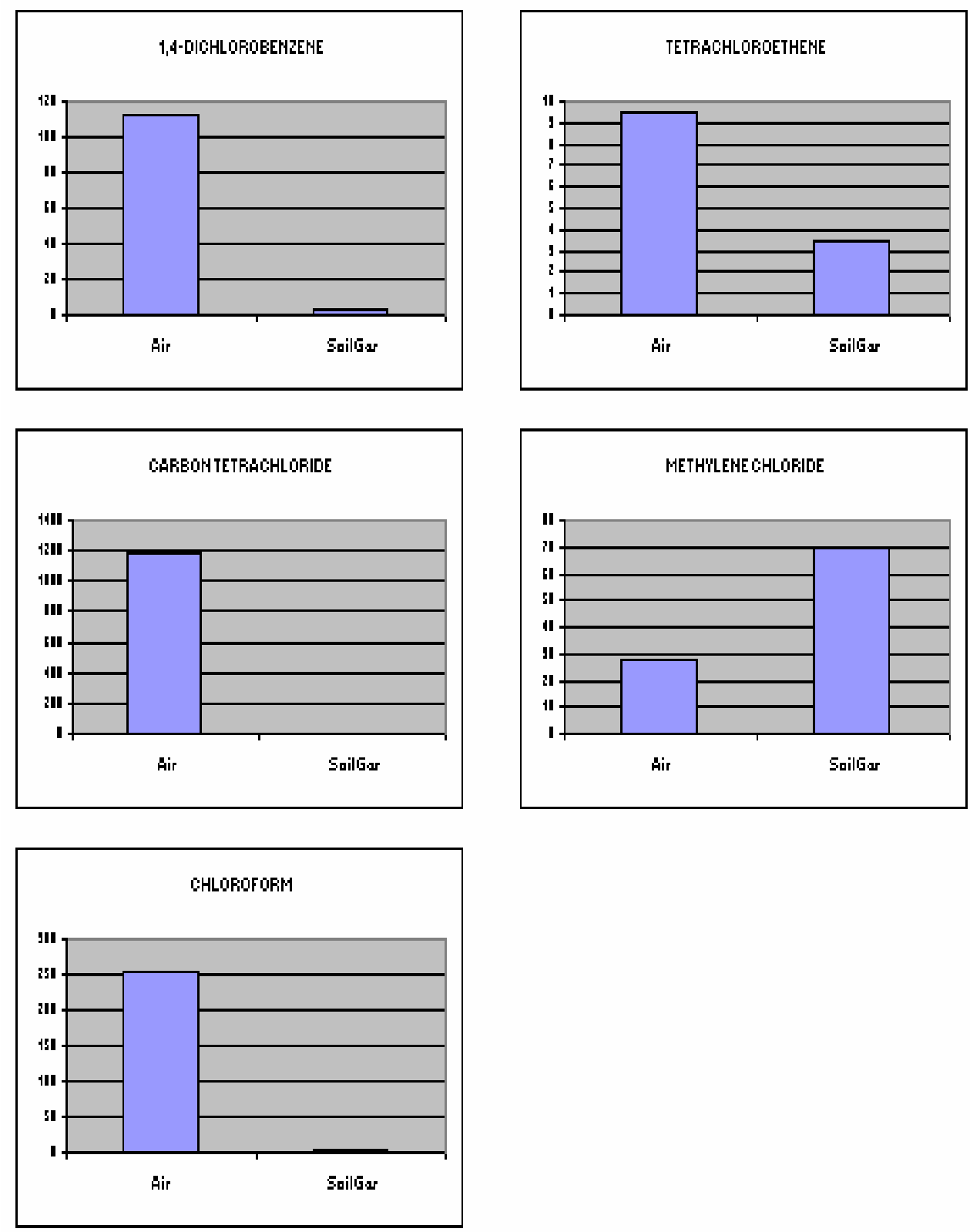
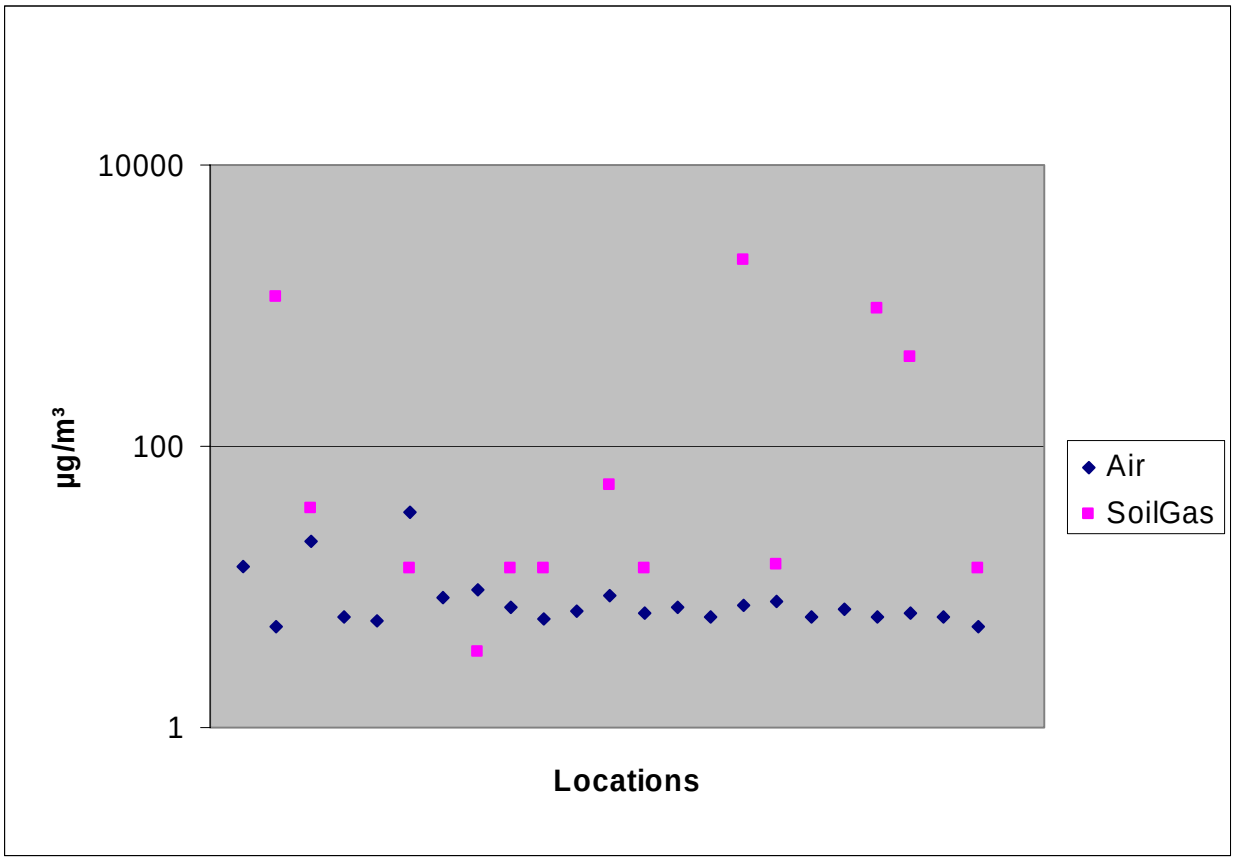


Figure 3. Concentrations of Perc in the Indoor Air and Active Soil Vapor Samples (μg/ m^3)



Note: Line in graph indicate scale change in concentrations.

Appendix B - Cancer Risk Evaluations

The major exposure pathway by which residents can be exposed to VOCs is breathing contaminated indoor air.

The following assumptions were made to estimate inhalation exposure dose for VOC inhalation:

(1) a resident's body weight is 70 kg,

(2) a resident spends 24 hours per day in the house,

(3) A resident breathes 20 cubic meters (m^3) per day

(4) addition of risks for selected VOCs is appropriate

The following mathematical formula was used to estimate the daily intake of inhaled VOCs:

Dose = Average daily air concentration x 20 m^3/70 kg/day

To evaluate the cancer risk, ATSDR used the EPA Region 3 inhalation cancer slope factors (CSFi) for inhalation exposures. CSFi is based on conservative assumptions such as fixed level of risk (i.e., a 1-in-1 million cancer risk) and a life time exposure (i.e., 365 days per year for 70 years). Together, with the very conservative assumptions used for the above dose calculation, ATSDR overestimates rather than underestimates risk by factors ranging from 10 to 1,000.

Cancer risk is calculated as follows:

(inhalation exposures)

= Average daily dose x CSFi x exposure factor (conservatively assumed to be 1.0)

Cancer risk evaluation results are presented in the table below.

Cancer Risk Evaluation Summary for the Site

VOCs	*Mean concentration($\mu g/m^3$)*	*Dose (mg/kg/day)*	*CSFi (per mg/kg/day)*	*Cancer Risk*
Methylene chloride	34.5	9.9E-03	1.65E-03	1.6E-05
1,4-dichlorobenzene	42.1	1.2E-02	2.2E-02	2.6 E-04
Perc	22.1	6.3E-03	2.0E-02	1.3E-04
Total cancer risk	3.9E-04			

Cancer Risk Evaluation Summary for Locations 593-AS-200 and 593-AS-201

VOCs	*Concentration ($\mu g/m^3$)*	*Dose(mg/kg/day)*	*CSFi(per mg/kg/day)*	*Cancer Risk*
Carbon tetrachloride	2,370	6.8E-02	5.3E-02	3.6E-03
Methylene chloride	52.5	1.5E-02	1.65E-03	2.5E-05
Trichloroethene	160	4.6E-02	6.0E-03	2.8E-04
1,4-dichlorobenzene	219.6	6.3E-02	2.2E-02	1.4E-03
Perc	13.8	3.9E-03	2.0E-02	7.8E-05

VOCs	*Concentration ($\mu g/m^3$)*	*Dose(mg/kg/day)*	*CSFi(per mg/kg/day)*	*Cancer Risk*
Total cancer risk	5.4E-03			

Cumulative cancer risk assessment indicates that risks from exposures are estimated to have been 2E-04 for inhalation for the site. For locations 593-AS-200 and 593-AS-201, assuming detected VOC concentrations represent average long-term daily concentrations, the cumulative cancer risk indicates that risks from exposures are estimated to have been 5.4E-03 for inhalation. However, further investigation is needed to verify the indoor air VOC concentrations for that residence.

It should be noted that (1) the slight increase in cancer risk is due, for the most part, to exposure in indoor air contaminants that have no correlation to the perc or gasoline plume; (2) the indoor air concentrations evaluated for cancer risk are averages of all measured values, and that a person's risk would depend on concentrations present in the indoor air; and (3) the transient nature of concentrations of contaminants in indoor air and the limited number of data points for this site are also limitations of the cancer risk assessment.