ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

WHITE SWAN CLEANERS/SUN CLEANERS AREA GROUNDWATER CONTAMINATION
(a/k/a WHITE SWAN LAUNDRY AND CLEANERS INCORPORATED)
WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY
EPA FACILITY ID: NJSFN0204241

AUGUST 17, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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PUBLIC HEALTH ASSESSMENT

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EPA FACILITY ID: NJSFN0204241

Prepared by:

New Jersey Department of Health and Senior Services
Public Health Services Branch
Consumer and Environmental Health Services
Hazardous Site Health Evaluation Program

Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary

On April 30, 2003, the United States Environmental Protection Agency proposed to add the White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site, Wall Township, Monmouth County, New Jersey to the National Priorities List. Volatile organic compounds, particularly tetrachloroethylene, have been detected in area ground and surface water, as well as the indoor air of residences and businesses. The source of contamination consists of commingling groundwater plumes from two former dry cleaning operations. Groundwater contamination extends from Route 35 eastward through Sea Girt Borough to the Atlantic Ocean. The site was added to the National Priorities List on September 23, 2004.

Through a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry, the New Jersey Department of Health and Senior Services conducted a Public Health Assessment of the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination site. The Public Health Assessment included a multichemical, multipathway exposure assessment and an evaluation of public health implications of site-related contaminants.

For residences affected by elevated indoor air concentrations of tetrachloroethylene, ventilation systems were installed based on interim remedial action levels. Since the groundwater plumes have not been fully delineated and all buildings located in the vicinity of the plume have not been sampled, it is not possible to assess exposures in all potentially impacted buildings. A remedial investigation is currently being conducted for the site. As such, current exposures pose an ***Indeterminate Public Health Hazard***. A number of substances detected in the indoor air may be associated with the use and storage of household cleaning products and solvents.

Although the concentration of tetrachloroethylene detected in municipal wells was below the New Jersey Maximum Contaminant Level, a treatment system was installed as a precautionary measure.

In the past, there were completed exposure pathways associated with the inhalation of contaminants in the indoor air through vapor intrusion, and incidental ingestion, dermal contact and inhalation of contaminants in the well water during outdoor use. Potential pathways were also identified and included ingestion of biota from the Wreck Pond. Based on the average concentrations of site-related contaminants, an evaluation of past exposures indicated that non-cancer adverse health effects were unlikely. Based on the average concentrations, the cumulative lifetime excess cancer risks were four in 10,000 to the exposed population, primarily due to tetrachloroethylene in indoor air from vapor intrusion. Non-cancer and cancer health effects associated with incidental ingestion, dermal contact and inhalation of contaminants in irrigation well water during outdoor use were also evaluated and found to be unlikely. Therefore, based on cumulative lifetime excess cancer risk levels, past exposures posed a ***Public Health Hazard***. A review of health outcome data is not recommended due to the relatively small size of the impacted population.

Recommendations for the site include conducting a site-specific background study to establish final remedial action levels, delineation and remediation of the contaminant plumes, implementation of an indoor air sampling program, surface water/sediment sampling of the Hannabrand Brook and Wreck pond and community education and outreach regarding the use of irrigation wells and household cleaning products.

The indoor air of area residences and other buildings were sampled and remediation systems were installed to reduce contaminant exposures. Several public availability sessions were held to provide local residents with a public health interpretation of their individual air sampling results. Fact sheets on health effects of tetrachloroethylene or PCE and benzene were also prepared and provided to the residents.

Copies of this report have been made available to concerned residents in the vicinity of the site via the township library and the internet. As additional data become available, the New Jersey Department of Health and Senior Services and the Agency for Toxic Substances and Disease Registry will evaluate the public health implications of contaminants detected and provide assistance to residents in reducing exposures to chemicals.

Statement of Issues

The White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site is located in a residential and commercial area of Wall Township, Monmouth County, New Jersey (see Figure 1). Two groundwater contaminant plumes, one from each of the former dry cleaning and laundering establishments, have converged to become the source of extensive area environmental contamination. Other potential contributing sources to this contaminant plume are being investigated. Volatile organic compounds (VOCs), particularly tetrachloroethylene, also known as perchloroethylene (PCE), have been detected in groundwater and surface water, as well as the indoor air of residences and businesses. PCE, a probable human carcinogen, is widely used for dry cleaning of fabrics and in metal-degreasing operations.

Figure 1: Location of White Swan Cleaners/Sun Cleaners Site

On April 30, 2003, the USEPA proposed to add the White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site to the National Priorities List (NPL). As required by the 1986 Superfund Amendments and Reauthorization Act (SARA) to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the ATSDR is mandated to conduct a Public Health Assessment for each site listed or proposed to be added to the NPL. The site was added to the National Priorities List on September 23, 2004.

Through a cooperative agreement with the ATSDR, the NJDHSS reviewed environmental data available for the site and conducted a comprehensive analysis of past, current, and future human exposures. Public health implications of exposure to groundwater, indoor air, and surface water contaminants were also evaluated.

Background

Site Description and History

The White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site is located within a residential and commercial area of Wall Township, Monmouth County (see Figures 2 and 3). The site's commingled groundwater plume begins along Route 35 and continues east through Sea Girt Borough to the Atlantic Ocean. A small portion of northern Manasquan Borough is also affected by the contaminant plume. The

Hannabrand Brook and the Judas Creek define the site's northern and southern boundaries, respectively.

As cited by the 2003 USEPA Hazard Ranking System report, Tri-Tech Environmental Engineering, Inc. conducted Phase I and Phase II Site Assessments of the Sun Cleaners property in 1995 and 1996. PCE was detected in soil samples at a concentration of 51 milligrams of PCE per kilogram of soil (mg/kg). Subsequent sampling results confirmed the presence of PCE at concentrations up to 7,400 mg/kg in subsurface soil and up to 200,000 micrograms of PCE per liter of water (μg/L) in groundwater.

In August 1997, a Magnolia Avenue, Wall Township resident informed the Monmouth County Health Department (MCHD) that groundwater samples collected in 1990 from three private irrigation wells had concentrations of PCE up to 1,546 μg/L. Subsequently, MCHD collected groundwater samples from 38 private irrigation wells in 1999 and confirmed the presence of PCE in 22 area wells. PCE levels detected were as high as 1,068 μg/L.

Between 1999 and 2000, the New Jersey Department of Environmental Protection (NJDEP), in cooperation with the MCHD, further investigated the contamination of the shallow groundwater; results of this investigation indicated at least two plumes of PCE and associated degradation/transformation products (USEPA 1998). The groundwater contamination covers an area about 2.5 miles long. Based on soil and groundwater sampling results, three potential sources of this contamination were identified:

Potential Sources of Contamination

Facility Name	Address	Period of Operation
White Swan Cleaners (currently a Fleet Bank)	1322 Sea Girt Avenue	1964 - 1982
Sun Cleaners	2213 Route 35	1960 - 1992
Gulf Service Station	Route 35 near the traffic circle	presently in operation

In February 2001, the responsible party for the White Swan Cleaners property (i.e., Fleet Bank, see Photograph 1) entered into a Memorandum of Agreement with the NJDEP to conduct a site assessment and remediation of the on-site property (USEPA 2003). No additional environmental delineation of the soil and groundwater contamination was conducted at the Sun Cleaners property. The NJDEP collected six soil samples from the Gulf Service Station, which borders the former White Swan Cleaners property to the northwest. PCE was detected in only one sample at a concentration of 58 mg/kg. Groundwater samples collected from the east/southeast border of the Gulf Service Station property detected PCE at concentrations ranging from

4 - 130 µg/L. PCE was not detected in groundwater samples collected from the western border of the property.

Based on an assessment of available environmental data (i.e., shallow water table and high concentration of PCE in the groundwater), the NJDEP performed indoor air sampling of area residences and commercial properties (NJDEP 2001). Elevated levels of PCE were detected and property owners were provided with ventilation systems (i.e., fans, sub-slab depressurization systems, or fans and sub-slab depressurization systems) (see Photograph 2).

In 2001, a NJDEP/MCDH investigation identified two defunct dry cleaners and an operating gas station in Wall Township as potential sources of area groundwater contamination (USEPA 2003). Extensive on-site soil and groundwater PCE contamination was confirmed at the former White Swan Cleaners. In December 2001, Fleet Bank (the current property owner and potentially responsible party (PRP)), excavated and disposed of about 820 cubic yards of on-site contaminated soil. The excavated areas were backfilled with clean soil. To date, no contamination delineation has been conducted by PRPs for the former Sun Cleaners and the Gulf Service Station.

In December 2001, the NJDEP referred the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination site to the USEPA. To date, the USEPA and the NJDEP collected more than 300 indoor air samples from approximately 220 area residences, schools, and businesses. In December 2002, based on indoor air sampling results and ATSDR's evaluation of lifetime excess cancer risks associated with background PCE levels in the indoor air available from the literature (ATSDR 2002c), USEPA and NJDEP established PCE interim remedial action levels and installed ventilation systems in affected buildings. The established PCE interim remedial action levels and responsible agency for ventilation system installation were as follows:

PCE Interim Remedial Action Levels*

PCE Concentration (µg/m^3)	Responsible Agency
60 and above	USEPA
6 to <60	NJDEP

*Since December 2001, the USEPA uses 6 µg/m^3 as the PCE interim remedial action level

In addition, environmental sampling was performed by the USEPA at potential source areas. The USEPA collected soil samples from the White Swan Cleaners and Sun Cleaners properties. PCE was detected at concentrations ranging from 0.0025 - 57 mg/kg at the former White Swan Cleaners property, and 0.02 - 1,200 mg/kg at the former Sun Cleaners property.

In April 2002, the USEPA also initiated a soil gas investigation of area buildings. PCE levels in the soil gas ranged from non-detect to 10,381 µg/m^3. Excluding

background samples, PCE was detected in every soil gas sample analyzed. This evaluation of the contaminant release and environmental data resulted in the site being proposed to be added to the NPL in 2003.

Site Visit

On June 27, 2003, a site visit of the Judas Creek was conducted. Individuals present during the site visit were Steven Miller, Sharon Kubiak, and Julie Petix of the NJDHSS, Leah Escobar of the ATSDR, representatives of the EPA and the Fleet Bank, the current owner of the former White Swan Cleaners property.

The creek is easily accessible as residential backyards that lack continuous fencing abut the wooded area where the creek flows. The section of the creek located behind the landscaping business (Waterbrook Florist and Garden Center on Sea Girt Avenue) was also visited. The landscaping business uses an irrigation well to water the plant stock. From the garden center, the creek is difficult to reach due to the steep topography, extremely dense, thorny brush, and mud. Access from the opposite side of the creek, however, is easy since residential yards abut the creek and lack continuous fencing. The inspection also included the former Sun Cleaners property located on Route 35 near the Manasquan Circle.

Subsequent to the site visit, NJDHSS recommendations to the USEPA included obtaining additional surface water samples from: 1) the culvert located behind the Rite Aid Pharmacy; 2) the creek in the vicinity of the Sun Cleaners; and 3) a resample of the previously denoted Philadelphia Avenue sample (where 996 µg/L PCE was detected) (NJDHSS 2003). It was also recommended that Availability Sessions be scheduled with area residents to discuss the ongoing environmental investigation.

On February 5, 2004, a second site visit was conducted by the NJDHSS. Individuals present during the site visit were Christa M Fontecchio, Somia Aluwalia, Steven Miller, Tariq Ahmed, and Julie Petix, NJDHSS; and a representative of the NJDEP. The NJDEP representative provided a summary of all site activities conducted by the NJDEP and USEPA to date. He noted that since the ATSDR report (1999) did not indicate health risks associated with the non-potable use of irrigation wells, Wall Township continued to issue permits for new home construction and irrigation wells.

Community Health Concerns

During the June 27, 2003 site visit, a Wildwood Avenue resident informed the NJDHSS that they have lived at this address for approximately 35 years and they only had water (about three inches) in their basement once.

On August 19, 2003, the NJDEP requested assistance of the NJDHSS regarding a Magnolia Avenue resident's concern about foul tasting zucchini grown in their backyard garden. The resident's irrigation well was used to water the garden. A review of recent scientific literature indicated that there was no reported adverse health effects associated

with eating homegrown produce irrigated with water containing VOCs (DEQ 2001). Volatile contaminants (i.e., PCE and TCE) detected in the irrigation wells evaporate easily at normal temperatures. During irrigation, the chemicals will tend to volatilize, rather than be taken up or absorbed by plants.

On September 4, 2003, the USEPA held an Availability Session for area residents. The purpose of the session was to discuss the remedial investigation and plans to obtain additional environmental samples.

Past NJDHSS or ATSDR Activities

In October 1999, the USEPA and the MCHD requested that the ATSDR review information related to area groundwater contamination, and to advise the community about the use of irrigation wells. ATSDR determined that the reported PCE levels in irrigation wells do not pose a public health hazard when used for non-potable purposes (ATSDR 1999) (see Appendix I).

In 2002, the USEPA requested that the ATSDR provide assistance in evaluating the public health implications of exposure to elevated concentrations of VOCs detected in the Brookside School and Old Mill School, both located in Sea Girt. In response to this request and through a cooperative agreement with the ATSDR, the NJDHSS prepared two Health Consultations (ATSDR 2002a, b) (see Appendix II).

The USEPA also requested that the ATSDR provide assistance in evaluating the public health implications of exposure to PCE and benzene detected in the indoor air of approximately 220 Wall Township residences. In response to this request, two health consultations were prepared (ATSDR 2002c and 2002d) (see Appendix III).

Environmental Contamination

An evaluation of site-related environmental contamination consists of a two-tiered approach: 1) a screening analysis; and 2) a more in-depth analysis to determine public health implications of site-specific exposures. First, maximum concentrations of detected substances are compared to media-specific environmental guideline comparison values (CVs). If concentrations exceed the environmental guideline CV, these substances, referred to as Contaminants of Concern (COC), are selected for further evaluation. Contaminant levels above environmental guideline CVs do not mean that adverse health effects are likely, but that a health guideline comparison is necessary to evaluate site-specific exposures. Once exposure doses are estimated, they are compared with health guideline CVs to determine the likelihood of adverse health effects.

Environmental Guideline Comparison

There are a number of environmental guideline CVs available for the screening environmental contaminants to identify COCs. These include ATSDR Environmental

Media Evaluation Guides (EMEGs) and Reference Media Evaluation Guides (RMEGs). EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic health effects. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects. If the substance is a known or a probable carcinogen, ATSDR's Cancer Risk Evaluation Guides (CREGs) were also considered as comparison values. CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (70 years). In the absence of an ATSDR CV, other comparison values may be used to evaluate contaminant levels in environmental media. These include New Jersey Maximum Contaminant Levels (NJMCLs) for drinking water, and USEPA Region 3 Risk-Based Concentrations (RBCs). RBCs are contaminant concentrations corresponding to a fixed level of risk (i.e., a hazard quotient[1] of 1, or lifetime excess cancer risk of one in one million, whichever results in a lower contaminant concentration) in water, air, biota, and soil. For soils and sediments, other CVs include the New Jersey Residential and Non-Residential Direct Contact Soil Cleanup Criteria (RDSCC, NRDSCC). Based primarily on human health impacts, these criteria may also take into account natural background concentrations, analytical detection limits, and ecological effects.

Substances exceeding applicable environmental guideline CVs were identified as COCs and evaluated further to determine whether these contaminants pose a health threat to exposed or potentially exposed receptor populations.

Site Conditions

The White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site is located along Route 35 in Wall Township, Monmouth County (Figure 3). The currently known groundwater contaminant plumes extend from Route 35 eastward through Sea Girt Borough to the Atlantic Ocean. The Hannabrand Brook represents the northern hydraulic boundary of the site. The southern boundary is defined by the Judas Creek. A small section of northern Manasquan Borough is also affected by the contamination.

Hydrogeologically, the site is in a flat region of the Atlantic Coastal Plain Physiographic Province. The surface elevation ranges from about 50 feet above mean sea level in the west to sea level in the east. The unconsolidated sediments of the Kirkwood-Cohansey aquifer system underlie the area. The Kirkwood-Cohansey aquifer thickness is about 150 feet in the vicinity of the site. The aquifer consists of two geologic formations: the Cohansey Sand, or upper stratigraphic unit, and the Kirkwood Formation, or lower stratigraphic unit. Hydrogeologic data collected for the Waldick Aerospace Superfund site (located about 0.5 mile north of the White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site) indicated that the upper and the lower stratigraphic units are hydraulically connected (NJDEP 2003). Aquifer hydrogeological investigations showed that there is a net seasonal (May to October) downward hydraulic gradient from the shallow aquifer unit to deeper aquifer unit, and, as such, there is a potential for

[1]The ratio of estimated site-specific exposure to a single chemical in a particular medium from a site over a specified period to the estimated daily exposure level at which no adverse health effects are likely to occur.

contamination of the deeper aquifer. The water table depth at the former White Swan Cleaners and Sun Cleaners properties ranges from approximately 18 - 22 feet below ground surface (bgs) and 3 - 15 feet bgs, respectively. Depth to groundwater varies with precipitation.

On-site Contamination

Irrigation Wells

The White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site has impacted the groundwater quality of Wall Township, Sea Girt Borough, and Manasquan Borough. In 1999, 38 irrigation wells were sampled for PCE; results indicated contamination of 22 wells. The wells are screened in the shallow Kirkwood-Cohansey aquifer with a maximum depth of 50 feet (ATSDR 1999) and are currently used by area residents to water lawns and gardens and to fill swimming pools. PCE detected in area irrigation wells ranged from 0.9 - 1,068 µg/L (see Table 1). The mean and median of the PCE concentrations were 194 µg/L and 305 µg/L, respectively. The maximum concentration of PCE exceeded its environmental guideline CV (see Table 1).

Groundwater

In order to assess the horizontal extent of contamination, the NJDEP collected 68 groundwater samples (see Figure 4) using direct-push Geoprobe® technology in April 2003. The samples were collected from within the seasonal fluctuation zone of the water table (10 - 20 feet). The primary contaminants detected were PCE and its degradation/transformation products, trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-1,2-DCE) (USEPA 1998). A summary of the detected contaminants is presented in Table 2. Based on this sampling event, the horizontal extent of PCE contamination originating from the source areas is shown in Figure 5. Vertical delineation of the contaminant plume has not been conducted to date.

Since the concentrations of chloroform, cis-1,2-DCE and TCE in the irrigation wells were unavailable, the maximum and mean concentration of these contaminants detected in the groundwater were used for comparison purposes to be conservative. The maximum and average concentrations of these groundwater contaminants, along with the New Jersey MCLs, are also presented (see Table 2). The maximum concentration of chloroform was lower than the New Jersey MCL, and as such, is unlikely to cause any adverse health effects. Based on the maximum concentrations of PCE in the irrigation wells and cis-1,2-DCE and TCE detected in the groundwater, these contaminants are considered contaminants of concern (COC) and were retained for further evaluation.

Municipal Supply Wells

Residences located in the boroughs of Sea Girt and Manasquan have been connected to a public water supply since 1928 and 1904, respectively (A. M. Fournier, Township of Wall, personal communication, 2004). With a few exceptions, all residences located in Wall Township were connected to public water in 1959 (L. Kubacz, Township of Wall, personal communication, 2004). By 1965, the remaining homes were also connected to the public water supply system. Although the Sun Cleaners began operations in 1960, due to the location of the source area (west side of Route 35) and slow movement of groundwater in the vicinity of the site, it was assumed that the residents were not exposed to contaminated drinking water from private wells.

There are three municipal drinking water supply wells (numbers 5, 6 and 7, see Figure 3) maintained by Sea Girt Borough which are located in the path of the contaminant plume. These wells draw water from the Englishtown aquifer and the deeper section of the Kirkwood-Cohansey aquifer. The Englishtown aquifer is believed to be hydraulically isolated from the shallow section of the Kirkwood-Cohansey aquifer (NJDEP 2003). Wells number 6 and 7 are the primary wells that provide water to Sea Girt residents whereas well number 5 is used during peak demand. More specific information for the three wells is as follows:

Sea Girt Municipal Supply Well Parameters (USEPA 2003)

Parameter	**No. 5**	**No. 6**	**No.7**
Aquifer Name	Englishtown	Kirkwood-Cohansey	Kirkwood-Cohansey
Installation Date	1963	1972	1981
Screen interval, feet bgs	650 - 715	83 - 123	92 - 129
% Water Production*	3.5	45	45

*The balance of demand is purchased from neighboring utilities.

Prior to September 1999, PCE was not detected in water samples collected from well number 6. However, subsequent sampling of this well in the fall of 2000 indicated 0.52 µg/L of PCE (USEPA 2003). Additionally, two groundwater monitoring wells located near the production wells indicated the presence of PCE at concentrations of 0.54 and 0.63 µg/L. Well testing conducted by MCHD also indicated that two deep irrigation wells located on Magnolia Avenue were contaminated with PCE ranging from 1.5 - 14.1 µg/L (USEPA 2003). These wells are located about 2,200 feet upgradient of the Sea Girt Municipal Supply wells. As of December 18, 2003, no contamination has been detected in the treated drinking water (A. M. Fournier, Township of Wall, personal communication, 2004; P. Cohn, NJDHSS, personal communication, 2004). However, as

a precautionary measure, Sea Girt Borough installed a VOC treatment system (i.e., air stripper) for the municipal supply wells.

No COCs were identified in the municipal water supply.

Surface Water

The Wreck Pond is located in the northeast corner of the site contaminant plume site (see Figure 3). According to the ATSDR (1999), the pond is not used for swimming but is utilized for boating, fishing and crabbing. In 1999, the NJDEP collected surface water and sediment samples from the Wreck Pond. PCE concentrations detected in surface water ranged from non-detect to 16 µg/L. No PCE was detected in sediment samples.

In 2001, the NJDEP collected three surface water samples from the Judas Creek (also referred to as Watson Creek, and Jason Creek) for VOC analysis. The creek is supplied by both groundwater and surface water runoff. Results indicated the presence of VOCs including PCE, TCE and cis-1,2-DCE. In April 2003, the NJDEP conducted resampling of the Judas Creek. Results indicated that the creek is contaminated with chloroform, cis-1,2-dichloroethene, tetrachlorothene, trichloroethene and vinyl chloride (see Table 3). The maximum concentrations of chloroform and vinyl chloride detected in the surface water were lower than their environmental guideline CVs and are unlikely to cause any adverse health effects. The maximum concentrations of cis-1,2-DCE, PCE and TCE exceeded their environmental guideline CVs; these contaminants are considered contaminants of concern (COC) and were retained for further evaluation.

Portions of Judas Creek are intermittent (i.e., not always flowing), and become a "losing stream" due to recharge (possibly contaminated via migration downward through contaminated stream sediment) entering the aquifer. This may also be caused by the lowering of the water table by pumping activities of local commercial establishments such as nurseries. These sporadic aquifer recharge conditions may give the appearance of multiple small plumes (see Figure 5) migrating from the Judas Creek or possibly a groundwater PCE "smearing" effect along the downgradient (northern) side of the creek. As such, more groundwater investigation is warranted in this area (J. Marchesani, NJDEP, personal communication, 2004).

The Hannabrand Brook, the northern hydraulic boundary of the site, has not been sampled to date.

Indoor Air

In 2001 and 2002, the NJDEP and USEPA collected more than 300 indoor air samples from approximately 220 potentially impacted residences, schools, and businesses. The results showed elevated indoor air concentrations of VOCs, and PCE concentrations as high as 1,632 µg/m^3. A list of site related contaminants (i.e., contaminants that were detected in the groundwater), along with the frequency of

detection, minimum, maximum, mean, median and standard deviation of the concentrations is presented in Table 3. The maximum and the mean concentration of indoor air contaminants detected in sampled buildings are presented in Table 4. The maximum and the mean concentration of cis-1,2-DCE was lower than its corresponding RBC of 33 $\mu g/m^3$, and as such, is unlikely to cause adverse health effects. The maximum and the mean concentrations of chloroform[2], PCE and TCE exceeded their corresponding RBCs. These contaminants are considered COC and were retained for further evaluation.

Interim Remedial Measures

Based on an evaluation of risks associated with PCE levels in the indoor air and USEPA Region 3 Risk-Based Concentrations (RBC), PCE interim remedial action levels were established for installing ventilation systems in affected buildings. Contaminants detected in the indoor air of buildings already sampled include PCE and degradation/transformation products of PCE (e.g., TCE).

For residences with TCE levels above 0.016 $\mu g/m^3$ (RBC and NJDEP Reporting Limit for TCE are 0.016 $\mu g/m^3$ and 3 $\mu g/m^3$, respectively), both the TCE and PCE concentrations were plotted (see Figure 6). PCE levels in four (2, 3, 6 and 7) of the 13 residences exceeded the PCE interim remedial action level of 6 $\mu g/m^3$. These residences were provided with the appropriate ventilation system to prevent inhalation exposures. The TCE levels of four (1, 4, 5 and 8) of the remaining nine homes exceeded the NJDEP residential indoor air screening level (3 $\mu g/m^3$), but PCE levels in those homes did not exceed the interim remedial action level. Therefore, ventilation systems have not been installed and the residents in these homes may continue to be exposed to indoor air TCE. Use of the PCE interim remedial action level alone does not address exposures to TCE in the indoor air of all residences. It is also unclear to what degree observed levels of PCE, TCE and other VOCs are attributable to vapor intrusion or to other background sources.

In addition to PCE and its products of degradation/transformation, many other VOCs were detected in the indoor air of the buildings sampled. The concentration of these substances, along with the frequency of detection, minimum, maximum, mean, median and standard deviation are presented in Appendix IV. Common sources and typical background concentrations for the chemicals detected in the indoor air of residences are provided in Appendix IV. Household cleaners and solvents, automobile exhaust and individual lifestyles (i.e., smoking, hobbies) may be the source of these compounds. As such, health implications associated with these substances will not be addressed as part of this Public Health Assessment.

The USEPA is negotiating with the RP to conduct a remedial investigation of the groundwater contamination which will include the indoor air sampling of buildings (M. Westgate, USEPA, personal communication, 2006).

[2]Chloroform is detected in the groundwater (see Table 2). In addition chloroform has also been identified as one of the photocatalytic degradation products of PCE with ultraviolet irradiation (Fukami et al., 2001)

Contaminants of Concern: Summary

The maximum concentration of contaminants detected in irrigation wells, groundwater, surface water and indoor air, along with Environmental Guideline CVs are presented in Tables 1 through 4. The following contaminants exceeded their corresponding environmental guideline CVs, and as such, are designated as the contaminants of concern (COCs) for the site:

Loction/Media	Contaminants of Concern
Irrigation Wells	tetrachloroethene
Groundwater	cis-1,2-dichloroethene, tetrachloroethene, trichloroethene
Municipal Water	None
Surface Water	cis-1,2-dichloroethene, tetrachloroethene, trichloroethene
Indoor Air	chloroform, tetrachloroethene, trichloroethene

A brief discussion of the toxicologic characteristics of the COC in surface water is presented in Appendix V.

Discussion

Since the presence of contaminated environmental media does not necessarily mean that there are exposures, the next step in the public health assessment process is to determine whether there is a completed exposure pathway from a contaminant source to a receptor population.

Exposure Pathway Evaluation

An exposure pathway is a series of steps starting with the release of a contaminant to an environmental medium, movement of the contaminant, and ending at the interface with the human body. A completed exposure pathway consists of five elements:

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

Generally, the ATSDR categorizes exposure pathways as follows: 1) *completed* exposure pathways, that is, all five elements of a pathway are present; 2) *potential* exposure pathways, that is, one or more of the elements may not be present, but information is insufficient to eliminate or exclude the element; and 3) *eliminated* exposure pathways, that is, one or more of the elements is absent. Exposure pathways are used to evaluate specific ways in which people were, are, or will be exposed to

environmental contamination in the past, present, and future. Completed and potential pathways may be *interrupted* by remedial or public health interventions that disrupt the pathway. Information provided by area residents regarding circumstances of exposure to environmental contaminants was taken into consideration in evaluating exposure pathways.

Completed Pathways

A completed exposure pathway must include each of the elements that link a contaminant source to a receptor population. Based on available information, it is reasonable to assume that completed exposure pathways existed among those individuals who live (or lived) in the area of the contaminant plume. Based on contaminant physicochemical and transport properties, the completed exposure pathways are as follows:

Incidental ingestion, dermal contact and inhalation of VOCs in well water during outdoor use (past, present, future). Residents impacted by site related groundwater contamination use irrigation wells for the watering of lawns and gardens and to fill swimming pools. The use of this water by residents may have exposed them to groundwater contaminants through incidental ingestion (e.g., an occasional drink from the hose), dermal contact and inhalation.

Inhalation of VOCs via vapor intrusion (past, present, future). For the White Swan Cleaners/Sun Cleaners Groundwater Contamination site, individuals were exposed to groundwater contaminants in the indoor air of buildings via vapor intrusion. Volatile chemicals in groundwater can migrate through subsurface soils and into indoor air spaces of overlying buildings (USEPA 2002). The vapor intrusion pathway may be important for buildings with or without a basement. Vapors can accumulate in occupied spaces to concentrations that may pose safety hazards, health effects, or aesthetic problems (e.g., odors). In residences with low contaminant concentrations, the primary concern is whether the chemicals pose an unacceptable health risk due to chronic exposures.

Completed exposure pathways identified for the site are presented in Table 5. Since the available data represent a snapshot in time, the NJDHSS and ATSDR cannot definitively determine the magnitude or duration of exposure. However, given that the exposure is likely to have persisted without any intervention, it is assumed that completed exposure pathways may have lasted up to 30 years (ATSDR 2002c).

Potential Pathways

The following potential exposure pathways were identified for the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination site:

Ingestion of contaminated biota in Wreck Pond (past, present, future). As stated in the 1999 ATSDR report, a more definitive evaluation of fishing and crabbing activities

of the Wreck Pond is required before public health implications can be determined. Therefore, this pathway was not evaluated as part of this public health assessment.

Delineation and migration of the groundwater contaminant plume (past, present, future). The contaminated groundwater plume has not yet been fully delineated and not all buildings located in the vicinity of the contaminated plume have been sampled (J. Boyer, NJDEP, personal communication, 2004), therefore it is not possible to assess exposures in all potentially impacted buildings. Private wells and the indoor air of buildings may become contaminated due to the migration of the groundwater contaminant plumes.

Operation and maintenance of the ventilation systems (future). Mechanical failure and/or lack of maintenance oversight of installed ventilation systems at affected buildings may lead to contaminant exposure.

Potential exposure pathways for the site are also presented in Table 5.

Public Health Implications

Once it has been determined that individuals have or are likely to come in contact with site-related contaminants (i.e., a completed exposure pathway), the next step in the public health assessment process is the evaluation of site-specific exposure doses. This is called a health guideline comparison which involves looking more closely at site-specific exposure conditions, the estimation of exposure doses, and the evaluation with health guideline comparison values (CVs). Health guideline CVs are based on data drawn from the epidemiologic and toxicologic literature and often include uncertainty or safety factors to ensure that they are amply protective of human health.

Completed human exposure pathways associated with the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination site are incidental ingestion, inhalation and dermal contact with the VOCs in well water during outdoor use and inhalation of indoor air. Since there is insufficient information available on the potential exposures associated with the ingestion of biota from the Wreck Pond and on the current extent of the contamination plume, an evaluation of potential pathways could not be conducted.

Non-Cancer Health Effects

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

uncertainty (or safety) factors or through the use of statistical models. In toxicological literature, observed effect levels include:

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

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or in experimental animals. A LOAEL is the lowest dose of a substance that has been reported to cause harmful (adverse) health effects in people or in experimental animals. In order to provide additional perspective on the potential for adverse health effects, calculated exposure doses may also be compared to the NOAEL or LOAEL. As the exposure dose increases beyond the MRL to the level of the NOAEL and/or LOAEL, the likelihood of adverse health effects increases.

To ensure that MRLs are sufficiently protective, the extrapolated values can be several hundred times lower than the observed effect levels in studies of people or experimental animals. When MRLs for specific contaminants are unavailable, other health based comparison values such as the USEPA's Reference Dose (RfD) are used. The RfD is an estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure.

Incidental Ingestion - Well Water

Although the area residents receive their potable water from public water supply systems, they use contaminated irrigation wells for the watering of lawns and gardens and to fill swimming pools. The concentration of cis-1,2-DCE and TCE in the well water were unavailable, therefore, the maximum concentrations of cis-1,2-DCE and TCE detected in the groundwater were used to calculate the exposure dose.

In order to assess exposures from incidental ingestion of groundwater contaminants, an exposure dose was calculated using the following formula:

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF}{BW} \qquad (1)$$

where mg/kg/day = milligrams of contaminant/kilogram of body weight/day;
C = concentration of contaminant in water (mg/L);
IR = ingestion rate (L/day);
EF = exposure factor representing the site-specific exposure scenario; and,
BW = body weight (kg).

The following exposure assumptions (USEPA 1997) were used to calculate contaminant doses.

Incidental Ingestion Rate (mL/event)[a]	Number of months exposed per year (months/year)	Body Weight (kg)	
		Child	Adult
50	5	21	70

[a]daily exposure

The estimated exposure dose was then compared to health guideline CVs. Based on the maximum concentration of PCE, TCE, and cis-1,2-DCE detected, the chronic exposure doses calculated for adults and children were lower than the corresponding health guideline CVs (see Table 6). As such, exposures associated with incidental ingestion of groundwater are unlikely to cause non-cancer adverse health effects.

Inhalation and dermal contact - Well water (exposures to VOCs during outdoor use)

The use of groundwater for lawn watering (sprinklers) and filling swimming pools is likely to have exposed the residents to contaminants through dermal contact and inhalation. As indicated earlier, since the concentration of cis-1,2-DCE and TCE in the well water were unavailable, the concentrations of cis-1,2-DCE and TCE detected in the groundwater were used to calculate the exposure dose.

(a) Lawn and garden watering: The following assumptions were used to calculate an inhalation exposure concentration during lawn and garden watering:

- watering for 60 minutes/day (daily);
- water flow rate = 3 gallons/minute;
- typical lawn size = 100 ft x 100 ft;
- watering period = May through September;
- exposed person stays in the lawn/garden area for the entire watering period; and,
- all of the groundwater contaminants transfer from the water to air.

The ambient and 24-hour time-weighted average (TWA) air concentration from a single lawn was calculated using an air dispersion model (ISCST3[3]) for area sources (see Table 7). The details of the analysis are presented in Appendix VI. The table also presents the ambient and 24-hour time-weighted average (TWA) air concentration from 100 lawns with sprinklers operating concurrently.

The calculated TWA ambient air concentrations of chloroform, cis-1,2-dichloroethylene, PCE and TCE concentrations associated with both the single and multiple lawn sprinkler scenarios were several orders of magnitude lower than their corresponding health guideline CVs (see Table 7). As such, non-cancer adverse health

[3]ISCST3 is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources.

effects from inhalation of contaminants during lawn and garden watering are not expected.

(b) Swimming Pools: Residents were exposed to groundwater contaminants during the use of swimming pools through oral, dermal and inhalation routes. Contaminants exposure dose was estimated using the SWIMODEL[4] version 3.0 (EPA 2003). The contaminant concentration in the pool water as a function of time was estimated by assuming contaminant mass transfer coefficient (Schwarzenbach et al. 1993), typical pool dimensions and operating parameters (L. Muetter, DHSS, personal communication, 2006). The water to air contaminant flux was used as input to an air dispersion model (ISCST3) to estimate the air concentrations above the swimming pool. The mean aqueous and ambient air concentrations were used as inputs to the SWIMODEL to estimate the contaminant exposure doses. The details of the analysis are presented in Appendix VI.

The child and adult exposure doses calculated for chloroform, cis-1,2-dichloroethylene, PCE and TCE were several orders of magnitude lower than their corresponding health guideline CVs (see Table 8). As such, non-cancer adverse health effects from the use of swimming pool are not expected.

Inhalation – Indoor Air

Inhalation of VOCs in the indoor air via vapor intrusion. The maximum and mean indoor air concentrations of chloroform, PCE and TCE, along with their health guideline CV, are presented in Table 9. The maximum concentration of chloroform was below its health guideline CV, and, therefore, is unlikely to cause non-cancer adverse health effects. The maximum concentration of PCE (1,632 µg/m^3) and TCE (44.68 µg/m^3) detected in the indoor air exceeded their respective chronic health guideline CVs. A brief evaluation of non-cancer health implications of PCE and TCE are presented below:

PCE: Figure 7 shows the indoor air concentration of PCE detected in descending order of magnitude and the MRL (i.e., 300 µg/m^3). PCE levels in only two residences exceeded the MRL. The chronic inhalation MRL for PCE is based on the LOAEL (i.e., neurobehavioral effects in long-term female employees of dry cleaning facilities) of approximately 101,000 µg/m^3. The MRL incorporates a safety factor of 333 to account for the use of the LOAEL, human variability (including sensitive populations such as children), and in converting from an occupational exposure to a continuous exposure (ATSDR 1997). The maximum PCE concentration is about 62 times lower than the LOAEL (see Table 9). Additionally, the mean PCE concentration (29.5 µg/m^3) was about an order of magnitude lower than the MRL. As such, the likelihood of non-cancer adverse health effects for exposures to PCE is low.

[4]The model uses standard exposure assessment equations to calculate swimmers' total exposure expressed as lifetime average daily dose (mg/kg/day) or a mass-based intake value (mg/event).

TCE: The maximum concentration of TCE (44.68 µg/m^3) detected in the indoor air exceeded the EPA RfC (see Table 9). The chronic inhalation RfC for TCE is based on the LOAEL (i.e., central nervous system effects in two occupational studies) of 38,000 µg/m^3. The RfC incorporates a safety factor of 1,000 to account for the use of the LOAEL, human variability (including sensitive populations such as children), (EPA 2001). The maximum TCE concentration is about 850 times lower than the LOAEL. Additionally, the mean TCE concentration (5.33 µg/m^3) was about an order of magnitude lower than the RfC. As such, the non-cancer adverse health effects for exposures to TCE are not expected.

Cancer Heath Effects

The site-specific lifetime excess cancer risk (LECR) indicates the cancer potential of contaminants. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 46 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of several common types of cancer ranges approximately between 1 in 100 and 10 in 100 (SEER 2005). Typically, health guideline CVs developed for carcinogens are based on a lifetime risk of one excess cancer case per 1,000,000 individuals. ATSDR considers estimated cancer risks of less than one additional cancer case among one million persons exposed as insignificant or no increased risk (expressed exponentially as 10^{-6}).

According to the United States Department of Health and Human Services (USDHHS), the cancer class of contaminants detected at a site is as follows:

1 = Known human carcinogen
2 = Reasonably anticipated to be a carcinogen
3 = Not classified

For the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination site, contaminants with cancer class 3 were not evaluated.

Incidental Ingestion - Well Water

Incidental Ingestion of VOCs in Well Water During Outdoor Use. The contaminant exposure dose for ingestion pathway was calculated using the following formula:

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times ED}{BW \times AT} \qquad (2)$$

where, C = concentration of contaminant in water (mg/L)
IR = ingestion rate (L/day)
ED = exposure duration (years)

BW = body weight (kg)
AT = averaging time (years)

The USDHHS cancer class (1 and 2) for the volatile contaminants detected in the indoor air is presented in Table 10. The Unit Risk or the USEPA Region 3 carcinogenic slope factor for ingestion (CSF) is also provided in Table 10. LECRs were calculated by multiplying: 1) the concentration of contaminant with the Unit Risk; or 2) the exposure dose with the CSF.

The LECR for adults was calculated by multiplying the exposure dose by the cancer slope factor. The calculated exposure dose and the LECRs for the contaminants are presented in Table 10. LECRs from ingestion for both maximum and average concentration of contaminants detected in the groundwater are shown in the table. Based on the maximum concentration of PCE and TCE detected in the well water, the LECRs calculated were two in 10,000 and three in 100,000 to the exposed population. At the mean PCE and TCE concentrations, the more likely exposure scenario, the LECRs were three in 100,000 and six in 10,000,000 to the exposed population. As indicated earlier, the LECRs presented in this table are associated with a number of uncertainties including the duration and level of exposure to area residents.

Inhalation and Dermal Contact – Well water

(a) Lawn and Garden Watering: The release of groundwater contaminants and the resulting ambient air concentration were modeled using an air dispersion model (see Table 7). The calculated exposure dose and the LECRs for the contaminants are presented in Table 11. LECR associated with exposures to ambient air during lawn and garden watering was determined to be less than one additional cancer case among one million persons exposed.

(b) Swimming Pool: The exposure dose during the use of swimming pool was calculated using the SWIMODEL (see Table 8). LECRs for the contaminants were calculated and presented in Table 12. Based on the maximum concentration of PCE detected in the well water, the LECRs calculated were one in 100,000 to the exposed population. At the mean PCE concentrations, the more likely exposure scenario, the LECR was two in 1,000,000 to the exposed population. LECR associated with exposures to mean concentration of PCE and both the maximum and mean concentration of TCE was determined to be less than one additional cancer case among one million persons exposed.

Inhalation – Indoor Air

Inhalation of volatile contaminants in the indoor air via vapor intrusion. The inhalation exposure doses were calculated using the following formula:

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times CR \times ED}{BW \times AT} \qquad (3)$$

where, C = concentration of the contaminant in air (mg/m^3)
CR = contact (inhalation) rate (m^3/day)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (years)

The USDHHS cancer class (1 and 2) for the volatile contaminants detected in the indoor air is presented in Table 13. The Unit Risk or the USEPA Region 3 carcinogenic slope factor for ingestion (CSF) is also provided in Table 13. LECRs were calculated by multiplying: 1) the concentration of contaminant with the Unit Risk; or 2) the exposure dose with the CSF.

Based on the maximum concentration of contaminants detected in the indoor air, the LECR values show that the VOCs having a cancer class of 1 or 2 posed a risk greater than one in 1,000,000. Based on the maximum concentration of PCE and TCE detected in the indoor air, the LECRs calculated were four in 1,000 and two in 1,000, respectively, to the exposed population. At the mean concentrations, the more likely exposure scenario, the corresponding LECRs were seven in 100,000 and three in 10,000 to the exposed population.

Assessment of Joint Toxic Action of Chemical Mixtures

At the White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site, residents were exposed to PCE and its degradation products via dermal contact, ingestion and inhalation. Although toxicological effects associated with site-related contamination were evaluated individually, the cumulative or synergistic effects of mixtures of contaminants may increase their public health impact. This depends upon the specific contaminant, its pharmacokinetics, and toxicity in the receptor population. Research on the toxicity of mixtures indicates that adverse health effects are unlikely when the mixture components are present at levels well below their individual toxicological thresholds (ATSDR 2005).

Non-Cancer

To evaluate the risk for non-cancer adverse health effects of chemical mixtures, a hazard index (HI) for the chemicals was calculated (ATSDR 2005). The hazard index is defined as the sum of the hazard quotients (i.e., estimated exposure dose of a chemical divided by applicable health guideline CV). If the HI is less than 1.0, it is highly unlikely that significant additive or toxic interaction would occur, so no further evaluation is necessary. If the HI is greater than 1.0, then further evaluation is necessary. For the White Swan Cleaners/Sun Cleaners Area Ground Water Contamination site, based on the mean concentration of contaminants detected (the more likely scenario), the calculated HI for ingestion (0.27) and inhalation (0.24) was less than 1 (see Table 14); as such, it is unlikely that significant additive or toxic interaction would occur.

Cancer

As measures of probability, individual cancer risk estimates can be added. The cumulative LECR associated with inhalation and incidental ingestion of contaminants was calculated (see Tables 10, 12, and 13). The cumulative estimated LECR for chloroform, PCE, and TCE, based on maximum concentrations ($2.2 \times 10^{-4} + 1.17 \times 10^{-5} + 6.28 \times 10^{-3}$), is seven in 1,000 to the exposed population. Based on the mean concentrations of the contaminants (the likely scenario), the cumulative ($3.48 \times 10^{-5} + 2 \times 10^{-6} + 3.43 \times 10^{-4}$) LECR is four in 10,000 to the exposed population.

Health Outcome Data

Based on a review of data available from the NJDEP and the USEPA, completed exposure pathways existed among area residents who used contaminated groundwater for outdoor use, and, inhaled contaminated indoor air. Exposures may have continued for approximately 30 years until ventilation systems were installed by the NJDEP and the USEPA. A review of health outcome data (e.g., adverse pregnancy outcomes, cancers, deaths) may be conducted to assess the public health significance of these completed exposure pathways. However, due to the small number of individuals exposed, an evaluation of available health data is unlikely to produce interpretable results.

Child Health Considerations

The NJDHSS and ATSDR recognize that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination in their environment. Children are at greater risk than adults from certain types of exposures to hazardous substances. 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 occur during critical growth stages. Most important, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

The NJDHSS and ATSDR evaluated the potential non-cancer and cancer risk for area residents (including children) who were exposed to contaminants in the groundwater. The maximum concentration of PCE and TCE detected in the indoor air exceeded the environmental guideline CVs, however, the likelihood of non-cancer adverse health effects is considered low. Based on the maximum and mean concentration of chloroform, PCE and TCE detected, the cumulative LECRs were 70 and four in 10,000, respectively, to the exposed population.

Chlorinated organics were identified as one of the potential groups of contaminants responsible for adverse pregnancy outcomes. A study conducted in Woburn, Massachusetts concluded that the elevated incidence of childhood leukemia was

associated with the mother's potential exposure to chlorinated organic compounds, particularly during pregnancy (Massachusetts Department of Public Health 1997). The study also suggested that exposures to these contaminants, whether multichemical or specific in nature, might have had an effect on blood-forming organs during fetal development, but not during childhood. Similarly, a New Jersey study found a statistically elevated rate of childhood leukemia in towns served by community water supplies contaminated with TCE and PCE (NJDHSS 1993).

Public Comment

The public comment period for this public health assessment was from May 9 to June 10, 2007. No comments were received during this period.

Conclusions

VOC contamination detected in groundwater and surface water, as well as the indoor air of residences and businesses in several municipalities of Monmouth County was investigated. PCE groundwater contaminant plumes originating from two former dry cleaning establishments were identified as the sources of extensive area contamination.

Completed exposure pathways were inhalation of contaminants in the indoor air and incidental ingestion, dermal contact and inhalation of contaminants in the well water during outdoor use. Potential pathways were also identified and included ingestion of biota from the Wreck Pond. Based on the maximum concentration of site-related contaminants, an evaluation of past exposures indicated that the potential for non-cancer adverse health effects from PCE and TCE are low; the cumulative LECR was seven in 1,000 to the exposed population. Based on mean contaminant concentrations (the more likely exposure scenario), past exposures indicated no non-cancer adverse health effects and a LECR of four in 10,000 to the exposed population, primarily due to tetrachloroethylene in indoor air from vapor intrusion. Cumulative or synergistic effects of mixtures of contaminants may increase the public health impact for both non-cancer adverse health effects and cancer risks. Non-cancer and cancer health effects associated with incidental ingestion, dermal contact and inhalation of contaminants in irrigation well water during outdoor use were also evaluated and found to be unlikely. Therefore, based on cumulative lifetime excess cancer risks levels, past exposures posed a ***Public Health Hazard***. A review of health outcome data is not recommended due to small size of the known impacted population.

Although the concentration of PCE detected in municipal wells was below the New Jersey Maximum Contaminant Level, Sea Girt Borough installed a VOC treatment system as a precautionary measure. For sampled buildings affected by elevated indoor concentrations of PCE, ventilation systems were installed based on PCE interim remedial action levels. It is important to note that the PCE interim remedial action level which triggers remedial action does not address indoor air contamination from PCE degradation/transformation products or other VOCs. Since the groundwater plumes have

not yet been fully delineated and site-specific background contaminant levels are not available, it is not possible to assess exposures in all potentially impacted buildings. In addition, sediment and biota sampling of the Wreck Pond and Hannabrand Brook has not been conducted. As such, current exposures associated with the contamination pose an ***Indeterminate Public Health Hazard***.

In addition to PCE, a number of chemicals were detected in the indoor air of buildings. These chemicals may be associated with the use and storage of household cleaning products and solvents.

Recommendations

1. The USEPA should consider conducting site-specific background studies to determine the typical concentration of PCE and other site-related VOCs in a non-impaired residence in the area. The interim action levels for the installation of ventilation systems should be revised or updated using the results of this background study, current RBCs and NJDEP indoor air screening levels.

2. Efforts by the USEPA to fully delineate the groundwater contaminant plume (i.e., horizontal and vertical) should continue. This will help track the potential migration of the groundwater contaminant plume. Additionally, the USEPA should consider implementing an indoor air sampling program in order that potential exposures may be identified and addressed. The USEPA and NJDEP should continue to ensure the proper operation and maintenance of ventilation systems.

3. The USEPA should conduct surface water/sediment sampling of the Hannabrand Brook and Wreck Pond.

4. Since the maximum concentration of PCE in groundwater (4,998 µg/L) was higher than that detected in irrigation wells (1,068 µg/L), the potential exists for future contamination of wells above known contaminant levels. Although it had been determined that the use of irrigation wells for non-potable purposes is not associated with increased health risks, it is recommended that individuals residing in areas with highest concentrations of VOCs have their irrigation wells tested.

Public Health Action Plan

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

Actions Undertaken

1. The USEPA and the NJDEP have sampled the indoor air of area residences and other buildings, including several area schools. In addition, the USEPA and NJDEP, collectively, have taken actions (i.e, installed ventilation systems) to reduce VOC exposures based on a PCE interim remedial action level.

2. The USEPA and the ATSDR have participated in a public availability session with local residents to provide them with a public health interpretation of their individual air sampling results. In addition, the ATSDR and NJDHSS have participated in a public meeting to inform area residents of the public health implications of indoor air exposures.

3. The ATSDR has prepared fact sheets for PCE and benzene to accompany individual sampling results sent to the residents by the USEPA.

4. Copies of this Public Health Assessment were made available to concerned residents in the vicinity of the site via the township library and the Internet.

Actions Planned

1. Indoor air samples collected from residential and commercial buildings indicated elevated levels of VOCs not associated with the groundwater contaminant plumes. These contaminants are generally related to smoking, hobbies and behavioral patterns. Public education and outreach materials dealing with reducing exposures from common indoor air contaminants detected will be made available to the residents.

2. As additional soil gas and groundwater data become available, the NJDHSS and ATSDR will evaluate the public health implications of contaminants detected and provide assistance to residents in reducing exposures to chemicals.

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CERTIFICATION

The public health assessment for the White Swan Cleaners/Sun Cleaners Area Groundwater Contamination, Wall Township, Monmouth County, New Jersey was prepared by the New Jersey Department of Health and Senior Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the public health assessment was initiated.

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

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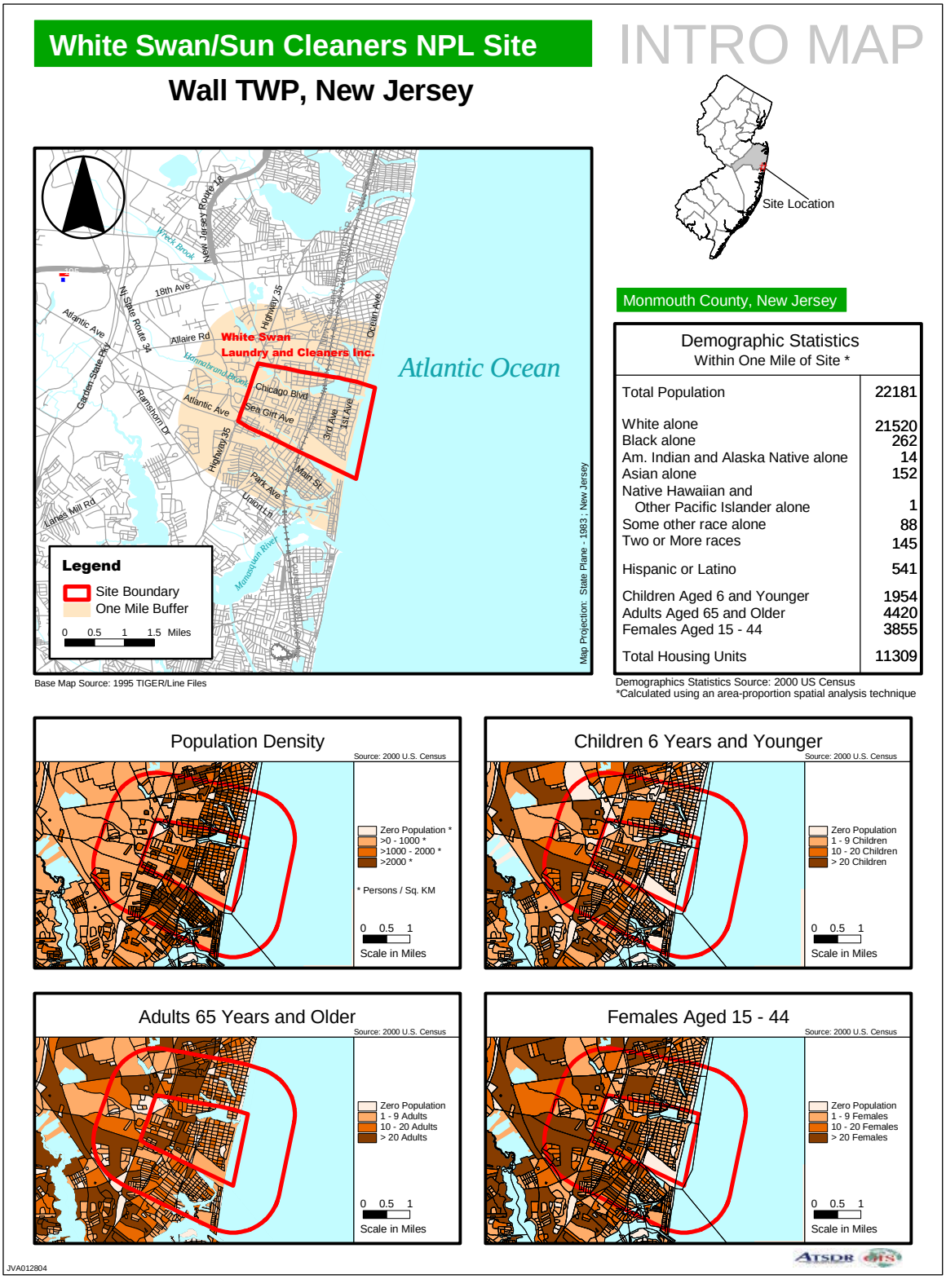

Figure 2: Demographic information of White Swan Cleaners/Sun Cleaners Groundwater Contamination Site based on 2000 U.S. Census

Figure 3: Site Location Map

Figure 4: Groundwater Sample Location Map (Source: NJDEP 2003)

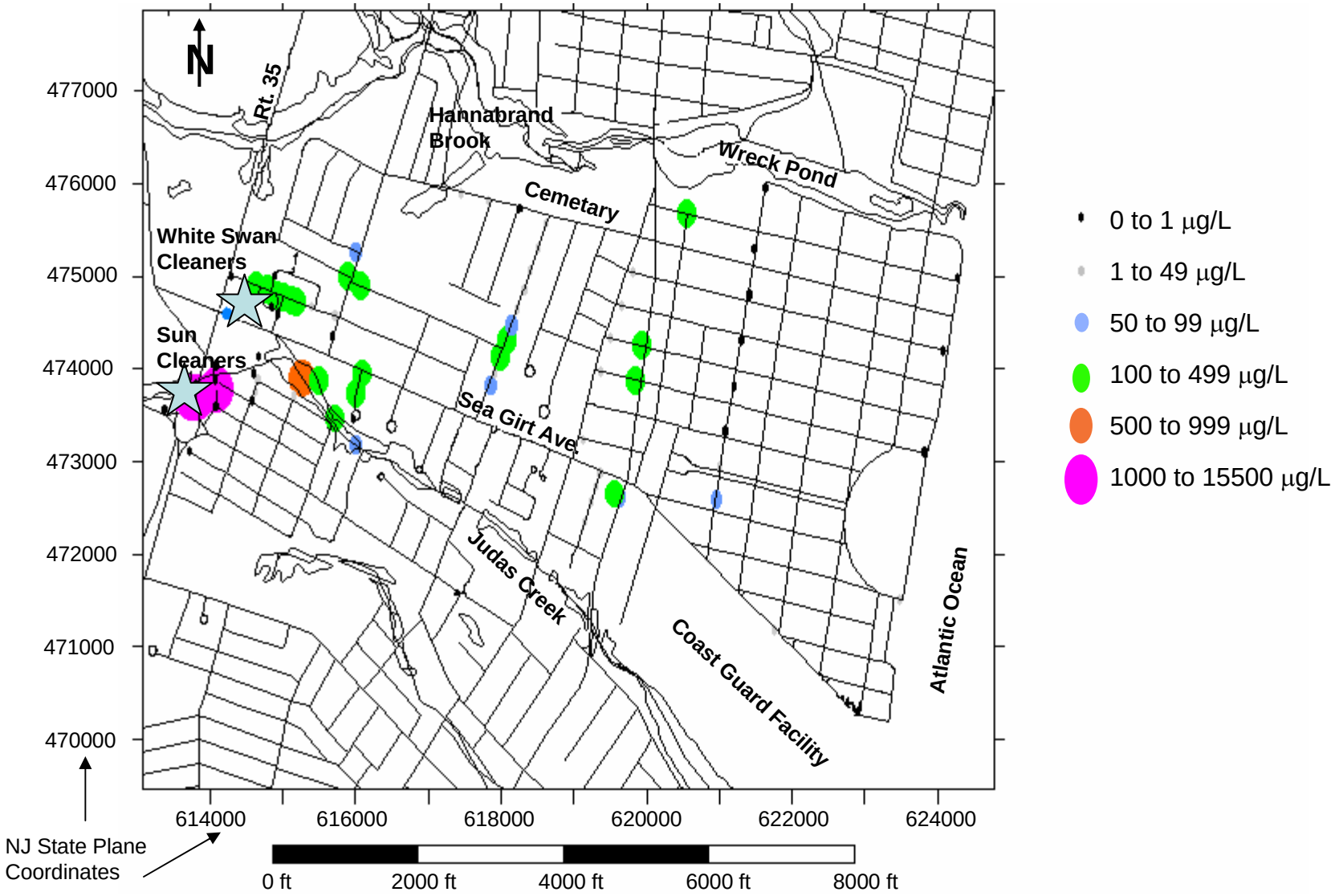

Figure 5: Shallow Groundwater/Judas Creek PCE Concentration Plot, Wall Township, Monmouth County (Drive point data collected March 2000 through April 2003)
Source: NJDEP

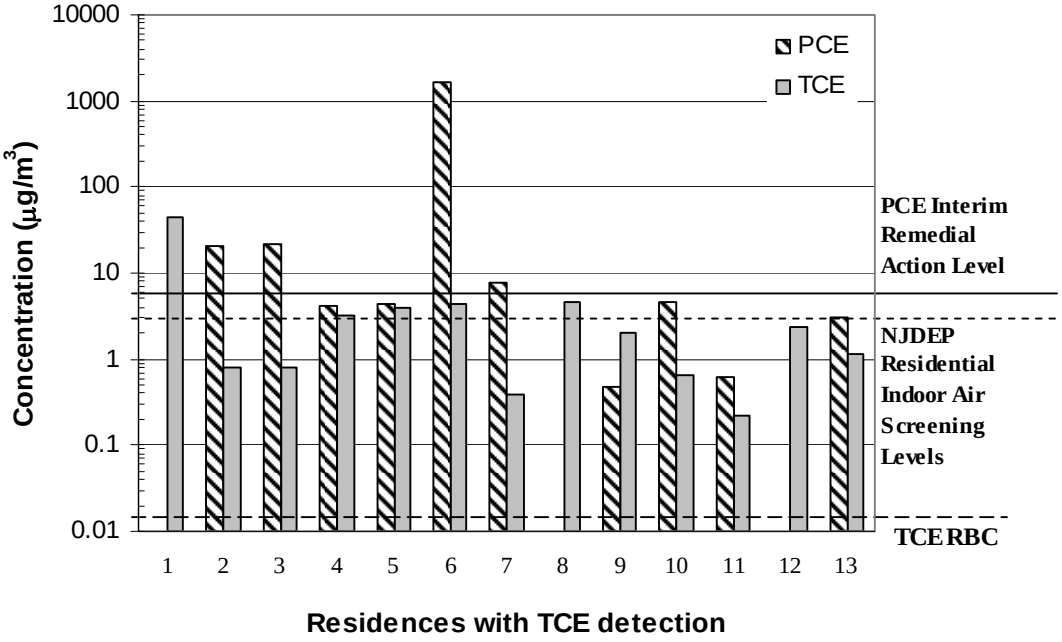

Figure 6: Residences with TCE levels in the indoor air that exceeded the RBC

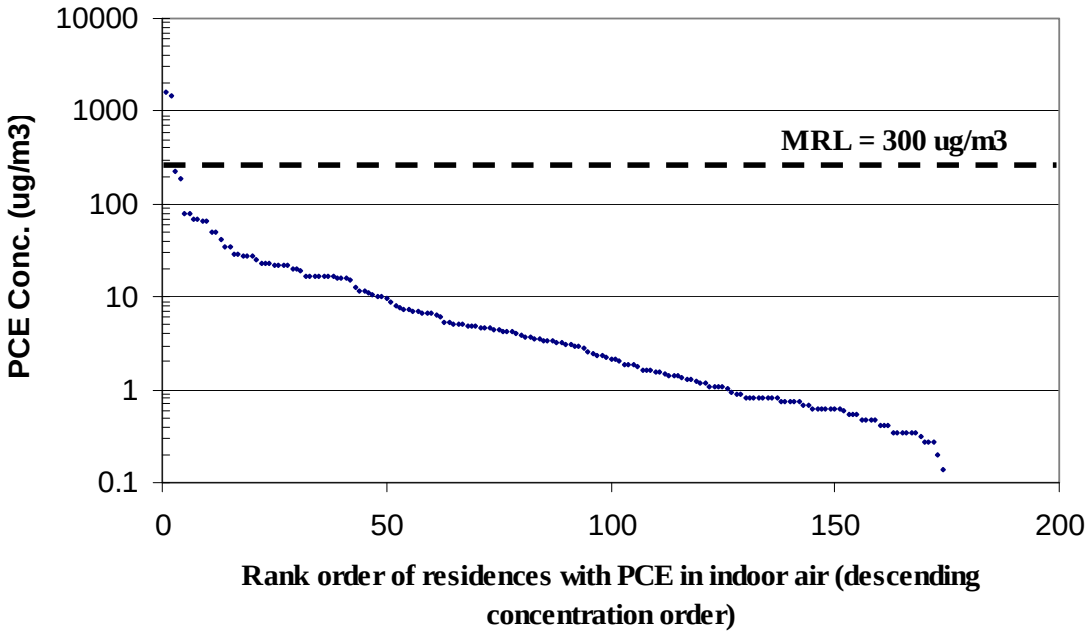

Figure 7: Distribution of PCE detected in the indoor air of buildings, White Swan Cleaners/Sun Cleaners Groundwater Contamination site

Site Photographs

Photograph 1: White Swan Cleaners property (now Fleet Bank)

Photograph 2: Ventilation System installed at a residential building

Table 1: Summary of Irrigation Well Sampling[a] Data of White Swan Cleaners/Sun Cleaner Groundwater Contamination Site

Contaminant	Detection Frequency	Range of Detected Conc. (µg/L)	Median of Detected Conc. (µg/L)	Mean of Detected Conc. (µg/L)	Environmental Guideline CV (µg/L)	COC[b]
Tetrachloroethylene	22	0.9 - 1,068	305	194 (72)[c]	1 (NJMCL[d])	**Yes**

[a]Number of Samples = 38; [b]Contaminant of Concern; [c]Standard deviation; [d]New Jersey Maximum Contaminant Level

Table 2: Summary of Groundwater Sampling[a] Data of White Swan Cleaners/Sun Cleaner Groundwater Contamination Site

Contaminant	Detection Frequency	Range of Detected Conc. (µg/L)	Median of Detected Conc. (µg/L)	Mean of Detected Conc. (µg/L)	Environmental Guideline CV (µg/L)	COC[b]
Chloroform	18	0.21 – 8.7	0.33	1.48 (2.44)[c]	80[d] (NJMCL[e])	No
cis-1,2-Dichloroethene	15	0.2 – 657	1.21	46 (169)	70 (NJMCL)	**Yes**
Tetrachloroethylene	47	0.28 - 4,998	6.97	139 (734)	1 (NJMCL)	**Yes**
Trichloroethylene	19	0.22 - 243	0.59	14.3 (55)	1 (NJMCL)	**Yes**

[a]Number of Samples = 38; [b]Contaminant of Concern; [c]Standard deviation; [d](Bromodichlormethane + Chloroform) $\leq$ 80 ppb; [e]New Jersey Maximum Contaminant Level

Table 3: Summary of Surface Water Sampling[a] Data of White Swan Cleaners/Sun Cleaner Groundwater Contamination Site

Contaminant	Detection Frequency	Range of Detected Conc. (μg/L)	Median of Detected Conc. (μg/L)	Mean of Detected Conc. (μg/L)	Environmental Guideline CV (μg/L)	COC[b]
Chloroform	1	0.33	0.33	0.33	80[b] (NJMCL[c])	No
cis-1,2-Dichloroethylene	3	4.7 – 81	14	33.23 (41.6)[e]	70 (NJMCL)	**Yes**
Tetrachloroethylene	3	56 – 996	149	400 (517.9)	1 (NJMCL)	**Yes**
Trichloroethylene	3	2.1 – 29	6	12.36 (14.5)	1 (NJMCL)	**Yes**
Vinyl Chloride	1	0.23	0.23	0.23	2 (NJMCL)	No

[a]Number of Samples = 3; [b]Contaminant of Concern; [b](Bromodichlormethane + Chloroform) $\leq$ 80 ppb; [c]New Jersey Maximum Contaminant Level; [e]Standard deviation;

Table 4: Summary of Indoor Air Sampling[a] Data, White Swan Cleaners/Sun Cleaner Groundwater Contamination Site

Contaminant	Frequency of Detection	Range of Detected Conc. (μg/m^3)	Median of Detected Conc. (μg/m^3)	Mean of Detected Conc. (μg/m^3)	Environmental Guideline CV (μg/L)	COC[b]
Chloroform	91	0.15 – 8.4	0.44	1.1 (0.44)[c]	0.04 (CREG[d])	**Yes**
cis-1,2-Dichloroethylene	3	1.26 – 3.33	3.13	2.57 (3.13)	62[e] (RBC[f])	No
Tetrachloroethylene	174	0.14 – 1,632	3.3	29 (3.3)	0.31 (RBC)	**Yes**
Trichloroethylene	13	0.22 – 44.68	2	5.33 (2)	0.016 (RBC)	**Yes**

[a]Number of Samples = 300; [b]Contaminants of Concern; [c]Standard Deviation; [d]ATSDR Cancer Risk Evaluation Guide; [e]Based on cis-1,2-DCE; [f]EPA Reg. 3 Risk Based Concentration

Table 5: Major Completed and Potential Contaminant Exposure Pathways for White Swan Cleaners/Sun Cleaner Groundwater Contamination Site

Environmental Pathway	Exposure Point	Exposure Scenario(s)	Route of Exposure	Receptor	Timeframe of Exposure		
					Past	Present	Future
Groundwater	Well Water	Irrigation/ Swimming Pools[a]	Ingestion/Inhalation/ Dermal	Residents	Completed[b]	Completed[b]	Completed[b]
	Indoor Air	Vapor Intrusion	Inhalation	Residents/ Building Occupants	Completed[b]	Interrupted[b,c]	Interrupted[b,c]
Surface Water	Brook/ Pond	Recreation[d]	Ingestion/Inhalation/ Dermal	Residents/ Visitors	Potential	Potential	Potential
	Brook/ Pond	Biota	Ingestion	Residents/ Visitors	Potential	Potential	Potential

[a]Past and current use of irrigation water for non-potable purpose but with incidental ingestion and inhalation; [b]Since contaminant plume delineation is incomplete, some residents may continue to be exposed via well water and indoor air; [c]The exposure pathways have been interrupted using the ventilation systems; [d]Contaminated water in the Wreck Pond

Table 6: Comparison of Exposure Dose from Incidental Ingestion of Irrigation Water with the Health Guideline CVs

Contaminant	Maximum of Detected Concentration (μg/L)	Exposure Dose[a] (mg/kg/day)		Health Guideline CV[b] (mg/kg/day)	Further Evaluation Indicated
		Adult	Child		
cis-1,2-DCE[c]	657	0.0002	0.0006	0.02 (RfD_o)[d]	No
PCE	1,068	0.00032	0.001	0.01 (RfD)[e]	No
TCE[c]	243	0.00007	0.00024	0.0003 (RfD_o)	No

[a]Exposure Dose is based on (daily) 0.05 L/day ingestion rate and 70 kg and 16 kg body weight for adult and child, respectively; [b]Comparison Value; [c]Contaminants detected in the groundwater; [d]EPA Region 3 Reference Dose Oral, based on trans-1,2-DCE; [e] EPA Oral Reference Dose

Table 7: Comparison of Calculated Lawn Air Concentration with Non-Cancer Health Guideline Values

Contaminant	Groundwater Concentration ($\mu g/m^3$)		Calculated Ambient Air Concentration ($\mu g/m^3$)		TWA[a] Concentration ($\mu g/m^3$)		Health Guideline CV[b] ($\mu g/m^3$)	Further Evaluation Indicated
	Max.	Mean	Max.	Mean	Max.	Mean		
Single Lawn								
Chloroform	8.7	1.48	0.0038	6.6×10^{-4}	0.0083	1.1×10^{-5}	100 (EMEG)[c]	No
cis-1,2-DCE	657	46	0.3	0.02	0.0018	0.0003	62 (RBC)[d]	No
PCE	1,068	194	0.47	0.08	0.005	0.001	300 (EMEG)	No
TCE[c]	243	14.3	0.108	0.006	6.7×10^{-5}	0.0001	40 (RfC)[e]	No
Multiple Lawns								
Chloroform	8.7	1.48	NA[f]	0.001	NA	1.8×10^{-5}	100 (EMEG)	No
cis-1,2-DCE	657	46	NA	0.03	NA	0.0005	62 (RBC)	No
PCE	1,068	194	NA	0.13	NA	0.0023	300 (EMEG)	No
TCE[c]	243	14.3	NA	0.01	NA	0.00017	40 (RfC)	No

[a]Time Weighted Average (based on 1 hour per day and 5 months per year); [b]Comparison Value; [c]ATSDR Environmental Media Evaluation Guide; [d]EPA Reg. 3 Risk Based Concentration; [e]EPA Reference Concentration; [f]Not Applicable

Table 8: Comparison of Maximum Exposure Dose during Swimming with Non-Cancer Health Guideline Values

Contaminant	Maximum Exposure Dose[a] (mg/kg/day)		Health Guideline CV[b] (mg/kg/day)	Further Evaluation Indicated
	Child (7 – 10 yr)	Adult		
Chloroform	3.82×10^{-7}	1.16×10^{-7}	0.01 (MRL[c])	No
cis-1,2-DCE[c]	3.26×10^{-5}	7.68×10^{-6}	0.02 (RfD_o[d])	No
PCE	1.27×10^{-4}	4.77×10^{-5}	0.01 (RfD[e])	No
TCE[c]	1.3×10^{-5}	4.2×10^{-6}	0.0003 (RfD_o)	No

[a]Exposure Dose calculated using SWIMODELfor adult and child; [b]Comparison Value; [c]ATSDR Minimum Risk Level; [d]EPA Region 3 Reference Dose Oral, based on trans-1,2-DCE; [e]EPA Oral Reference Dose

Table 9: Comparison of Indoor Air Concentration with Non-Cancer Health Guideline Values

Contaminant	Detected Concentration ($\mu g/m^3$)		Health Guideline CV[a] ($\mu g/m^3$)	Further Evaluation Indicated
	Maximum	Mean		
Chloroform	8.37	1.12	100 (MRL[b])	No
PCE	1,632	29.46	300 (MRL)	**Yes**
TCE	44.68	5.33	40 (RfC[c])	**Yes**

[a]Comparison Value; [b]ATSDR Minimum Risk Level; [c]EPA (Proposed) Reference concentration

Table 10: Calculated Lifetime Excess Cancer Risk (LECR) from Incidental Ingestion of Irrigation Water (LECR in parentheses is based on mean concentration)

Contaminant	Maximum Concentration (μg/L)	Exposure Dose[a] (mg/kg/day)	USDHHS[b] Cancer Class	CSF[c] $(mg/kg/day)^{-1}$	LECR
PCE	1,068	3.49×10^{-4}	2	0.54	1.88×10^{-4} (3.42×10^{-5})
TCE[d]	243	7.96×10^{-5}	2	0.4	3.19×10^{-5} (6.12×10^{-7})
				Sum =	2.2×10^{-4} (3.48×10^{-5})

[a]Exposure Dose is based on 32 years exposure duration, 0.05 L/day ingestion rate, 70 years averaging time, 70 kg body weight; [b]United States Department of Health and Human Services; [c]Cancer Slope Factor; [d]Contaminants detected in the groundwater

Table 11: Lifetime Excess Cancer Risk (LECR) Associated with Inhalation of Ambient Lawn and Garden Air

Contaminant	Max. TWA[a] Concentration ($\mu g/m^3$)	Exposure Dose (mg/kg/day)	USDHHS[b] Cancer Class	CSF[c] $(mg/kg/day)^{-1}$	LECR
Single Lawn					
Chloroform	0.0083	1.01×10^{-6}	2	0.081	8.2×10^{-8}
cis-1,2-DCE	0.0018	2.2×10^{-7}	3	NA[d]	NA
PCE	0.005	6.1×10^{-7}	2	0.02	1.2×10^{-8}
TCE	6.7×10^{-5}	8.2×10^{-9}	2	0.4	3.2×10^{-9}
Multiple Lawns[e]					
Chloroform	1.8×10^{-5}	2.2×10^{-9}	2	0.081	1.7×10^{-10}
cis-1,2-DCE	0.0005	6.1×10^{-7}	3	NA	NA
PCE	0.0023	2.8×10^{-7}	2	0.02	5.6×10^{-9}
TCE	0.00017	2.0×10^{-8}	2	0.4	8.3×10^{-9}

[a]Time Weighted Average (see Table 7); [b]United States Department of Health and Human Services; [c]Cancer Slope Factor; [d]Not Applicable; [e]Based on Mean concentration

Table 12: Calculated Lifetime Excess Cancer Risk (LECR) Associated with exposures to the Maximum and Mean Concentration of Contaminants in the Swimming Pool (LECR in parentheses is based on mean concentration)

Contaminant	Cancer Exposure Dose[a] (mg/kg/day)	USDHHS[b] Cancer Class	CSF[c] $(mg/kg/day)^{-1}$	LECR
Chloroform	4.9×10^{-8}	2	NA[d]	NA
cis-1,2-DCE	3.3×10^{-6}	3	NA	NA
PCE	2.04×10^{-5}	2	0.54	1.1×10^{-5} (2.0×10^{-6})
TCE	1.8×10^{-6}	2	0.4	7.2×10^{-7} (4.3×10^{-8})
			Sum =	1.17×10^{-5} (2.0×10^{-6})

[a]Exsposure Dose from SWIMODEL: 120 event/year for 30 years; [b]United States Department of Health and Human Services; [c]Cancer Slope Factor; [d]Not Available

Table 13: Calculated Lifetime Excess Cancer Risk (LECR) Associated with exposures to the Maximum and Mean Concentration of Indoor Air (LECR in parentheses is based on mean concentration)

Contaminant	Maximum Indoor Air Concentration ($\mu g/m^3$)	Exposure Dose[a] (mg/kg/day)	USDHHS[b] Cancer Class	CSF[b] $(mg/kg/day)^{-1}$	LECR
Chloroform	8.37	1.02×10^{-3}	2	0.081	8.2×10^{-5} (1.1×10^{-5})
PCE	1,632	1.99×10^{-1}	2	0.02	4×10^{-3} (7.2×10^{-5})
TCE	44.68	5.47×10^{-3}	2	0.4	2.2×10^{-3} (2.6×10^{-4})
				Sum =	6.28×10^{-3} (3.43×10^{-4})

[a]Exposure Dose ; [b]United States Department of Health and Human Services; [c]Cancer Slope Factor

Table 14: Multiple Chemical Exposure Analysis: Ingestion and Inhalation

Contaminant	Exposure Dose (mg/kg/day)	Health Guideline CV[a] (mg/kg/day)	Hazard Quotient	HI[b]
Ingestion				
cis-1,2-DCE	0.0002	0.02	0.01	0.27
PCE	0.00032	0.01	0.032	
TCE	0.00007	0.0003	0.23	
Inhalation[c]				
Chloroform	1.12 $\mu g/m^3$	100 $\mu g/m^3$	0.011	0.24
PCE	29.46 $\mu g/m^3$	300 $\mu g/m^3$	0.1	
TCE	5.33 $\mu g/m^3$	40 $\mu g/m^3$	0.13	

[a]Comparison Value; [b]Hazard Index; [c]Based on mean concentration

APPENDICES

Appendix I: ATSDR Report

- Author Information -

Author: Tom Mignone Action Date: 10/01/1999
User ID: TKM0 Time: 11:00 AM

- Site Specific Information -

Name: MAGNOLIA LANE PCE
Site Qualifier: PUBLIC HEALTH CONSULTATION (FINAL)
Address: City:
County: State: Zip Code:
CERCLIS #: NJXCR2#NJ000 CRS #: 2-41 Region: Congr. District:

- Site Status -

(1): NPL Non-NPL RCRA **X** Non-Site Specific SACM Federal*
(2): Emergency Response Remedial Removal **X** Other: INVESTIGATION

- Activities -

Incoming Call	Public Meeting*	1 Health Consult*	Site Visit*
Outgoing Call	Other Meeting	Health Referral	Info Provided
Confrnce Call	Data Review	Written Respons	Training
Incoming Mail	Trip Report	Worker Health	Tech Assist
Immed Removal	Other Activity:		

- Requestor and Affiliation -

Requestor: WILLIAM SIMMONS
Affiliation: COUNTY HEALTH, ENV. PROGRAM ADMINISTRATOR
Work Phone: (732)431-7456 Other Phone: ( ) -
Address: 3435 HIGHWAY 9
FREEHOLD, NJ 07728
County: MONMOUTH Congressional District: 06

- Contacts and Affiliations -

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ARTHUR BLOCK	ATSDR, SR. REGIONAL REPRESENTATIVE

Program Area: Public Health Consultation

Enclosures: N
Signature: Date: 10/01/199

CC: file S. Moore J. Pasqualo
PERISB A. Block (NJDHSS)
C. Welsh D. Munhall(EPA)

MAGNOLIA LANE PCE Action Date: 10/01/1999

- Narrative Summary -

Background and Statement of Issues

The Monmouth County Department of Health (MCDH) requested the Agency for Toxic Substances and Disease Registry (ATSDR) to review data pertaining to irrigation well and surface water contamination, and to comment on the possibility of a health threat posed by the contaminant [1]. ATSDR has been requested to address two concerns. The first request is for guidance on the usage of water from the contaminated irrigation wells. The second request is for an evaluation of the public health threat posed by the contaminants in Wreck Pond.

A plume, consisting primarily of perchloroethylene (PCE), as well as lower concentrations of related contaminants (trichloroethylene, cis-1,2-dichloroethylene), has impacted private irrigation wells in the municipalities of Sea Girt, Manasquan, and Wall (located in south eastern Monmouth County, NJ). An area map showing sampling locations and PCE concentration is attached as Figure 1. In addition, PCE has been found in a nearby surface water body, Wreck Pond. The origin of the contamination is unknown, but the source is under investigation PCE has been detected in area irrigation wells at concentrations up to 1,000 ug/L. These irrigation wells draw water from the shallow Kirkwwod-Cohansey aquifer, and differ in construction, installation date, and depth (to 50 feet) [2]. The irrigation wells are typically used to water lawns and gardens of the area residents. In March 1999, the MCDH issued an advisory recommending that, unless a current water analysis shows PCE levels below 1 ug/L (the NJDEP Ground Water Quality Standard), the irrigation wells should not be used for any purpose, including watering lawns, washing cars, and filling swimming pools [3,4].

Area residents receive their potable water from a public distribution system. This water is drawn from the deeper Kirkwwod-Cohansey aquifer, which is hydraulically isolated from the shallow contaminated aquifer. The Borough of Sea Girt has three public water supply wells located in the impacted area. To date no contamination has been detected in the borough's public supply wells [4]. This finding is based on monthly sampling of wells which began in April 1999, and is continuing.

Surface water collected from Wreck Pond (Figure 1) shows PCE levels ranging from "not detected" to 16 ug/L. PCE has not been detected in any sediment samples from Wreck Pond. The pond is not used for swimming, but is utilized for boating, fishing, and crabbing activities [5,6].

- Narrative Summary (continued) -

Discussion

PCE,also known as perc, tetrachloroethylene, perclene, and perchlor, is a synthetic chemical, widely used for dry cleaning of fabrics and for metal degreasing operations. Various consumer products contain PCE. These include printing inks, glues, sealants, polishes, lubricants, as well as spot, rust and paint removers, and rug and upholstery cleaners. PCE is non-flammable at room temperature, and easily evaporates into the air.

PCE in water can readily evaporate into air, and once in air can be inhaled and absorbed into the blood through the lungs. The International Agency for Research on Cancer describes PCE as "probably carcinogenic to humans", and the U.S. Environmental Protection Agency is currently reviewing their assessment of the evidence of the carcinogenic potential of PCE. Studies of dry-cleaning workers exposed to PCE suggest a possible association between long-term, high inhalation exposure to PCE and increased cancer risk [7]. Most other studies of human environmental exposures to PCE are confounded by concomitant exposure to other solvents, uncertainty in establishing the duration and level of exposures, and problems associated with smoking habits. These problems tend to render the studies problematic, and the study findings have not established an association between exposure to PCE and cancer in humans [7].

Exposure pathways associated with the contaminated irrigation well water involve ingestion, inhalation, and dermal contact. Exposure pathways associated with Wreck Pond involve ingestion and dermal contact. A review of the literature did not find information indicating home-grown vegetables incorporate PCE from irrigation water [7], thus exposures due to ingestion of home-grown produce are not likely. In addition, available information indicates that dermal contact is not an important route of exposure for PCE [7]. Due to the unlikely nature of significant exposures through dermal contact and ingestion of irrigated produce, those exposure pathways are not considered further in this Health Consultation.

Likely exposure pathways involve ingestion of contaminated water (from irrigation well water and Wreck Pond) and inhalation of PCE that has vaporized from the contaminated irrigation water. These ingestion and inhalation pathways are given further consideration.

Groundwater

To date, the MCDH has sampled approximately 70 irrigation wells in Wall Township, Sea Girt, and Manasquan. PCE has been detected in 37 of

- Narrative Summary (continued) -

those irrigation wells. The PCE levels in the area irrigation wells range from "not detected" to 1,000 ug/L with an average concentration in contaminated wells of 150 ug/L.

Exposures associated with occasional ingestion of water (one drink per day) from the contaminated wells involves the use of the irrigation well water for potable (drinking) purposes. The amount of water consumed in this manner might account for 1-5% of the total daily water intake (one drink estimated at 50 ml of the 2000 ml total intake per day). (This assessment is reasonable in light of the significant efforts the MCDH has made to educate the community members and recommend "stop usage" of the irrigation well water.) When considering water contaminated at a concentration of 1000 ug PCE/L, such an occasional drinking exposure would result in an intake of water with an estimated daily equivalent of 10-50 ug PCE/L. This level slightly exceeds the federal drinking water standards (limit at 5 ug/L) and the NJ drinking water standard (1 ug/L), however due to built-in "safety factors" used to establish that drinking water limit, an occasional drink of water containing 10-50 ug PCE /L is not expected to result in an unacceptable increased risk of cancer. It is also unlikely that non-carcinogenic health effects will result in people exposed to occasional drinks of water from the contaminated irrigation wells.

An inhalation exposure scenario, based on use of irrigation well water for lawn and garden watering, was calculated using the following assumptions: watering for 30 minutes/day, water flow rate at 3 gallons/minute, with a PCE concentration of 1,000 ug/l, the exposed person is stationary for the full watering period, and all of the PCE evaporates form the water and remains within a 16 m3 area near the exposed person. Given this exposure scenario, the maximum air concentration of PCE is 0.32 ug/m3. This air concentration is below the Cancer Risk Evaluation Guide (established by ATSDR), and therefore no adverse cancer, and no adverse noncancer health effects are likely associated with such an exposure.

Surface Water/Sediment

Wreck Pond, located in Sea Girt, is a popular area recreation attraction [5]. Boating, fishing and crabbing are common activities at the pond, but it is not used for recreational swimming.

Six surface water samples were collected from Wreck Pond in June 1999 by the MCDH. Analytical results showed PCE was detected in three of the six samples with the highest concentration being 16 ug/L PCE (two locations @ 0.8 ug/L; one @ 16 ug/L; three not detected). The six sediment samples collected did not contain PCE.

- Narrative Summary (continued) -

Since dermal contact with PCE is not an important route of exposure, (approximately 1 % of a concomitant inhalation exposure) [7], even at the highest levels of PCE found in Wreck Pond (16 ug/L), incidental contact with the water does not pose a health threat.

- Action Required/Recommendations/Info Provided -

Due to low potential for bioconcentration of PCE in organisms and a low potential for bioaccumulation in the food chain [7], the PCE levels reported in Wreck Pond are not expected to pose a threat via ingestion of edible organisms taken from Wreck Pond. However, it should be noted that there is no data which defines the levels of PCE in edible organisms in Wreck Pond. A more definitive evaluation of the edible organisms in Wreck Pond will require further investigation.

Conclusions

1. The extent of the PCE contamination is not completely defined
2. The available data indicate that exposure to PCE from the area irrigation well water, via inhalation, does not present a health concern.
3. Based on the reported PCE levels in the area irrigation wells, incidental ingestion of the water (less than 50 ml per day) does not pose a public health hazard.
4. With regard to recreational activities at Wreck Pond, the available data indicate that PCE is not present at level of health concern.
5. While the available evidence suggests that edible organisms in Wreck Pond will not significantly biomagnify the PCE, further analyses are needed to fully assess that question.
6. The reported PCE levels in irrigation wells does not pose a public health hazard when used for nonpotable purposes.

MAGNOLIA LANE PCE Action Date: 10/01/1999

- Action Required/Recommendations/Info Provided (continued) -

Recommendations

1. Due to the uncertainty associated with describing the contaminant plume, monthly surveillance of the Sea Girt municipal supply wells should continue.

2. Investigations should define the extent of the PCE contamination, and remediation efforts should follow.

3. The extent of contamination in edible organisms from Wreck Pond should be determined

4. Communication with the community regarding the hazards associated with the PCE should continue. Concentrated education efforts should be made where tests have revealed PCE levels above 100 ug/L.

A. Thomas Mignone, Jr., MPH
Environmental Health Scientist

10/01/99
Date

Concurrence:

10-4-99
Date

References

1. Personal communication from Lester Jargowsky, Monmouth County Department of Health, to T. Mignone, ATSDR; 22 July 1999.

2. Correspondence from William Simmons, Monmouth County Department of

MAGNOLIA LANE PCE Action Date: 10/01/1999

- Action Required/Recommendations/Info Provided (continued) -

Health to Joseph Verruni, Administrator, Township of Wall; 3 August 1998.

3. Monmouth County Health Department, "Magnolia Lane Fact Sheet and Advisory"; 31 March 1999.

4. Memorandum from Jerzy Chojnacki, Monmouth County Department of Health, to Patricia Allen, Municipal Clerk, Borough of Sea Girt; 13 July 1999.

5. Correspondence from Jerzy Chojnacki, Monmouth County Department of Health, to James Brownlee, New Jersey Department of Health and Senior Services; 20 July 1999.

6. Correspondence from Jerzy Chojnacki, Monmouth County Department of Health, to Bob Gallagher, New Jersey Department of Environmental Protection; 20 July 1999.

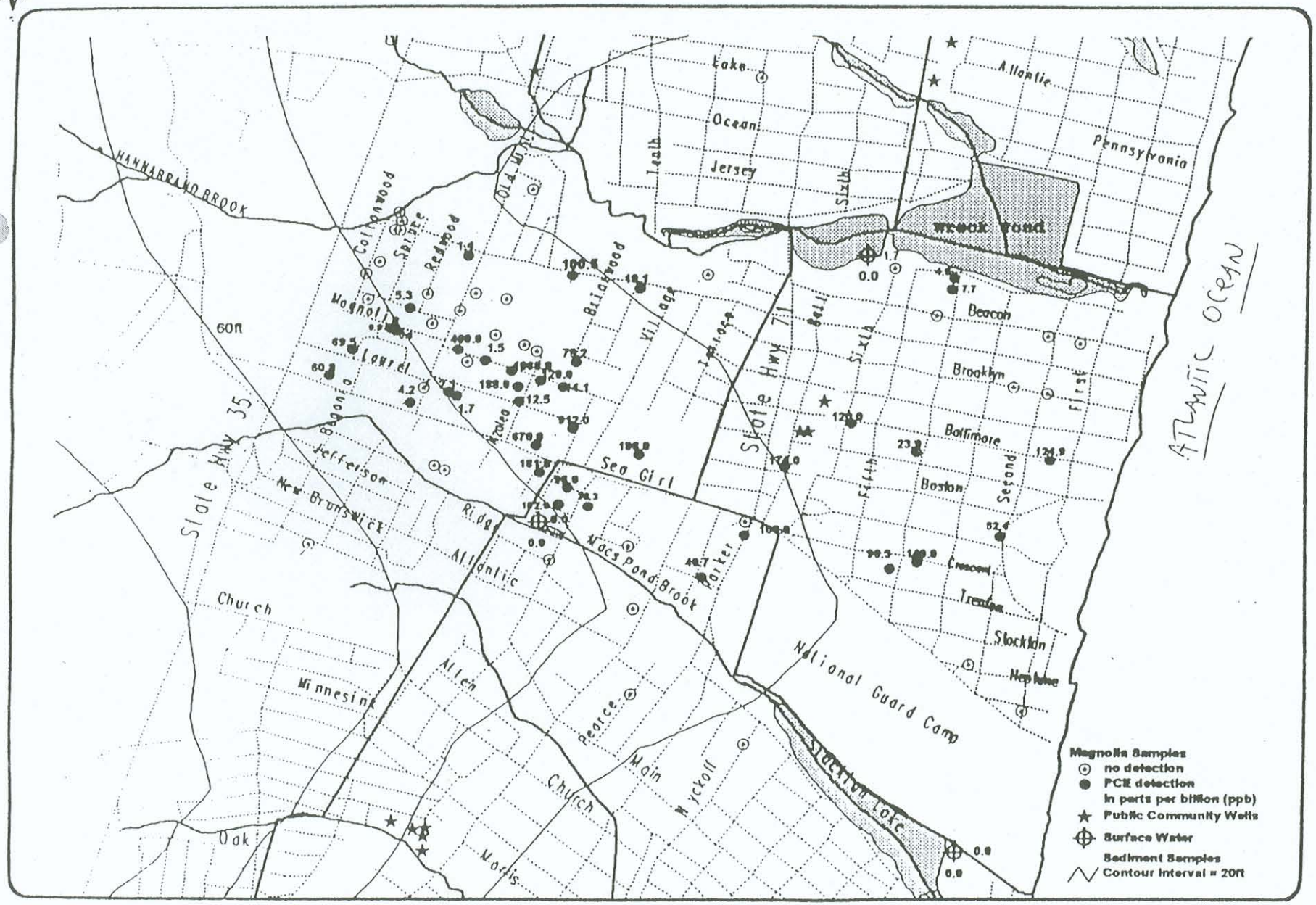
7. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Tetrachloroethylene (Update). Atlanta, Georgia. U.S. Department of Health and Human Services, Public Health Service. September 1997.

8. U.S. Environmental Protection Agency. Water Regulations and Health Advisories. Office of Drinking Water. Washington, D.C.

Monmouth County Health Department

The Magnolia Project

Tracking Perchloroethylene



Appendix II: Health Consultation: Brookside and Old Mill Schools

Health Consultation No. 1

Evaluation of Indoor Air Sampling at Brookside School

(FORMER) WHITE SWAN LAUNDRY AND CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUND WATER CONTAMINATION SITE)

SEA GIRT, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

JULY 31, 2002

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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HEALTH CONSULTATION NO. 1

Evaluation of Indoor Air Sampling at the Brookside School

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EPA FACILITY ID: NJSFN0204241

Prepared by:

New Jersey Department of Health and Senior Services
Hazardous Site Health Evaluation Program
Consumer and Environmental Health Services
Division of Epidemiology, Environmental, and Occupational Health
Under a Cooperative Agreement with the
Agency of Toxic Substances and Disease Registry

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
EMEG	Environmental Media Evaluation Guide
EPA	United States Environmental Protection Agency
HCV	Health-based Comparison Value
IRIS	Integrated Risk Information System
MCHD	Monmouth County Health Department
ND	Not Detected
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
PCE	Perchloroethylene (tetrachloroethylene)
RfC	Reference Concentration
RMEG	Reference Dose Media Evaluation Guide
TCE	Trichloroethylene
VOC	Volatile Organic Chemical

900000

Summary

This Health Consultation has been prepared in response to a request that was submitted in April 2002 by the U.S. Environmental Protection Agency (EPA) Region II and officials of the Brookside School to the Agency for Toxic Substances and Disease Registry (ATSDR) for an evaluation of indoor air sampling that was conducted at the school, located in Wall Township, Monmouth County, New Jersey. Concern has been raised about possible exposure by inhalation of chemicals that have been found in the groundwater in the vicinity of the (former) White Swan Laundry and Cleaner, Inc. (aka Magnolia Avenue Ground Water Contamination) site, also located in Wall Township, Monmouth County, New Jersey.

It is known that a shallow ground water plume containing trichloroethylene, *i.e.*, TCE, and tetrachloroethylene (perchloroethylene), *i.e.*, PCE, extends in an easterly direction from sources located in Wall Township (Monmouth), New Jersey. Moreover, the potential exists for exposure to these contaminants via inhalation of vapors that may have been transported from the ground water and subsequently into the indoor air of residences and other structures. Soil gas measurements are currently being performed by EPA to determine the contribution of site-related contaminants (including benzene) that have been found in soils to the concentrations of chemicals that have been detected in residential air samples.

The results of sampling show that benzene, carbon tetrachloride, and para-dichlorobenzene are present in the indoor air of the Brookside School at concentrations that slightly exceed ATSDR health-based comparison values (HCVs) and/or EPA Region III Risk-Based Concentrations (RBCs). Benzene is an ubiquitous substance that is a significant component of gasoline; it is commonly found at so-called "background" levels in the indoor air. The concentration of benzene that was found is similar to that found in many indoor air environments in urban and suburban areas. Carbon tetrachloride and para-dichlorobenzene have likely been introduced through routine maintenance activities at the school. Exposure to these chemicals, at the levels detected, is unlikely to cause adverse health effects.

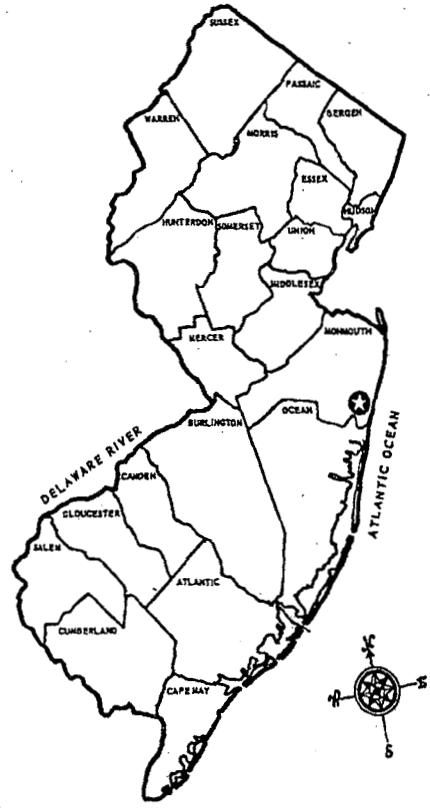
Several additional VOCs are present in the indoor air of the Brookside School, but their concentrations are below ATSDR HCVs and EPA RBCs; therefore, exposure to these chemicals, at the levels detected, is not likely to result in adverse health effects. Acetylene and propylene were detected in samples of the air at the Brookside School. Neither ATSDR nor EPA Region III has a health-based comparison value for acetylene or propylene. However, these chemicals have common indoor sources, and were detected at very low levels, so they do not represent any appreciable risk of an adverse health effect. Concentrations of all VOCs that were found in the Brookside School, particularly benzene, carbon tetrachloride, and para-dichlorobenzene, should be reduced through improved ventilation and HVAC operational procedures.

Based on the results of the sampling of the indoor air in the Brookside School, it is not likely that any exposure has occurred that would result in adverse health effects. There is no evidence that

inhalation of the air in the school would cause exposure at a level of public health significance, *i.e.*, the public health hazard category is **"No Apparent Public Health Hazard"**.

Purpose and Statement of Issues

In April 2002 the U.S. Environmental Protection Agency (EPA) Region II requested that the Agency for Toxic Substances and Disease Registry (ATSDR) assist in evaluating the public health implications of exposure to contaminants that had been detected in indoor air sampling of approximately 220 residences in Wall Township, Monmouth County, New Jersey (see inset). The sampling of indoor air was conducted during the period December 2001 - February 2002, in conjunction with the on-going investigation of releases of hazardous substances from the (former) White Swan Laundry and Cleaner site and from other nearby sources of ground water contaminants. Concern has been expressed by local officials regarding the potential for exposure, by inhalation, to chlorinated hydrocarbons, especially tetrachloroethylene (PCE) and trichloroethylene (TCE), that have been found to be present in the nearby shallow ground water, and could potentially volatilize into occupied structures.



On February 5, 2002, sampling was conducted at the Brookside School to determine if contaminants in the shallow ground water had been transported and volatilized inside the school. At the request of local school officials and the EPA, the New Jersey Department of Health and Senior Services (NJDHSS), working jointly under a cooperative agreement with the Superfund Site Assessment Branch, Division of Health Assessment and Consultation, ATSDR, has been asked to review and evaluate the results of indoor air sampling that was recently conducted at the school. The following discussion describes and evaluates the indoor air sampling results.

Background

Site History

In 1997 the Monmouth County Health Department (MCHD) became aware of the contamination of irrigation wells in the vicinity of Magnolia Avenue in Wall Township, Monmouth County, New Jersey by tetrachloroethylene (PCE). During 1999 and 2000, the MCHD and the New Jersey Department of Environmental Protection (NJDEP) performed a joint study of shallow ground water that identified a plume of PCE and trichloroethylene (TCE) contamination about 2.5 miles

long and one mile wide. The contamination plume was found to extend from Wall Township to the east into the Borough of Sea Girt (NJDEP, 2001).

During the period 1998 to 2000, NJDEP conducted site investigations at facilities that had been identified as potential sources of the ground water contamination. Soil and ground water samples collected at three sites confirmed that a release of volatile organic compounds (VOCs) had occurred at each of the sites. The three sources that NJDEP determined to have contributed to the Magnolia Avenue ground water contamination are: (1) the White Swan Laundry and Cleaners (aka: Fleet Bank or Summit Bank property), located on Sea Girt Avenue; (2) the Gulf Service Station, located at the intersection of State Highway 35 and Sea Girt Avenue; and (3) Sun Cleaners, located on State Highway 35 (NJDEP, 2001).

On February 23, 2001, Fleet Bank, the owner of the (former) White Swan Laundry and Cleaner property, entered into a memorandum of agreement with the NJDEP to conduct a site investigation and remedial investigation at the site; high concentrations of PCE contamination were found in the shallow groundwater beneath the property. Ground water was also sampled at three educational facilities in the vicinity of the site, *i.e.,* Sea Girt Elementary School, Old Mill School, and Brookside School. Based on these results, NJDEP determined that a ground water plume of contamination may have adversely effected the indoor air quality of nearby residential properties (NJDEP, 2001).

On October 25, 2001, the NJDEP conducted indoor air quality testing of three residential properties and one commercial property located near the Fleet Bank property. NJDEP provided the residents, and the owners of the commercial property, with fans for ventilating the basements of each of the buildings where PCE was detected.

At the request of the NJDEP, EPA announced plans on December 5, 2001 to take over the investigation in order to further characterize the contaminated ground water that underlies portions of Wall Township and the Borough of Sea Girt, and to determine if groundwater contaminants had volatilized in the indoor air of nearby structures. EPA also announced that they agreed to evaluate the site for potential listing on the National Priorities List (NPL), *i.e.,* Superfund. Since that time, EPA has collected and analyzed about 300 indoor air samples from at least 220 residential and business locations.

EPA has installed ventilation systems at all homes with PCE levels that are considered an immediate risk to public health, *i.e.,* greater than 60 $\mu g/m^3$ (micrograms per meter cubed) and NJDEP is working with the homeowners whose residences were found to have elevated PCE concentrations, *i.e.,* between 6 and 60 $\mu g/m^3$, and are interested in undertaking remedial measures. [Note: A companion Health Consultation (ATSDR, 2002) to this document specifically addresses residential exposure to PCE.] In April 2002, EPA sent the indoor air sampling results of the 220 residences to the respecitve homeowners (EPA, 2002). Included with this letter was a summary,

provided by ATSDR and NJDHSS, of the public health consequences of exposure to airborne PCE and benzene.

Summary of Previous ATSDR Activities

In October 1999, at the request of the MCHD and the EPA, ATSDR was asked to review the information that was then available regarding the ground water contamination, and to advise the community about the usage of the irrigation wells. ATSDR determined that the PCE that had been found in the ground water from irrigation wells posed no risk to human health, providing the water was used for non-potable purposes only. It was recommended that the extent of the plume be further characterized, and that the Sea Girt Municipal Well Field be monitored monthly for PCE (ATSDR, 1999).

Community Concerns

In conjunction with the survey of indoor air quality that has been conducted in the residences in Wall Township and Sea Girt, officials at two schools, the Brookside School and the Old Mill School, requested that the indoor air in their schools also be sampled and analyzed.

Discussion

Indoor Air Sampling at the Brookside School

Sampling of the indoor air at the Brookside School shows low concentrations of several VOCs to be present. The levels of benzene, carbon tetrachloride, and para-dichlorobenzene that were found in the indoor air exceed ATSDR HCVs and/or EPA Region III RBCs. Acetylene and propylene were also detected, but neither ATSDR nor EPA has a health-based comparison value for these chemicals. The remaining compounds that were analyzed were either not detected, or were found at concentrations that are below ATSDR HCVs and EPA RBCs. Exposure to these chemicals is not expected to result in any adverse health effect.

Health Assessment Methodology

In the course of creating a health assessment or consultation, ATSDR evaluates the environmental and human components that lead to human exposure from releases of hazardous substances at a site. An exposure pathway consists of five elements: (1) a source of contamination; (2) transport through an environmental medium; (3) a point of human exposure; (4) a route of human exposure; and (5) a receptor population. ATSDR categorizes exposure pathways in three groups: (1)"completed pathways", that is, those in which exposure is reasonably expected to have occurred, to be occurring, or to occur in the future; (2) "potential pathways", that is, those in which exposure might have occurred, may be occurring, or may yet occur, and (3) "eliminated pathways", that is,

those that can be eliminated from further analysis because at least one of the five elements listed above is missing and will never be present, or in which no contaminant of concern can be identified.

ATSDR follows a two-step process to assess the public health issues that are related to exposure pathways at hazardous waste sites. First, ATSDR obtains representative environmental monitoring data for the site and compiles a list of site-related contaminants. This list of contaminants is compared to health-based comparison values (HCVs) to identify those contaminants that do not have a realistic possibility of causing adverse health effects. [Appendix A contains a description of terms and definitions that pertain to HCVs.] Second, for the remaining contaminants, ATSDR evaluates site-specific conditions to determine what exposure scenario is realistic for a given exposure pathway. For the assumed exposure scenario, ATSDR determines an exposure dose, and compares this dose to scientific studies to determine whether the extent of exposure indicates a potential public health hazard. The health-based comparison values that are presented in this report are concentrations of contaminants below which, the current public health literature suggest, are unlikely to result in adverse health effects. These comparison values are conservative because they include safety factors that are intended to protect the most sensitive populations. ATSDR typically uses HCVs as follows: if a contaminant is never found at levels greater than its comparison value, exposure to the contamination is considered to be "safe" or "harmless". If, conversely, a contaminant is found at a concentrations that are greater than its HCV, ATSDR designates the pollutant as a contaminant of concern and examines it further in the assessment. Because HCVs are based on conservative assumptions, the presence of a contaminant at concentrations greater than an HCV does not necessarily suggest that adverse health effects will occur within the exposed population. Moreover, these health-comparison values are conservative, since they are assume continuous exposure over long-time frames (usually more than 30 years).

Analysis of Exposure Pathways and Contaminants of Concern

The exposure pathway of concern evaluated in this Health Consultation is exposure by inhalation to ground water contaminants that partition between the ground water and soils, and then volatilize and infiltrate the indoor air of the school.

Studies that have been conducted by the EPA have shown that most homes in the U.S. have measurable levels of volatile organic chemicals (VOCs) in indoor air. Although it is well known that outdoor air contains many VOCs, the EPA studies found that the concentrations of organic chemicals in indoor air are usually higher than the concentrations that are found in outdoor, *i.e.*, ambient air. These higher indoor air levels of VOCs presumably come from consumer products that are brought into the homes, from evaporation of home construction materials, and from personal activities. EPA studies showed that certain human activities were associated with increased levels of chemicals in indoor air. Examples of these activities are:

* smoking indoors increases benzene, xylene, ethyl benzene, and styrene levels in indoor air;
* bringing dry cleaning home increases the levels of PCE in indoor air;

* using hot water in the home increases chloroform levels in indoor air; and
* using room air fresheners, toilet bowl deodorizers, and moth crystals leads to higher levels of para-dichlorobenzene in indoor air (EPA, 1987).

Soil/gas measurements are currently being performed by EPA to determine the contribution of site-related contaminants (including benzene) that have been found in soils to the concentrations of chemicals that have been detected in residential air samples.

Public Health Implications

The aromatic hydrocarbons benzene, toluene, ethyl benzene, and xylenes, together known as BTEX, that were found in the air samples are primary constituents of gasoline. Benzene, classified by EPA as a known human carcinogen (carcinogenicity category A), is found in gasoline and automobile emissions, and is also a constituent of some paints, adhesives, and particle board. Since the maximum concentration of benzene, 1.56 $\mu g/m^3$ in Table 1, is less than indoor "background" levels of benzene that are typically found in the indoor air in homes (about 6 $\mu g/m^3$ on average), it is likely that the benzene and the other BTEX compounds that were detected came from indoor sources within the Brookside School. Benzene was the only BTEX detected above ATSDR HCVs and/or EPA RBCs. However, the measured concentrations of benzene represent little or no additional lifetime cancer risk beyond the cancer risk due to background levels. Consequently, no adverse health effects are expected from exposure to the levels of benzene that were found in the Brookside School air samples.

Carbon tetrachloride is a colorless liquid that is commonly used as a solvent in varnishes, lacquers, and resins. It has been classified in EPA carcinogenicity category B2, *i.e.*, a probable human carcinogen. The maximum concentration of carbon tetrachloride that was found in the Brookside School, *cf.* 0.57 $\mu g/m^3$ in Table 1, is slightly above EPA Region III's RBC and about eight times higher than ATSDR's HCV. Although carbon tetrachloride was detected at levels above these comparison values, the HCVs and RBCs are calculated by assuming long-term, continuous, exposures that are not likely to occur in a school setting. Therefore, it is unlikely that the concentrations of carbon tetrachloride that were detected would result in adverse health effects.

Para-dichlorobenzene, which has a mothball-like odor, is a chemical that is found in formulations of air deodorants and insecticides. It is classified in EPA carcinogenicity category C, *i.e.*, a possible human carcinogen. The maximum concentration that was found in the Brookside School, *cf.* 0.6 $\mu g/m^3$ in Table 1, slightly exceeds EPA Region III's RBC, but does not exceed ATSDR's HCV. Since RBCs are derived by assuming long-term, continuous exposure, intermittent short term exposure to para-dichlorobenzene, such as that occurring at the Brookside School, is not likely to result in adverse health effects.

The three Freons, *i.e.*, dichlorodifluoromethane (aka Freon 12), fluorotrichloromethane (aka Freon 11), and trichlorotrifluoroethane (aka Freon 113), that were identified in the air samples are used as refrigerants and as aerosol propellants. They were probably introduced to the school through operation of the heating, ventilation, and air conditioning (HVAC) system. Since the concentrations that were found are below ATSDR HCVs and EPA RBCs, exposure to these chemicals at the levels detected is not likely to result in any adverse health effects.

The other chlorinated VOCs that were found in the air samples, including chloromethane and methylene chloride, are solvents that are commonly used in consumer products. It is likely that these species were introduced to the school through routine building operations, such as through the use of cleaning products. The occasional exposure to these chlorinated VOCs, which were found at concentrations below their respective HCVs and RBCs, is unlikely to result in adverse effects to human health.

Acetylene, a gas that is used in welding, can act as an asphyxiant when its concentration becomes sufficiently high to displace oxygen (HSDB, 2002). The levels detected in the Brookside School air samples are well below those that would constitute a health threat for asphyxiation.

Propylene is a gas that is ubiquitous in the environment. Biological sources of propylene include garlic, essential oils, fir trees, Scotch pine, and natural gases; it is also released by germinating beans, corn, cotton, and pea seeds. Propylene can also be released into the environment by incomplete combustion, *e.g.*, combustion of biomass, natural gas, cigarettes, and gasoline. There are little data on typical indoor air concentrations, except for some studies of smoked-filled taverns where the levels of propylene due to cigarette smoking were about 100 times greater than the maximum level detected at the Brookside School. The levels detected at the Brookside School are in the low range of the levels detected in the ambient air in rural areas of the United States and Britain (HSDB, 2002). The levels detected in the school do not represent any appreciable risk of an adverse health effect.

Neither of the potentially site-related contaminants PCE and TCE was found in the indoor air of the school. Since there is no evidence of exposure to PCE or TCE, no adverse health effects can occur.

Conclusions

The results that are presented in Table 1 show that low concentrations of several VOCs are present in the indoor air of the Brookside School. The concentrations of benzene, carbon tetrachloride, and para-dichlorobenzene that were found are slightly above ATSDR HCVs and/or EPA Region III RBCs. Since continuous, long-term exposure, *i.e.*, 24 hours per day, 7 days per week for more than 30 years, is not likely within an educational setting such as the Brookside School, exposure to these chemicals at the measured concentrations is unlikely to cause adverse

health effects. The concentrations of benzene that were found are similar to those found in indoor air environments in urban and suburban areas.

Several other VOCs, including dichlorodifluoromethane (aka Freon 12™), methyl chloride, trichlorofluoromethane (aka Freon 11™), methylene chloride, trichlorotrifluoroethane (aka Freon 113™), toluene, ethyl benzene, and xylenes, were detected at concentrations that are below EPA's RBCs and ATSDR's HCVs; therefore, exposure to these chemicals is not likely to result in adverse health effects.

Acetylene and propylene were also detected at low concentrations in samples of the indoor air at the Brookside School. Neither ATSDR nor EPA Region III has a health-based comparison value for either chemical. However, these chemicals have common indoor sources and were detected at very low levels. The concentrations of acetylene and propylene that were detected in the school are not unusual, and do not represent any appreciable risk of an adverse health effect.

Neither PCE nor TCE was detected in the indoor air of the Old Mill school, so there is no evidence of exposure to these chemicals.

In summary, none of the chemicals that were found in the indoor air of the Brookside School were present at a concentration of public health concern. As a result, inhalation of the indoor air in the school is not likely to have an adverse effect on human health, *i.e.*, the public health hazard category is **"No Apparent Public Health Hazard"**. [See Appendix B for definitions of public health hazard categories.]

Recommendations

Recommendations to Cease/Reduce Exposure

As with any school or office building, the indoor air quality of the Brookside School may be improved by using well known methods, *e.g.*, additional ventilation should be provided by running the HVAC system at 100% outside air after using cleaning chemicals, or after an indoor pesticide treatment. Indoor concentrations of carbon dioxide, a surrogate that indicates the adequacy of ventilation, should not exceed 1000 parts per million by volume (ppmv). The indoor air quality of the Brookside School may also be improved by minimizing use of cleaning products that contain large quantities of chlorinated solvents and other VOCs.

If it is determined that ground water beneath the school contains site-related contaminants, it is recommended that, if ground water enters the school, either in the basement or via a sump, the indoor air be periodically monitored for VOCs.

Certification

This Health Consultation was prepared by the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It has been produced in accordance with approved methodology and procedures existing at the time the Health Consultation was begun.

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Technical Project Officer
Superfund Site Assessment Branch (SSAB)
Division of Health Assessment and Consultation (DHAC)
ATSDR

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

Roberta Erlwein
Chief, SPS, SSAB, DHAC
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Appendices

Appendix A: Description of Comparison Values

Description of Comparison Values

ATSDR's Comparison Values are media-specific concentrations that are considered to be "safe" under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific chemical substances that the health assessor has selected for further evaluation of potential health effects.

Generally, a chemical is selected for evaluation because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's Comparison Values. However, it cannot be emphasized strongly enough that Comparison Values are not thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a Comparison Value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not solely on environmental concentrations.

Screening values based on non-cancer effects are generally based on the level at which no health adverse health effects (or the lowest level associated with health effects) found in animal or (less often) human studies, and include a cumulative margin of safety (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10-fold to 1,000-fold or more. By contrast, cancer-based screening values are usually derived by linear extrapolation with statistical models from animal data obtained at high exposure doses, because human cancer incidence data for very low levels of exposure are rarely available. Cancer risk estimates are intended to represent the upper limit of risk, based on the available data.

Listed and described below are the types of comparison values that the ATSDR and the NJDHSS used in this Health Consultation:

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations of contaminants in an environmental medium (such as drinking water) that are expected to cause no more than one excess cancer case for every million persons who are continuously exposed to the concentration for an entire lifetime (equaling a risk of 1×10^{-6}). These concentrations are calculated from the EPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are known or suspected of being carcinogenic have CREG Comparison values.

Environmental Media Evaluation Guides (EMEGs) and Reference Dose Media Evaluation Guides (RMEGs) are estimates of chemical concentrations in an environmental medium (such as drinking water) that are not likely to cause an appreciable risk of deleterious, non-cancer health effects, for fixed durations of exposure. These guides may be developed for special sub-populations such as children. EMEGs are based on ATSDR's Minimal Risk Level (MRL) while RMEGs are based on the EPA's Reference Dose (RfD).

Other health-based guides may also be used as Comparison Values, including drinking water Maximum Contaminant Levels (MCLs) established by the EPA or the NJDEP.

Appendix B: ATSDR Public Health Hazard Categories

ATSDR's Interim Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards..
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.

Category / Definition	Data Sufficiency	Criteria
C. Indeterminate Public Health Hazard This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

* *Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.*

Table 1. Air Sampling at Brookside School, Wall Township, February 5, 2002 (ppbv; in parentheses, $\mu g/m^3$)

Chemical	Sample				MW	ppbv = ($\mu g/m^3$)	ATSDR HCV	RBC ($\mu g/m^3$)
	D1	R1	D2	R2				
Acetylene	0.91	0.86	1.10	1.06	26	1.06	NONE	NONE
Propylene	0.40	0.40	0.56	0.56	42	1.72	NONE	NONE
Dichlorodifluoromethane	0.52	0.50	0.49	0.47	121	4.95	NONE	180
Methyl chloride	0.31	0.37	0.42	0.47	71	2.90	50	1.8C
Methyl bromide	ND	ND	0.05U	0.03U	95	3.88	5	5.1
Fluorotrichloromethane	0.36	0.36	0.22	0.21	137	5.60	NONE	730
Methylene chloride	0.07	0.07U	0.05U	0.03U	85	3.48	(3CREG)	3.8C
Trichlorotrifluoroethane	0.09	0.10	0.11	0.12	197	8.06	NONE	31000
Benzene	**0.41**	**0.41**	**0.49 (1.56)**	**0.46**	**78**	**3.19**	**(0.1CREG)**	**0.22C**
Carbon Tetrachloride	**0.09 (0.57)**	**0.09**	**0.03U**	**0.02U**	**154**	**6.30**	**(0.07CREG)**	**0.12C**
Trichloroethylene*	ND	ND	ND	ND	130	5.32	(40)RfC, UR	0.016C*
Toluene	0.36	0.41	0.58	0.58	92	3.76	80	420
n-Octane	ND	ND	ND	0.05U	114	4.66	NONE	NONE
Tetrachloroethylene	ND	ND	ND	ND	166	6.79	40UR	0.63C*
Ethylbenzene	0.05U	0.06U	0.07U	ND	106	4.33	1000int	1.6C**
m/p-Xylene	0.15	0.17	0.19	0.18	106	4.33	100total	7300
o-Xylene	0.07	0.09U	0.09U	0.09U	106	4.33	100total	7300
Paradichlorobenzene	**0.10 (0.6)**	**0.12U (0.72)**	**ND**	**ND**	**147**	**6.01**	**100**	**0.28C***

BOLD - exceeds EPA Region III RBC or ATSDR HCV
U - estimated, below detection limit
MW - molecular weight
ND - not detected
C - designated as carcinogen by EPA Region III
UR - Under review by ATSDR
CREG - ATSDR Cancer Risk Evaluation Guide
* Carcinogenicity not assessed by IRIS
** EPA IRIS indicates category D (carcinogenicity not classifiable)

NB: $\mu g/m^3$ = ppbv x MW/24.45 at room temperature

Health Consultation No. 2

Evaluation of Indoor Air Sampling at Old Mill School

(FORMER) WHITE SWAN LAUNDRY AND CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUND WATER CONTAMINATION SITE)

SEA GIRT, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

JULY 31, 2002

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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HEALTH CONSULTATION NO. 2

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Prepared by:

New Jersey Department of Health and Senior Services
Hazardous Site Health Evaluation Program
Consumer and Environmental Health Services
Division of Epidemiology, Environmental, and Occupational Health
Under a Cooperative Agreement with the
Agency of Toxic Substances and Disease Registry

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
EMEG	Environmental Media Evaluation Guide
EPA	United States Environmental Protection Agency
HCV	Health-based Comparison Value
MCHD	Monmouth County Health Department
ND	Not Detected
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
PCE	Perchloroethylene (tetrachloroethylene)
RfC	Reference Concentration
RMEG	Reference Dose Evaluation Guide
TCE	Trichloroethylene
VOC	Volatile Organic Chemical

Summary

This Health Consultation has been prepared in response to a request that was submitted to the Agency for Toxic Substances and Disease Registry (ATSDR) by the U.S. Environmental Protection Agency (EPA) Region II and officials of the Old Mill School in April 2002. Concern has been raised by local residents and school officials about possible exposure by inhalation to chemicals that have been found in the groundwater in the vicinity of the (former) White Swan Laundry and Cleaner, Inc. (also known as the Magnolia Avenue Groundwater Contamination) site, located in Wall Township, Monmouth County, New Jersey.

It is known that a shallow ground water plume containing trichloroethylene (TCE) and tetrachloroethylene (perchloroethylene) (PCE) extends in an easterly direction from sources located in Wall Township. Moreover, the potential exists for exposure to these contaminants via inhalation of vapors that may have been transported from the groundwater into soil gas and then subsequently into the indoor air of residences and other structures. Soil gas measurements are also being performed by EPA to determine the contribution of site-related contaminants, and other contaminants like benzene, that have may been found in soils to the concentrations of chemicals that have been detected in residential air samples.

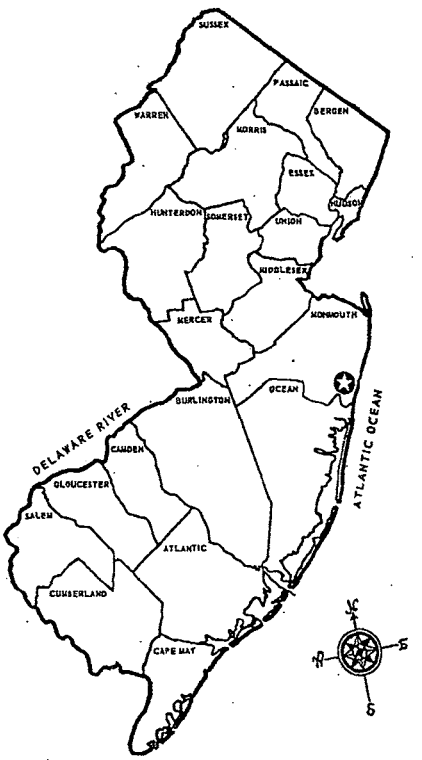
The results of the sampling show that low concentrations, *i.e.,* below ATSDR health-based comparison values (HCV) and EPA Region III Risk-Based Concentrations (RBC), of dichlorodifluoromethane, methylene chloride, and toluene are present in the indoor air of the Old Mill School. These species are commonly found in the indoor air of urban/suburban areas and are probably not related to the ground water contamination that has been identified in the vicinity of the school. Since the concentrations of these chemicals are below their respective HCV or RBC, it is unlikely that inhalation of these concentrations of the contaminants would pose a risk to the public health. The potentially site-related chemicals, *i.e.,* PCE and TCE, were not detected in any of the samples.

Chloromethane, another chemical that is commonly found in indoor air, was detected below its HCV, but slightly above its RBC. The RBC for chloromethane was based on limited data (one study of carcinogenicity in animals), so there is uncertainty as to whether chloromethane is a human carcinogen. Even if it is assumed that chloromethane is a carcinogen, the levels that were detected in the school are very similar to the RBC, and therefore the risk of an adverse health effect is slight.

The results of the sampling of the indoor air in the Old Mill School show that it is not likely that any exposure has occurred that would result in adverse health effects. There is no evidence that any of the potential human exposure pathways have been completed at levels of public health significance, *i.e.,* a public health hazard category of **"No Apparent Public Health Hazard"**.

Purpose and Statement of Issues

The U.S. Environmental Protection Agency (EPA) Region II requested that the Agency for Toxic Substances and Disease Registry (ATSDR) assist in evaluating the public health implications of exposure to benzene that was detected during indoor air sampling of approximately 220 residences in Wall Township, Monmouth County, New Jersey (see inset). The sampling of indoor air was conducted during the period December 2001 - February 2002, in conjunction with the on-going investigation of releases of hazardous substances from the (former) White Swan Laundry and Cleaner site, and from other nearby sources of ground water contaminants. Concern has been also been expressed by local officials regarding the potential for exposure, by inhalation, to tetrachloroethylene (PCE) and trichloroethylene (TCE), which have been found to be present in the near-by shallow groundwater and could potentially volatilize into occupied structures.



On January 19, 2002, sampling was conducted at the Old Mill School, located north of the White Swan site, to determine if contaminants in shallow ground water had been transported and volatilized inside the school. At the request of local school officials and the EPA, the New Jersey Department of Health and Senior Services (NJDHSS), working jointly under a cooperative agreement with the Superfund Site Assessment Branch, Division of Health Assessment and Consultation, ATSDR, has reviewed and evaluated the results of indoor air sampling that was recently conducted at the school. The discussion that follows contains an evaluation of the results that were obtained.

Background

Site History

In 1997, the Monmouth County Health Department (MCHD) became aware of the contamination of irrigation wells in the vicinity of Magnolia Avenue in Wall Township, Monmouth County, New Jersey by tetrachloroethylene (PCE). During 1999 and 2000, the MCHD and the New Jersey Department of Environmental Protection (NJDEP) performed a joint study of shallow ground water that identified a plume of PCE and trichloroethylene (TCE) contamination about 2.5 miles long and one mile wide. The contamination plume was found to extend from Wall Township to the east into the Borough of Sea Girt (NJDEP, 2001).

During the period 1998 to 2000, NJDEP conducted site investigations at three facilities that had been identified as potential sources of the ground water contamination. Soil and ground water samples collected at the three sites confirmed that a release of volatile organic compounds (VOCs) had occurred at each of the sites. The three sources that NJDEP determined to have contributed to the Magnolia Avenue ground water contamination site are: (1) the former White Swan Laundry and Cleaner (aka Fleet Bank or Summit Bank) property, located on Sea Girt Avenue; (2) the Gulf Service Station, located at the intersection of Sea Girt Avenue and State Highway 35; and (3) Sun Cleaners, located on State Highway 35, south of Sea Girt Avenue (NJDEP, 2001).

On February 23, 2001, Fleet Bank, the owner of the (former) White Swan Laundry and Cleaner property, entered into a memorandum of agreement with the NJDEP to conduct a site investigation and remedial investigation at the site; high levels of PCE contamination were found in the shallow groundwater beneath the property. Ground water was also sampled at three educational facilities in the vicinity of the site, *i.e.,* Sea Girt Elementary School, Old Mill School, and Brookside School. Based on these results, NJDEP determined that the plume of ground water contamination may have adversely effected the indoor air quality of nearby residential properties (NJDEP, 2001).

On October 25, 2001, NJDEP conducted indoor air quality testing of three residential properties and one commercial property located near the Fleet Bank property. Based on these results, NJDEP provided the residents, and the owners of the commercial property, with fans for ventilating the basements of each of the buildings where PCE was detected.

At the request of the NJDEP, EPA announced plans on December 5, 2001, to take over the site investigation in order to further characterize the contaminated ground water that underlies portions of Wall Township and the Borough of Sea Girt, and to determine if groundwater contaminants had volatilized in the indoor air of nearby structures. EPA also announced that they would evaluate the site for potential listing on the National Priorities List (NPL), *i.e.,* Superfund. Since that time, EPA has collected and analyzed about 300 indoor air samples from approximately 220 residential and business locations (EPA, 2002).

EPA has installed ventilation systems at all homes with PCE concentrations that are considered a health risk, *i.e.,* greater than 60$\mu g/m^3$ (micrograms per meter cubed), and NJDEP is assisting the homeowners whose residences were found to have elevated PCE concentrations, *i.e.,* between 6 $\mu g/m^3$ and 60 $\mu g/m^3$, and are interested in undertaking remedial measures. [Note: A companion Health Consultation to this document specifically addresses residential exposure to PCE (ATSDR, 2002).] In April 2002, EPA reported the results of indoor air sampling of the approximately 220 residences to individual homeowners (EPA, 2002). Included with this letter was a summary, provided by ATSDR and NJDHSS, of the public health consequences of exposure to airborne PCE and benzene.

Summary of Previous ATSDR Activities

In October 1999, at the request of the MCHD and the EPA, ATSDR was asked to review the information that was then available regarding the ground water contamination, and to advise the community about the usage of the irrigation wells. ATSDR determined that the PCE that had been found in the ground water that was pumped by irrigation wells posed no risk to human health, providing the water was used for non-potable purposes only. It was recommended that the extent of the plume be further characterized, and that the Sea Girt Municipal Well Field be monitored monthly for PCE (ATSDR, 1999).

Community Concerns

Residents in the vicinity of the White Swan/Magnolia Avenue Ground Water Contamination site have expressed concern about their potential exposure to PCE and TCE for several years, since it became known that these contaminants had been found in the Sea Girt municipal water system supply wells. More recently, officials at two schools, the Old Mill School and the Brookside School, requested that the indoor air in their schools be sampled and analyzed.

Discussion

Indoor Air Sampling at the Old Mill School

Four samples of the indoor air at the Old Mill School were taken on January 19, 2002. The results of the sample analyses, shown in Table 1, indicate that low levels, *i.e.*, below ATSDR HCVs and EPA RBCs, of dichlorodifluoromethane (aka Freon 12™), methylene chloride, and toluene were present in each of the samples that were taken in the school. Hexane (n-hexane) was also identified in one of the samples at a concentration below its HCV. The samples were analyzed for an additional 50 volatile organic compounds (VOCs), but no others were detected. No benzene, TCE, or PCE were found in any of the air samples. The only chemical found above its RBC was chloromethane.

Health Assessment Methodology

In the course of creating a health assessment or consultation, ATSDR evaluates the environmental and human components that lead to human exposure from releases of hazardous substances from a given site. An exposure pathway includes five elements: (1) a source of contamination; (2) transport through an environmental medium; (3) a point of human exposure; (4) a route of human exposure; and (5) a receptor population. ATSDR categorizes exposure pathways in three groups: (1)"completed pathways", that is, those in which exposure is reasonably expected to have occurred, to be occurring, or to occur in the future; (2) "potential pathways", that is, those in which exposure might have occurred, may be occurring, or may yet occur, and (3) "eliminated

pathways", that is, those that can be eliminated from further analysis because at least one of the five elements listed above is missing and will never be present, or in which no contaminant of concern can be identified.

After the pathways are designated as completed, potential, or eliminated, ATSDR follows a two-step process to comment on public health issues that are related to exposure pathways at hazardous waste sites. First, ATSDR obtains representative environmental monitoring data for the site of concern, and compiles a list of site-related contaminants. This list of contaminants is compared to health-based comparison values (HCV) to identify those contaminants that do not have a realistic possibility of causing adverse health effects. [Appendix A contains a description of terms and definitions that pertain to HCV.] Second, for the remaining contaminants, ATSDR evaluates site-specific conditions to determine what exposure scenario is realistic for a given exposure pathway. For this assumed exposure scenario, ATSDR determines a dose and compares this dose to scientific studies to determine whether the extent of exposure indicates a potential public health hazard. The health-based comparison values that are presented in this report are concentrations of contaminants that the current public health literature suggest are "safe" or "harmless". These comparison values are conservative because they include safety factors that are intended to protect the most sensitive populations. ATSDR typically uses HCVs as follows: if a contaminant is never found at levels greater than its comparison value, exposure to the contamination is considered to be "safe" or "harmless". If, conversely, a contaminant is found at a concentrations that are greater than its HCV, ATSDR designates the pollutant as a contaminant of concern and examines it further in the assessment. Because HCVs are based on conservative assumptions, the presence of a contaminant at concentrations greater than an HCV does not necessarily suggest that adverse health effects will occur within the exposed population.

Analysis of Exposure Pathways and Contaminants of Concern

The exposure pathway of concern evaluated in this Health Consultation is exposure to ground water contaminants that partition between the ground water and soils, and then volatilize and infiltrate the indoor air of the school. It has been assumed that the ground water has been contaminated, that any contaminants have been partitioned to soils beneath structures, and that the contaminants may have infiltrated these structures, for example, through cracks in the foundation.

Studies that have been conducted by the EPA have shown that measurable levels of volatile organic chemicals (VOCs) are present in the indoor air of most homes in the U.S. (EPA, 1987). Although it is well known that outdoor air contains many VOCs, the EPA studies found that the concentrations of organic chemicals in indoor air are usually higher than concentrations that are found in outdoor air. These higher indoor air levels of VOCs presumably come from consumer products that are brought into the homes, from evaporation of home construction materials, and from personal activities. EPA studies showed that certain human activities were associated with having increased levels of chemicals in indoor air. Examples of these activities are:

* smoking indoors increases benzene, xylene, ethyl benzene, and styrene levels in indoor air;
* bringing dry cleaning home increases the levels of PCE in indoor air;
* using hot water in the home increases chloroform levels in indoor air; and
* using room air fresheners, toilet bowl deodorizers, and moth crystals leads to higher levels of para-dichlorobenzene in indoor air (EPA, 1987)

For this investigation, soil gas measurements are also being performed by EPA to determine the contribution of site-related contaminants (including benzene) that have been found in soils to the concentrations of chemicals that have been detected in residential air samples.

Public Health Implications

Chloromethane (aka methyl chloride) is a colorless gas that has a faint, sweet odor. It is used as a solvent and as a degreaser. It is also used as a refrigerant, and as a propellant in the production of polystyrene foam, *i.e.,* Styrofoam™. Dichlorodifluoromethane (aka Freon 12™) is a nonflammable colorless gas that is used as a refrigerant, as an aerosol propellant, and as a foaming agent. Inhalation of dichlorodifluoromethane can cause dizziness and tremors. Methylene chloride (aka dichloromethane) is a nonflammable colorless liquid with a pleasant aromatic odor that is used as a solvent for organic compounds and as a degreaser. It is frequently found in paint remover and other consumer products, including many pesticide formulations. Toluene is a clear, colorless liquid with a sweet pungent odor. It is commonly used as a solvent and is a significant component of gasoline and other fuels.

Since chloromethane, methylene chloride, and toluene are solvents that are commonly found in consumer products, it is likely that these species were introduced to the school through routine cleaning or other activities. Dichlorodifluoromethane has likely been introduced to the school through the use of the heating, ventilation, and air conditioning (HVAC) system. Since the measured concentrations of these contaminants, except chloromethane, are below ATSDR's HCVs and EPA's RBCs (see Table 1), inhalation of these levels in the air is not expected to result in adverse health effects. Chloromethane was detected at levels slightly above its RBC, but below ATSDR's HCV. The RBC for chloromethane was based on a single study of carcinogenicity in animals. However, the EPA has since determined that current data are insufficient to characterize its human carcinogencity (EPA, 2001). Even if it is assumed that chloromethane is a human carcinogen, the concentrations that were detected in the school are very similar to EPA's RBC, and therefore represent little or no risk of an adverse health effect.

Conclusions

The results that are presented in Table 1 show that low concentrations of chloromethane, dichlorodifluoromethane, methylene chloride, and toluene are present in the indoor air of the Old Mill School. The concentrations of these contaminants are below ATSDR health-based comparison

values (HCVs). Chloromethane was detected at levels slightly above EPA Region III's Risk-Based Concentration (RBC), but not above ATSDR's HCV. The RBC for chloromethane was based on a single study of carcinogencity in animals, so the human carcinogenicity of chloromethane remains in question. However, even if it is assumed that chloromethane is a human carcinogen, the concentrations that were detected in the school are very similar to the RBC, so the risk of an adverse cancer health effect is little to none. No known site-related site-related chemicals, *i.e.,* PCE, TCE, and potentially benzene, were found in the indoor air of the Old Mill school. For the above reasons, inhalation of the indoor air in the Old Mill School is not likely to have an adverse effect on human health, *i.e.,* there is **"No Apparent Public Health Hazard."** [Definitions of the public health hazard categories are given in Appendix B.]

Recommendations

Recommendations to Cease/Reduce Exposure

As with any school or office building, well known methods of maintaining good indoor air quality should be followed, *e,g.,* adequate ventilation should be provided through proper operation of the HVAC system, particularly after using cleaning chemicals, or after a pesticide treatment. The HVAC system in the school should be operated to allow an adequate supply of outside air. Concentrations of carbon dioxide should not be allowed to exceed 1000 parts per million by volume (ppmv) in the indoor air.

If it is determined that ground water beneath the school is contaminated with site-related chemicals, it is recommended that the air in the school be periodically monitored for VOCs.

Certification

This Health Consultation was prepared by the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It has been produced in accordance with approved methodology and procedures existing at the time the Health Consultation was begun.

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

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Appendices

Appendix A: Description of Comparison Values

Description of Comparison Values

ATSDR's Comparison Values are media-specific concentrations that are considered to be "safe" under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific chemical substances that the health assessor has selected for further evaluation of potential health effects.

Generally, a chemical is selected for evaluation because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's Comparison Values. However, it cannot be emphasized strongly enough that Comparison Values are not thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a Comparison Value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not solely on environmental concentrations.

Screening values based on non-cancer effects are generally based on the level at which no health adverse health effects (or the lowest level associated with health effects) found in animal or (less often) human studies, and include a cumulative margin of safety (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10-fold to 1,000-fold or more. By contrast, cancer-based screening values are usually derived by linear extrapolation with statistical models from animal data obtained at high exposure doses, because human cancer incidence data for very low levels of exposure are rarely available. Cancer risk estimates are intended to represent the upper limit of risk, based on the available data.

Listed and described below are the types of comparison values that the ATSDR and the NJDHSS used in this Health Consultation:

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations of contaminants in an environmental medium (such as drinking water) that are expected to cause no more than one excess cancer case for every million persons who are continuously exposed to the concentration for an entire lifetime (equaling a risk of 1×10^{-6}). These concentrations are calculated from the EPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are known or suspected of being carcinogenic have CREG Comparison values.

Environmental Media Evaluation Guides (EMEGs) and Reference Dose Media Evaluation Guides (RMEGs) are estimates of chemical concentrations in an environmental medium (such as drinking water) that are not likely to cause an appreciable risk of deleterious, non-cancer health effects, for fixed durations of exposure. These guides may be developed for special sub-populations such as children. EMEGs are based on ATSDR's Minimal Risk Level (MRL), while RMEGs are based on the EPA's Reference Dose (RfD).

Other health-based guides may also be used as Comparison Values, including drinking water Maximum Contaminant Levels (MCLs) established by the EPA or the NJDEP.

Appendix B: ATSDR Public Health Hazard Categories

ATSDR's Interim Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.

Category / Definition	Data Sufficiency	Criteria
C. Indeterminate Public Health Hazard This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

* *Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.*

Table 1. Results of Indoor Air Sampling - Old Mill School, Wall Township, January 19, 2002 ($\mu g/m^3$)*

Chemical	MW	PQL	ATSDR HCV**	RBC**	Cafeteria	Kitchen	Library	Room 128
Tetrachloroethylene (PCE)	166	3.4	272 (40ppb) UR	0.63C	ND	ND	ND	ND
Trichloroethylene (TCE)	130	2.69	40RfC UR	0.016C	ND	ND	ND	ND
Benzene	78	1.60	0.1CREG	0.22C	ND	ND	ND	ND
Chloromethane	50	1.03	102 (50ppb)	1.8C***	**1.92**	1.66	**2.01**	1.74
Dichlorodifluoromethane (Freon 12)	122	2.48	NONE.	180	27.27	4.26	3.42	3.47
Methylene chloride	85	1.74	1043 (300ppb)	3.8C	2.40	3.45	3.00	2.96
n-Hexane	86	1.76	2110 (600 ppb) 200RfC	210	ND	ND	20.44	ND
Toluene	92	1.89	301(80ppb) 400RfC	420	4.15	1.92	1.92	ND

* report dated April 4, 2002

** $\mu g/m^3$ = ppbv x MW/24.45 at room temperature

*** EPA IRIS indicates carcinogenicity category D (carcinogenicity not classifiable)

BOLD - exceeds EPA Region III RBC

MW - molecular weight

PQL - Practical Quantitation Level

HCV - ATSDR Health-based Comparison Value

CREG - Cancer Risk Evaluation Guide

UR - Under review

ND - Not detected

C - classified as a carcinogen by EPA Region III

RBC - EPA Region III Risk Based Concentration

RfC - EPA Reference Concentration

Appendix III: Health Consultation: PCE and Benzene

Health Consultation

Public Health Implications and Interpretation of
Exposure to Benzene in Residential Indoor Air

(FORMER) WHITE SWAN LAUNDRY AND CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUNDWATER CONTAMINATION SITE)

WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

SEPTEMBER 25, 2002

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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HEALTH CONSULTATION

Public Health Implications and Interpretation of
Exposure to Benzene in Residential Indoor Air

(FORMER) WHITE SWAN LAUNDRY AND CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUNDWATER CONTAMINATION SITE)

WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

Prepared by:

Superfund Site Assessment Branch
Division of Health Assessment and Consultation
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
EMEG	Environmental Media Evaluation Guide
EPA	United States Environmental Protection Agency
HCV	Health-based Comparison Value
IRIS	Integrated Risk Information System
LECR	Lifetime Excess Cancer Risk
MCHD	Monmouth County Health Department
ND	Not Detected
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
PCE	Perchloroethylene (tetrachloroethylene)
RfC	Reference Concentration
RMEG	Reference Dose Media Evaluation Guide
TCE	Trichloroethylene
VOC	Volatile Organic Chemical

Summary

This Health Consultation has been prepared in response to a request that was submitted to the Agency for Toxic Substances and Disease Registry (ATSDR) by U.S. Environmental Protection Agency (EPA) Region II in April 2002, to assist in evaluating the public health implications of exposure to benzene that was detected in indoor air sampling of about 220 residences in Wall Township, Monmouth County, New Jersey. Concern has been raised by local residents and school officials about possible exposure by inhalation to chemicals that have been found in the ground water in the vicinity of the (former) White Swan Laundry and Cleaner, Inc. (also known as the Magnolia Avenue Ground Water Contamination) site, located in Wall Township, Monmouth County, New Jersey.

It is known that a shallow ground water plume containing trichloroethylene (TCE) and tetrachloroethylene (perchloroethylene) (PCE) extends in an easterly direction from sources located in Wall Township. Concern has been raised regarding the potential for exposure to these contaminants and benzene via inhalation of vapors that may have been transported from the ground water into residences and other structures, and that may subsequently have volatilized in the indoor air.

ATSDR has provided the following public health interpretation of the levels of benzene that have been found in the indoor air as a result of sampling about 220 residences of Wall Township as part of the on-going investigation of the (former) White Swan Laundry and Cleaner, Inc. site:

- All exposures to benzene above 32 micrograms per meter cubed ($\mu g/m^3$) represent a lifetime risk of cancer that is greater than that due to background levels;

- All exposures to benzene between 6 and 32 $\mu g/m^3$ represent a slightly increased lifetime cancer risk that is greater than that due to background levels; and

- All exposures to benzene below 6 $\mu g/m^3$ represent little or no additional lifetime cancer risk that is greater than that due to background levels.

ATSDR considers exposure to benzene at 32 $\mu g/m^3$ and above to be a **"Public Health Hazard"**. Actions taken by EPA to mitigate these exposures are protective of public health. Although exposures between 6 and 32 $\mu g/m^3$ represent a slightly increased risk of cancer above the background risk, ATSDR believes that the actions taken by the New Jersey Department of Environmental Protection (NJDEP), to reduce exposures in this range to below typical background levels, to be protective of public health. Taking into consideration indoor background levels in U.S. homes and the very low risk of an adverse cancer effect, ATSDR considers all exposures to benzene below 6 $\mu g/m^3$ to represent a **"No Apparent Public Health Hazard"**.

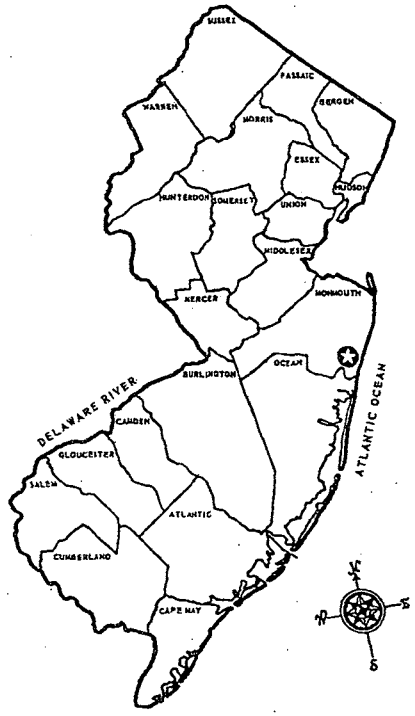
Most of the levels of benzene found in the homes in Wall Township are below ATSDR Minimal Risk Level (MRL) for exposures of intermediate duration (15-365 days). The maximum concentration of benzene that has been measured is about 30 times below the "less serious neurological effect" level that was determined in one animal study. None of the benzene levels were above ATSDR's acute MRL. Therefore, at the maximum benzene level that was detected, acute or intermediate duration exposures are not likely to result in any serious adverse non-cancer health effects.

Soil gas and ground water investigations should continue, in order to determine the extent and contribution of site-related contaminants being transported from ground water into the indoor air of homes and businesses. If these or other investigations provide additional information on local background levels of PCE in residential indoor air, the conclusions of this Health Consultation may be re-evaluated.

The above conclusions are based on a residential exposure scenario and do not apply to the evaluation of the public health implications of indoor air exposures under non-residential situations (e.g., schools and commercial buildings).

Background and Statement of Issues

The U.S. Environmental Protection Agency (EPA) Region II requested that the Agency for Toxic Substances and Disease Registry (ATSDR) assist in evaluating the public health implications of benzene concentrations that were detected in indoor air sampling of about 220 residences in Wall Township, Monmouth County, New Jersey. The sampling was conducted in conjunction with the on-going investigation of releases of hazardous substances from the White Swan Laundry and Cleaner, Inc. site and from other sources of ground water contaminants.



In 1997, the Monmouth County Health Department (MCHD) became aware of tetrachloroethylene (PCE) contamination of irrigation wells in the vicinity of Magnolia Avenue in Wall Township, New Jersey. Between 1999 and 2000, the MCHD and the New Jersey Department of Environmental Protection (NJDEP) performed a joint study of shallow ground water that mapped a plume of PCE and trichloroethylene (TCE) contamination about 2.5 miles long and one mile wide. The contamination plume extends from Wall Township into the Boroughs of Manasquan and Sea Girt and continues to the coastline (NJDEP, 2001).

In October 1999, at the request of the MCHD and EPA, ATSDR was asked to review the information regarding the ground water contamination and to advise the community about the usage of the irrigation wells. ATSDR determined that the amount of PCE in the ground water posed no health concerns or hazards when used for non-potable purposes (ATSDR, 1999).

During the period from 1998 to 2000, the NJDEP conducted site investigations at the three facilities identified as potential sources. Soil and ground water sampling confirmed that a release of volatile organic compounds (VOCs) had occurred at each of the sites. The (former) White Swan Laundry and Cleaner (aka Fleet Bank or Summit Bank) property, Gulf Service Station, and Sun Cleaners have been identified as contributing sources to the Magnolia Avenue ground water contamination (NJDEP, 2001).

On February 23, 2001, the owners of the (former) White Swan Laundry and Cleaner property entered into a memorandum of agreement with the NJDEP to conduct a site investigation and remedial investigation of the property. During the remedial investigation, the NJDEP concluded that

a ground water plume of contamination might be adversely effecting the indoor air quality of nearby residential properties (NJDEP, 2001).

Sampling by Fleet Bank at its branch office on Sea Girt Avenue found high levels of PCE contamination in shallow ground water. Based on these results, on October 25, 2001, the NJDEP conducted indoor air quality testing of three residences and one commercial property located near to the Fleet Bank property. The NJDEP provided the residents and the owners of the commercial property with fans for ventilating the basements of each of these buildings where PCE was detected.

At the request of the NJDEP, the EPA announced plans on December 5, 2001, to take over the investigation of the contaminated ground water plume that underlies portions of Wall Township and the Boroughs of Sea Girt and Manasquan. The EPA also announced that they agreed to evaluate the site for listing on the National Priorities List (NPL), *i.e.*, Superfund. Since that time, EPA has collected about 300 indoor air samples from at least 220 residential and business locations. The sampling has also included several schools within the area, including Sea Girt Elementary School, Old Mill School, and Brookside School (EPA, 2002).

In accordance with their mandate to protect public health under the National Contingency Plan (NCP), EPA has installed ventilation systems at all homes with benzene and PCE levels that would be considered a health risk, and the NJDEP is working with the homeowners whose homes had slightly elevated levels and are interested in undertaking remedial measures. [Note: A companion Health Consultation to this document specifically addresses residential exposure to PCE (ATSDR, 2002).] In April 2002, the EPA sent the results of indoor air sampling of the 220 residences to individual homeowners. Included with this letter, ATSDR provided a fact sheet containing a public health interpretation of the benzene air exposures, a contaminant of concern for the site (see Appendix A). Although it has not been definitively determined that benzene is a site-related contaminant, it has been detected in many samples of air from homes in the area, thus suggesting that benzene might be related to one of the potential sources of ground water contamination that are being investigated.

Discussion

Health Assessment Methodology

In the course of creating Public Health Assessments and Health Consultations, ATSDR evaluates the environmental and human components that lead to human exposure from releases of hazardous substances from a given site. A pathways analysis consists of five elements: (1) a source of contamination; (2) transport through an environmental medium; (3) a point of human exposure; (4) a route of human exposure; and, (5) a receptor population. ATSDR classifies exposure pathways into three groups: (1) "completed pathways", that is, those in which exposure is reasonably expected

to have occurred, to occur, or to occur in the future; (2) "potential pathways", that is, those in which exposure might have occurred, may be occurring, or may yet occur, and, (3) "eliminated pathways", that is, those that can be eliminated from further analysis because at least one of the five elements listed above is missing and will never be present, or in which no contamination of concern can be identified.

After the pathways are designated as "completed", "potential", or "eliminated", ATSDR follows a two-step methodology to comment on public health issues related to exposure pathways at hazardous waste sites. First, ATSDR obtains representative environmental monitoring data for the site of concern and compiles a list of site-related contaminants. ATSDR compares this list of contaminants to health-based values (health comparison values or HVCs) to identify those contaminants that do not have a realistic possibility of causing adverse health effects. Second, for the remaining contaminants, ATSDR evaluates site-specific conditions to determine what exposure scenario is realistic for a given exposure pathway. Given this exposure scenario, ATSDR determines a dose and compares this dose to scientific studies to determine whether the extent of exposure indicates a public health hazard.

The health-based comparison values used in this report are concentrations of contaminants that the current public health literature suggests are "safe" or "harmless". These comparison values are quite conservative because they include ample safety factors that account for the most sensitive populations. ATSDR typically uses HCVs as follows: if a contaminant is never found at levels greater than its comparison value, ATSDR concludes the levels of corresponding contamination are "safe" or "harmless". If, however, a contaminant is found at greater than its HCV, ATSDR designates the pollutant as a contaminant of concern and examines it further in the assessment. Because HCVs are based on extremely conservative assumptions, the presence of concentrations greater than an HCV does not necessarily suggest that adverse health effects will occur among the exposed population.

Exposure Pathways and Contaminant of Concerns

The exposure pathway of concern that is evaluated in this Health Consultation is inhalation of benzene that is in the indoor air of private residences near the (former) White Swan Laundry and Dry Cleaner site. It has been assumed that benzene from at least one of the potential sources has contaminated the ground water, has been transported to soils beneath the homes, and finally has infiltrated these homes through cracks in the foundation or directly from soils into homes.

Studies by the EPA have shown that most homes in the U.S. have measurable levels of organic chemicals in indoor air. While outdoor air contains many organic chemicals, a surprising finding from EPA studies is that the concentrations of organic chemicals in indoor air are usually higher than in outdoor air. These higher indoor air levels of VOCs presumably come from consumer products that are brought into the homes, from off-gassing of home building materials, and from personal activities. EPA studies showed that certain human activities were associated with having

increased levels of chemicals in indoor air. Examples of these activities are listed below (EPA, 1987):

- smoking indoors increases benzene, xylene, ethyl benzene, and styrene levels in indoor air;
- bringing dry cleaning home causes higher PCE levels in indoor air;
- using hot water in the home increases chloroform levels in indoor air; and
- using room air fresheners, toilet bowl deodorizers, and moth crystals leads to higher levels of para-dichlorobenzene in indoor air.

Additional studies by EPA are underway to determine the contribution of site-related contaminants found in the ground water (including benzene) to the levels of chemicals detected in residential air samples. Therefore, at this time benzene exposures can only be considered a potential exposure pathway related to the site.

The levels of benzene detected in the more than 300 samples of indoor air from 220 residences range from not detected (ND) to 38.4 $\mu g/m^3$ (micrograms per cubic meter). In a majority of the homes, benzene was detected in the air at levels above the health comparison value of 0.22 $\mu g/m^3$ (based on EPA Region III's Risk-Based Concentration, *i.e.*, RBC). The EPA Region III RBC is based on cancer effects. The ATSDR Cancer Risk Evaluation Guideline for benzene is 0.1 $\mu g/m^3$. For non-cancer effects, ATSDR's Minimal Risk Levels, *i.e.*, MRL (see definition below) for intermediate exposures (15-364 days), and for acute exposures (1-14 days), are 13 $\mu g/m^3$ and 162 $\mu g/m^3$, respectively. Many of the air samples were in the range of what may be considered typical background levels in U.S. homes. Benzene is a component of gasoline emissions, cigarette smoke, paints and adhesives, particle board, wood composites, and wood smoke. The estimated average of the medians (50% values) for typical background levels found in several studies was reported to be approximately 6 $\mu g/m^3$, with generally higher levels being found in homes with smokers (Wallace, L., 1996). However, it is important to note that any given level of benzene in a household air sample that falls within this typical background level for indoor air in the U.S. does not necessarily indicate that the benzene is entirely due to a non-site-related source. In addition, there may be differences in the studies of homes in others areas (as reported by Wallace, 1996) versus Wall Township (e.g., basements, age, and construction) and differences in other factors that may effect local indoor background benzene levels. Because benzene is considered a potential site-related contaminant of concern, all exposures above background levels may be related to the site; therefore, ATSDR considers exposures to concentrations of benzene above 6 $\mu g/m^3$ to result in a completed (or at least a potential) exposure pathway.

Since the available data represent a snapshot in time, it is not possible for ATSDR to determine the duration and concentration of a resident's exposure. However, given that the exposure is likely to persist without any intervention, it has been assumed, conservatively, that the exposure may continue over a duration of 30 years.

Public Health Implications

Benzene: Chronic Exposure and Non-Cancer Health Effects

To evaluate non-carcinogenic health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites. A MRL is an estimate of a level of daily human exposure to a contaminant below which non-cancerous adverse health effects are unlikely. MRLs are developed for each route of exposure, *e.g.*, ingestion and inhalation, and for the length of exposure, *i.e.*, acute, less than 14 days; intermediate, 15–364 days; and chronic, 365 days or more. Because ATSDR has no methodology to determine amounts of chemicals absorbed through the skin, there are no MRLs for skin exposure. ATSDR presents information on MRLs in its series of Toxicological Profiles on hazardous substances. These chemical-specific profiles provide information on health effects, environmental transport, human exposure, and regulatory status. If a MRL has not been developed for a contaminant, the EPA Reference Dose (RfD) is used (if available). The RfD is an estimate of the daily exposure of the human population to a potential hazard that is likely to be without risk of a non-carcinogenic adverse health effects during a person's lifetime.

Most of the levels of benzene found in the homes in Wall Township are below ATSDR's intermediate MRL of 13 $\mu g/m^3$ for less serious neurological effects that were found in a study of mice (Li et al., 1992). The ATSDR MRL includes an uncertainty or margin-of-safety factor of 90. The maximum level of benzene that has been detected is about 30 times below the "less serious neurological effect" seen by Li et al. None of the benzene levels were above ATSDR's acute MRL. Therefore, at the maximum benzene level that was detected, acute or intermediate duration exposures are not likely to result in any serious adverse health effects. For chronic exposures, the effect of concern is cancer, which is discussed below.

Benzene: chronic exposure and cancer

Exposure to benzene can cause adverse effects on the blood. Persons who breathe high levels of benzene for long periods of time are likely to have reduced red blood cell production, *i.e.*, anemia. Studies of workers have consistently linked benzene exposures with a particular type of leukemia. Studies have also shown that benzene causes cancer in animals (ATSDR, 1997). The primary end point of concern for exposure to benzene in air is leukemia, specifically, acute myelogenous leukemia (AML), the only form of cancer that is consistently associated with high levels of occupational exposures to benzene.

One way to evaluate the possibility of benzene causing cancer in Wall Township residents is to compare the estimated benzene levels in air to the levels in human studies that have caused cancer. While this approach cannot provide a definitive answer that benzene exposure might cause cancer in Wall Township residents, it gives some insight into the likelihood of benzene exposures causing cancer.

Complicating this comparison, however, is the lack of information regarding the time frame and concentrations of exposure over time in any given household. The actual exposures to most residents are likely to be much less than those shown to cause cancer in human and animal studies. In fact, there is little scientific evidence of serious adverse health effects in animals or humans exposed to long-terms levels of benzene at concentrations less than 32,000 $\mu g/m^3$.

The two exposure levels (Wall Township residents and the human studies) can be compared by using a margin of safety (MOS) approach. A MOS can be calculated by dividing the exposure level in human studies that caused cancer by the estimated exposure concentrations in Wall Township residents. As can be seen in Appendix A, based on various exposure ranges in relation to typical background levels, the MOS ranged from less than 1,000 to greater than 5,333. The MOS for exposures to concentrations of 32 $\mu g/m^3$ and above represent a lifetime cancer risk that is greater than the risk due to background benzene levels. Exposure levels between 6 -32 $\mu g/m^3$ represent a slightly increased lifetime excess cancer risk above the cancer risk due to background benzene levels. Exposure to benzene at concentrations below 6 $\mu g/m^3$ would result in little or no increased risk of developing cancer, and is at least 5,333 times less than the level that scientific studies have shown cause serious adverse health effects in humans and animals (see Appendix A).

Conclusions

ATSDR has provided the following public health interpretation of the levels of benzene that have been found in the air in about 220 residences of Wall Township that were sampled as part of the on-going investigation of the (former) White Swan Laundry and Cleaner, Inc. site:

- All exposures to benzene above 32 $\mu g/m^3$ represent a lifetime risk of cancer that is greater than that due to background levels;

- All exposures to benzene between 6 and 32 $\mu g/m^3$ represent a slightly increased lifetime cancer risk that is greater than that due to background levels; and

- All exposures to benzene below 6 $\mu g/m^3$ represent little to no additional lifetime cancer risk beyond that due to background levels.

ATSDR considers exposure to benzene at 32 $\mu g/m^3$ and above to be a **"Public Health Hazard"** because of the existence of a completed pathway and an unacceptable risk of cancer beyond background benzene levels [See Appendix B for a description of ATSDR's Public Health Hazard categories.] Although exposures between 6 and 32 $\mu g/m^3$ represent only a slightly increased risk of cancer above the background risk, ATSDR considers the measures taken by the NJDEP to reduce or eliminate exposures in this range to be protective of public health. Taking into consideration typical indoor background levels in U.S. homes and the very low risk of an adverse cancer effect, ATSDR considers all exposures to benzene below 6 $\mu g/m^3$ to represent a **"No Apparent Public Health Hazard"**.

The above conclusions are based on a residential exposure scenario and do not apply to the evaluation of the public health implications of indoor air exposures under non-residential situations (e.g., schools and commercial buildings).

Recommendations

On-going soil gas and ground water investigations should continue, in order to determine the extent and contribution of site-related contaminants being transported from ground water into the indoor air of homes and businesses. If these or other investigations provide additional information on local background levels of PCE in residential indoor air, the conclusions of this Health Consultation may be re-evaluated.

Public Health Action Plan (PHAP)

The Public Health Action Plan (PHAP) for the (former) White Swan Laundry and Cleaner, Inc. site contains descriptions of the actions to be taken by ATSDR and other agencies at or in the vicinity of the site. The purpose of a PHAP is to ensure that this Health Consultation not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The environmental sampling data and remedial activities that have been conducted have been evaluated within the context of human exposure pathways and other relevant public health factors. Included is a commitment on the part of ATSDR to monitor this plan to ensure that the plan is implemented. ATSDR will provide follow-up to this PHAP, outlining the actions which have been completed, and actions that are in progress, as needed. The public health actions to be implemented by ATSDR are as follow:

Actions Undertaken

(1) EPA and the NJDEP have sampled the indoor air of numerous residences and other structures, including several schools in the vicinity of the site property. In addition, the EPA and NJDEP, collectively, have taken action to reduce benzene exposure to below the level of public health concern.

(2) ATSDR and NJDHSS have participated in a public availability session with local residents to provide them with a public health interpretation of their individual air sampling results. In addition, ATSDR and NJDHSS have participated in a public meeting to inform the general public of the public health issues of air exposures.

(3) ATSDR has prepared a fact sheet for benzene to accompany individual sampling results sent to the residents by the EPA.

Actions Planned

(1) ATSDR will provide a copy of this document to all concerned residents in the vicinity of the site.

(2) As additional soil gas and ground water data become available, ATSDR and the NJDHSS will evaluate the public health implications of indoor air exposures to other chemicals found to be related to the site.

(3) ATSDR will coordinate as deemed necessary with the appropriate environmental agencies to develop plans to implement the recommendations contained in this document.

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Appendix A

Fact Sheet
Benzene Residential Air Exposures
Public Health Interpretations

Agency for Toxic Substances and Disease Registry (ATSDR)
Fact Sheet

Residential Exposure to Benzene in Air
Public Health Implications and Interpretation

General Public Health Issues:

- Benzene is found in gasoline emissions, cigarette smoke, paints and adhesives, particle board, wood composites and wood smoke.
- Indoor air studies have shown that background levels in U.S. homes have an average of approximately 6 $\mu g/m^3$, with generally higher levels in homes with smokers. This value is not a site-specific background level, but is presented to provide perspective.
- Benzene causes adverse effects to the blood. Persons who breathe high levels of benzene for long periods of time may have reduced red blood cell production leading to anemia.
- Studies of workers have consistently linked benzene exposures with a particular type of leukemia.
- Benzene is known to cause cancer in animals.
- The scientific community has determined that benzene is linked to cancer in humans, particularly leukemia (acute myeloid leukemia or AML), although there is some debate as to whether benzene causes cancer at low concentrations.

Perspective on Site-Specific Exposure:

- To be protective of public health, the interpretation of benzene air exposures in the attached table is based on conservative assumptions.
- The actual length of exposure to residents is not known. Because air sampling results are only available over a short time frame, and the actual exposure levels over time are also not known, the public health interpretation that is presented below may over- or underestimate the chance of getting cancer.
- The risk of someone getting cancer is dependent on many factors; for example, lifestyle, nutritional status, genetics, and other exposures at home and in the workplace.
- The actual exposures to most residents are likely to be much less than those shown to cause cancer in human and animal studies. In fact, there is little scientific evidence of serious adverse health effects in animals or humans exposed to long-terms levels of benzene at concentrations less than 32,000 $\mu g/m^3$.
- Since benzene is a known human carcinogen, prudent public health practice dictates that, no matter the source, exposure should be minimized.

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Agency for Toxic Substances and Disease Registry (ATSDR)
Public Health Interpretation of Exposure to Benzene in Residential Air

Concentration of Benzene in Air ($\mu g/m^3$)	Public Health Interpretation	Estimated Margin of Safety (MOS)*	Estimated Background Level in U.S. Homes ($\mu g/m^3$)**
Less Than 6	Little to no additional lifetime cancer risk beyond the cancer risk due to background benzene levels	Greater Than 5,333	6
6 - 32	Slight additional lifetime cancer risk beyond the cancer risk due to benzene background levels	1,000-5,333	
32 and Above	Increased lifetime cancer risk beyond the cancer risk due to benzene background levels	Equal To or Less Than 1,000	

* Estimated margin of safety (MOS) is based on 32,000 $\mu g/m^3$ benzene in air. For example, if benzene were detected at 32 $\mu g/m^3$ in a resident's indoor air sample, the margin of safety would represent how much below (in this case 1,000 times) the actual exposure is, when compared to levels, above which scientific studies have shown serious adverse effects in humans and animals.

** Reported value represents the average of the medians for background levels found in several studies, as reported by Wallace, L., Environmental Health Perspectives, Vol. 104, S6, December 1996. This level does not represent specific background levels for the Wall Township, New Jersey area, but are presented to provide perspective. Any level of benzene in a household sample result that falls within this range of background levels for indoor air in the U.S. does not necessarily indicate that the benzene is entirely due to non-site-related sources.

Appendix B: ATSDR Public Health Hazard Categories

ATSDR's Interim Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.
C. Indeterminate Public Health Hazard This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.

Category / Definition	Data Sufficiency	Criteria
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

**Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.*

Health Consultation

Public Health Implications and Interpretation of
Exposure to Tetrachloroethylene (PCE) in Residential Indoor Air

(FORMER) WHITE SWAN LAUNDRY AND CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUNDWATER CONTAMINATION SITE)

WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

SEPTEMBER 25, 2002

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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HEALTH CONSULTATION

Public Health Implications and Interpretation of
Exposure to Tetrachloroethylene (PCE) in Residential Indoor Air

(FORMER) WHITE SWAN LAUNDRY AND DRY CLEANER, INCORPORATED
(a/k/a MAGNOLIA AVENUE GROUNDWATER CONTAMINATION SITE)

WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY

EPA FACILITY ID: NJSFN0204241

Prepared by:

New Jersey Department of Health and Senior Services
Hazardous Site Health Evaluation Program
Consumer and Environmental Health Services
Division of Epidemiology, Environmental, and Occupational Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
EMEG	Environmental Media Evaluation Guide
EPA	United States Environmental Protection Agency
HCV	Health-based Comparison Value
LECR	Lifetime Excess Cancer Risk
MCHD	Monmouth County Health Department
MRL	Minimal Risk Level
ND	Not Detected
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
PCE	Perchloroethylene (tetrachloroethylene)
RBC	Risk-Based Concentration
RfC	Reference Concentration
RfD	Reference Dose
RMEG	Reference Dose Evaluation Guide
TCE	Trichloroethylene
VOC	Volatile Organic Chemical

Summary

This Health Consultation has been prepared in response to a request that was submitted in April 2002 by the U.S. Environmental Protection Agency (EPA) Region II to the Agency for Toxic Substances and Disease Registry (ATSDR) to assist in evaluating the public health implications of exposure to tetrachloroethylene (PCE) that was detected in indoor air sampling of about 220 residences in Wall Township, Monmouth County, New Jersey. Specifically, this Health Consultation provides a public health interpretation of the tetrachloroethylene (perchloroethylene), *i.e.*, PCE action levels in air that were proposed by the EPA and the New Jersey Department of Environmental Protection (NJDEP). Concern has been raised about possible exposure, by inhalation, to chemicals that have been found in the ground water in the vicinity of the (former) White Swan Laundry and Cleaner, Inc. (aka Magnolia Avenue Ground Water Contamination) site, also located in Wall Township, Monmouth County, New Jersey.

It is known that a shallow ground water plume of trichloroethylene, *i.e.*, TCE, and tetrachloroethylene (perchloroethylene), *i.e.*, PCE, exists that extends in an easterly direction from sources located in Wall Township, Monmouth County, New Jersey. Concern has been raised regarding the potential for exposure to these contaminants via inhalation of vapors that may have been transported from the ground water into residences and other structures, and subsequently volatilized in indoor air.

Based on the action levels proposed by the EPA and the NJDEP, ATSDR and the NJDHSS have provided the following public health interpretation of the levels of PCE that were found as a result of sampling the indoor air in about 220 residences in Wall Township in conjunction with the on-going investigation of the White Swan site:

- All exposures to PCE concentrations that are above 60 $\mu g/m^3$ represent a lifetime risk of cancer greater than that due to background concentrations;
- All exposures to PCE concentrations between 6 and 60 $\mu g/m^3$ represent a cancer risk that is slightly greater than that due to background levels; and,
- All exposures to PCE concentrations that are less than 6 $\mu g/m^3$ represent little or no lifetime cancer risk greater than that due to background levels.

EPA has installed ventilation systems at all homes with PCE concentrations of 60 $\mu g/m^3$ and above, and the NJDEP, in accordance with their mandate to reduce exposures to background levels, is working with the homeowners who have slightly elevated levels and are interested in undertaking remedial measures.

ATSDR and the NJDHSS consider exposures to PCE at concentrations of 60 $\mu g/m^3$ and above to be a **"Public Health Hazard"**. Actions taken by EPA to mitigate these exposures are

protective of public health. Although exposures to concentrations between 6 and 60 $\mu g/m^3$ represent a slightly increased risk of cancer beyond the background risk, ATSDR and the NJDHSS consider that remedial actions taken by NJDEP to mitigate exposures in this range to also be protective of public health. Taking into consideration typical indoor background levels in U.S. homes and the very low risk of cancer, ATSDR and the NJDHSS consider all exposures to PCE below 6 $\mu g/m^3$ to represent **"No Apparent Public Health Hazard".** No remedial actions are necessary.

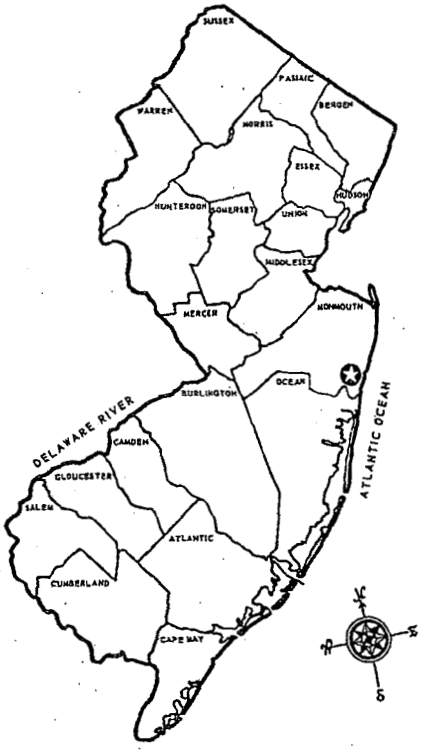
ATSDR and the NJDHSS have also evaluated the likelihood of an adverse non-cancer effect from the PCE air exposures in the 220 residences that were sampled in Wall Township. All but one sample were below ATSDR's Minimal Risk Levels (MRL) for short-term non-cancer health effects. The one sample that was above the short-term MRL was from a sump at a residence on Laurel Street. Because this sample was taken from an enclosed sump, only short-term intermittent exposures are likely to have occurred. Based on further evaluation of potential health effects from the short-term exposures to the levels of PCE found in the air in the sump area, it is not likely that exposure to any residents would result in any serious non-cancer adverse health effects.

Soil gas and ground water investigations in the vicinity of the (former) White Swan Laundry and Cleaner, Inc. site should be continued in order to determine the extent and contribution of site-related contaminants that infiltrate from ground water into the indoor air of homes and businesses. If these or other investigations provide additional information on local background levels of PCE in residential indoor air, the conclusions of this Health Consultation may be re-evaluated.

The above conclusions are based on a residential exposure scenario and do not apply to the evaluation of the public health implications of indoor air exposures under non-residential situations (e.g., schools and commercial buildings).

Background and Statement of Issues

The U.S. Environmental Protection Agency (EPA) Region II requested that the Agency for Toxic Substances and Disease Registry (ATSDR) assist in evaluating the public health implications of exposure to tetrachloroethylene (PCE) that was detected in indoor air sampling of about 220 residences in Wall Township, Monmouth County, New Jersey. The sampling was conducted in conjunction with the on-going investigation of releases of hazardous substances from the (former) White Swan Laundry and Dry Cleaner, Inc. site. Specifically, this Health Consultation provides a public health interpretation of the PCE action levels in air that were proposed by the EPA and the New Jersey Department of Environmental Protection (NJDEP). The New Jersey Department of Health and Senior Services (NJDHSS), under a cooperative agreement with ATSDR, and working jointly with the Superfund Site Assessment Branch, Division of Health Assessment and Consultation, ATSDR, will address EPA's request in this Health Consultation.



In 1997, the Monmouth County Health Department (MCHD) became aware of tetrachloroethylene (PCE) contamination of irrigation wells on Magnolia Avenue in Wall Township, Monmouth County, New Jersey. Between 1999 and 2000, the MCHD and the New Jersey Department of Environmental Protection (NJDEP) performed a joint study of shallow ground water that mapped a plume of PCE and trichloroethylene (TCE) contamination about 2.5 miles long and one mile wide. The contamination plume extends from Wall Township into the Boroughs of Manasquan and Sea Girt and continues to the coastline (NJDEP, 2001).

In October 1999, at the request of the MCHD and EPA, ATSDR was asked to review the information related to the ground water contamination, and to advise the community about the usage of the irrigation wells. ATSDR determined that the concentrations of PCE that were found in the irrigation wells posed no public health concern, providing the water was used for non-potable purposes only (ATSDR, 1999).

During the period from 1998 to 2000, the NJDEP conducted site investigations at three facilities that were identified as potential sources. Soil and ground water samples collected at the three sites confirmed that a release of volatile organic compounds (VOCs) had occurred at each of the sites. The (former) White Swan Laundry and Cleaner (aka: Fleet Bank or Summit Bank)

property, a Gulf Service Station, and Sun Cleaners were identified as contributing sources to the Magnolia Avenue ground water contamination site (NJDEP, 2001).

On February 23, 2001, the owners of the (former) White Swan Laundry and Cleaner, Inc. property entered into a memorandum of agreement with the NJDEP to conduct a site investigation and remedial investigation at the site. During the remedial investigation, the NJDEP determined that a ground water plume of contamination might be adversely effecting the indoor air quality of nearby residential properties (NJDEP, 2001).

Sampling by Fleet Bank at its branch office on Sea Girt Avenue found high levels of PCE contamination in shallow ground water. Based on these results, on October 25, 2001, the NJDEP conducted indoor air quality testing of three residential properties and one commercial property located near to the Fleet Bank property. The NJDEP provided the residents and the owners of the commercial property with fans for ventilating the basements of each of these buildings where PCE was detected. The NJDEP conducted additional sampling of various residences in October through December, 2001.

At the request of the NJDEP, the EPA announced plans on December 5, 2001, to take over the investigation of the contaminated ground water plume that underlies portions of Wall Township and the Boroughs of Sea Girt and Manasquan. The EPA also announced that they agreed to evaluate the site for listing on the National Priorities List (NPL), *i.e.*, Superfund. Since that time, EPA has collected about 300 indoor air samples from at least 220 residential and business locations. The sampling has also included various educational facilities within the area, including Sea Girt Elementary School, Old Mill School, and Brookside School (EPA, 2002).

In accordance with their mandate to protect public health under the National Contingency Plan (NCP), EPA has installed ventilation systems at all homes with PCE levels above 60 $\mu g/m^3$ and the NJDEP, in accordance with their mandate to reduce exposures to background levels, is working with the homeowners who have slightly elevated levels and are interested in undertaking remedial measures (EPA, 2002). In April 2002, the EPA sent the results of indoor air sampling of the 220 residences to individual homeowners. Included with this letter, ATSDR and NJDHSS provided a public health interpretation of air exposures to PCE based on EPA's and the NJDEP's proposed action levels [Appendix A shows the fact sheet on PCE that was distributed to individual homeowners].

Discussion

Health Assessment Methodology

In the course of creating Public Health Assessments (PHA) and Health Consultations (HC), ATSDR evaluates the environmental and human components that lead to human exposure to a

release of hazardous substances from a given site. A pathways analysis consists of five elements: (1) a source of contamination; (2) transport through an environmental medium; (3) a point of human exposure; (4) a route of human exposure; and (5) a receptor population. ATSDR categorizes exposure pathways into three groups: (1) "completed pathways", that is, those in which exposure is reasonably expected to have occurred, to be occurring, or to occur in the future; (2) "potential pathways", that is, those in which exposure might have occurred, may be occurring, or may yet occur, and (3) "eliminated pathways", that is, those that can be eliminated from further analysis because at least one of the five elements listed above is missing and will never be present, or in which no contamination of concern can be identified.

After the pathways are designated as "completed", "potential", or "eliminated", ATSDR follows a two-step methodology to comment on public health issues related to exposure pathways at hazardous waste sites. First, ATSDR obtains representative environmental monitoring data for the site of concern and compiles a list of site-related contaminants. ATSDR compares this list of contaminants to health-based values (health comparison values or HVCs) (definitions of HVCs are shown in Appendix B) to identify those contaminants that do not have a realistic possibility of causing adverse health effects. Second, for the remaining contaminants, ATSDR evaluates site-specific conditions to determine what exposure scenario is realistic for a given exposure pathway. Given this exposure scenario, ATSDR determines an exposed dose and compares this dose to scientific studies to determine whether the extent of exposure indicates a public health hazard.

The health-based comparison values used in this report are concentrations of contaminants that the current public health literature suggest are "safe" or "harmless". These comparison values are quite conservative because they include ample safety factors that account for the most sensitive populations. ATSDR typically uses HCVs as follows: if a contaminant is never found at levels greater than its comparison value, ATSDR concludes the levels of corresponding contamination are "safe" or "harmless". If, however, a contaminant is found at concentrations that are greater than its HCV, ATSDR designates the pollutant as a contaminant of concern and examines it further in the assessment. Because HCVs are based on extremely conservative assumptions, the presence of concentrations greater than an HCV does not necessarily suggest that adverse health effects will occur among the exposed population.

Exposure Pathways and Contaminant of Concerns

The pathway of concern evaluated in this Health Consultation is exposure to ground water contaminants that off-gas or volatilize from ground water to soils and then infiltrate into the air of various homes. It has been assumed that ground water beneath the White Swan site (and possibly other sources) is contaminated with PCE, that the PCE has off-gassed to soils beneath nearby homes, and, finally, that the PCE has infiltrated into these homes through cracks in the foundation or directly from soils into homes.

In addition to the site-related PCE that may have infiltrated homes from off-gassing from ground water, it is possible that some of the PCE may be coming from indoor sources. Studies by the EPA have shown that most homes in the U.S. have measurable levels of organic chemicals in indoor air. While outdoor air contains these organic chemicals, a surprising finding from the EPA studies is that indoor levels of organic chemicals are usually higher than outdoor air. These higher indoor air levels of VOCs presumably come from consumer products that are brought into the homes, from off-gassing of home building materials, and from personal activities. EPA studies showed that certain human activities were associated with having increased levels of chemicals in indoor air. Examples of these activities are (EPA, 1987):

- smoking indoors increases benzene, xylene, ethyl benzene, and styrene levels in indoor air;
- bringing dry cleaning home causes higher PCE levels in indoor air;
- using hot water in the home increases chloroform levels in indoor air; and
- using room air fresheners, toilet bowl deodorizers, and moth crystals leads to higher levels of para-dichlorobenzene in indoor air.

Additional studies by EPA are underway to determine the contribution of site-related contaminants found in the ground water (including PCE) to the levels of chemicals detected in residential air samples.

PCE is a solvent that is commonly used in the commercial dry cleaning industry and in some household products. Studies have shown that background levels in U.S. homes, in areas similar to Wall Township, average about 3 - 6 $\mu g/m^3$ (micrograms per cubic meter) (EPA, 1987). Reported values are the ranges of medians for background concentrations found in several U.S. cities, as reported by EPA's TEAM Study, 1987. However, these are not site-specific background concentrations for the White Swan Laundry and Cleaner site, but are presented to provide perspective. If the concentration of PCE in a household sample is within this range, it does not necessarily indicate that the PCE is entirely due to non-site related sources. Moreover, there are many uncertainties related to applying the estimates of background from the EPA TEAM Study to Wall Township. That is, there may be differences due to the types of homes in the study versus Wall Township (e.g., basements, age, and construction) and differences in other factors that may effect local indoor background levels of PCE. Because PCE is considered a site-related contaminant of concern, all exposures above typical background levels are considered to be an exposure that may be related to the site; therefore, ATSDR and NJDHSS consider this pathway to be a completed, or at least a potential, exposure pathway.

The levels of PCE detected in the over 300 samples of indoor air from 220 residences ranged from not detected (ND) to 223.4 $\mu g/m^3$. However, one air sample collected by the NJDEP from the air space of a confined sump located in a basement of a home contained 1,760 $\mu g/m^3$ of PCE. In a majority of the homes, PCE was either not detected at all, or the levels of PCE in the air were less than the health comparison value of 0.63 $\mu g/m^3$ (based on EPA Region III's Risk-Based Concentration or RBC). The RBC for PCE is based on cancer effects. ATSDR currently does not

have a Cancer Risk Evalaution Guide (CREG) for PCE in air. For non-cancer effects due to long-term exposures to PCE, ATSDR's Minimal Risk Level or MRL (see definition below) is 271 $\mu g/m^3$. For non-cancer effects due to short-term PCE exposures, ATSDR's MRL is 1,356 $\mu g/m^3$. Many of the air samples were in the range of what may be considered typical background levels.

Since the available data represent a snapshot in time, ATSDR and NJDHSS cannot definitively determine the concentration or duration of a resident's exposure. However, given that the exposure is likely to persist without any intervention, it is assumed, conservatively, that the exposure duration is 30 years.

Public Health Implications

Tetrachloroethylene (PCE): Chronic Exposure and Non-Cancer Effects

To evaluate non-carcinogenic health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites. The MRL is an estimate of the level of daily human exposure to a contaminant below which non-cancerous adverse health effects are unlikely. MRLs are developed for each route of exposure, *e.g.,* ingestion or inhalation, and for the length of exposure, *i.e.,* acute (less than 14 days); intermediate (15–364 days); and chronic (365 days or more). Because ATSDR has no methodology to determine amounts of chemicals absorbed through the skin, no MRLs have been established for skin exposure. ATSDR presents information on MRLs in its series of Toxicological Profiles on hazardous substances. These chemical-specific profiles provide information on health effects, environmental transport, human exposure, and regulatory status. If ATSDR has not developed an MRL for a contaminant, the EPA Reference Dose (RfD) is used, if available. The RfD is an estimate of the daily exposure of the human population to a potential hazard that is likely to be without risk of a non-carcinogenic adverse health effects during a person's lifetime. To date, none of the air samples from residential living areas were above ATSDR's long-term or short-term MRL. Therefore, adverse non-carcinogenic health effects from either short- or long-term exposures to PCE are not expected. One sample obtained from the sump at a residence on Laurel Avenue did contain PCE above ATSDR's short-term MRL. Exposure to this concentration of PCE is considered to be of short-term duration when the cover over the sump is opened. For this reason, this exposure is further evaluated below. Since the concentrations of PCE in several other homes were above the HCV for cancer effects and typical background levels in U.S. homes, ATSDR and NJDHSS will also evaluate the public health implications of these exposures.

The highest concentration of PCE that was measured (1,760 $\mu g/m^3$ in the residential sump) exceeds ATSDR's short-term MRL of 1,356 $\mu g/m^3$. However, it should be noted that the short-term MRL for PCE is based on a human study of neurological effects (hand-eye coordination) of PCE (Altman et al., 1992), which is considered by ATSDR to be of a less serious nature. Moreover, the short-term MRL for PCE that was determined by the study is 200 times below the Lowest Observed

Adverse Effect Level (LOAEL)–the value of 200 is considered an uncertainty or margin-of-safety factor. Furthermore, the concentration that was that was measured at the sump is about 40 times less than the No Observed Adverse Effect Level (NOAEL). Moreover, because this sample was taken from an enclosed sump, only short-term intermittent exposures are likely to have occurred. Based on this information, it does not appear likely that the residents would experience any short-term adverse non-cancer effects from their exposures.

Tetrachloroethene (TCE): chronic exposure and cancer

PCE is a common commercial chemical that is used in the dry cleaning industry. Because of the potential for high PCE exposure, a number of epidemiological studies of dry cleaning workers have been conducted. These studies suggest a possible association between long-term PCE exposure and an increased risk of cancer. The cancer types most consistently showing an increased risk are esophageal cancer, bladder cancer, cervical cancer, and non-Hodgkin's lymphoma. Since dry cleaning workers are also exposed to other chemicals, it is difficult to determine whether these cancers are associated with PCE or some other chemical used in the drying cleaning industry. Another study of a community exposed to PCE only through their drinking water showed an increase in leukemia and bladder cancer in the exposed population (Aschengrau *et al*,1993; Webler *et al*, 1993). Adding to the complexity is the contribution that smoking and other life-style variables might have on producing these cancers. One scientist reviewed these studies and concluded that esophageal cancer might have been caused by cigarette smoking and alcohol consumption, and that bladder cancer might have been caused by exposure to other solvents that are used in the dry cleaning industry (Weiss 1995; ATSDR 1997).

Near-lifetime exposure to PCE by inhalation has been shown to cause cancer in rats and mice. In a 2-year study of rats, Mennear et al. showed an increase in mononuclear cell leukemia (a cancer of the blood) following exposure to 1,356,000 $\mu g/m^3$ PCE for 5 days a week, 6 hours a day. Mennear et al. also showed that inhalation of PCE caused an increase in liver cancer in mice exposed at 678,000 $\mu g/m^3$ for 5 days a week, 6 hours a day for over 2 years.

Much discussion exists in the scientific community about whether PCE exposure can cause cancer in humans. The EPA is currently reviewing its cancer classification for PCE. The National Toxicology Program (NTP), within the federal Department of Health and Human Services, has reviewed the available cancer information and has determined that there is sufficient evidence that PCE can cause cancer in animals, but that the evidence in humans is inconclusive. The NTP has concluded that PCE may reasonably be anticipated to be a carcinogen (ATSDR, 1997). Overall, the scientific community is uncertain whether PCE causes cancer in humans. However, to be protective of public health, ATSDR and the NJDHSS believe it is reasonable to consider PCE a probable human carcinogen.

Since EPA Region III's Risk Based Concentration (RBC) for PCE is 0.63 $\mu g/m^3$, a concentration of 6 $\mu g/m^3$ (a typical background concentration found in indoor air) represents a

Lifetime Excess Cancer Risk (LECR) of 1 x 10^{-5} (1 in 100,000). [A concentration of 60 $\mu g/m^3$, a factor of 10 greater than the average background concentration, therefore represents a LECR of 1 x 10^{-4} (1 in 10,000)]. Exposure levels of 6 - 60 $\mu g/m^3$ represent a slightly increased lifetime excess cancer risk beyond the cancer risk due to background PCE levels. The LECRs were calculated based on EPA's draft provisional cancer reassessment of exposure to PCE by inhalation (EPA, 2002). This determination was based on a study of liver cancer in female mice, an outcome that is considered by many to be the most appropriate when comparing rodent studies to human health effects.

The method used to calculate the LECR is based on EPA's Cancer Slope Factor (CSF), which assumes that high dose animal exposure data can be used to estimate the risk for low dose exposures in humans. The method also assumes that there is no "safe" level for exposure, and that the total duration of past, current, and future exposure could be as much as 30 years – a very conservative assumption. While this calculation may not determine a real-life increase in cancer to those who are exposed to PCE, it is evidence of a potential added risk, suggesting a difference between the cancer incidence under the exposure conditions and the background incidence in the absence of exposure. The actual possibility of any one person (child or adult) getting cancer is probably lower than the calculated risk and is dependent on many factors, for example, lifestyle, nutritional status, genetics, and other exposures at home and in the workplace. Moreover, the actual exposures to the residents are likely to be much lower than those shown to cause cancer in animals, or than exposures to workers at dry cleaning establishments.

Conclusions

Based on the action levels proposed by the EPA and the NJDEP, the public health interpretation of the levels of PCE that were found in the indoor air in about 220 residences in Wall Township that were sampled in conjunction with the on-going investigation of the White Swan site is as follows:

- Exposures to PCE concentrations above 60 $\mu g/m^3$ represent a lifetime risk of cancer greater than that due to background concentrations;
- Exposures to PCE concentrations between 6 and 60 $\mu g/m^3$ represent a lifetime cancer risk that is slightly greater than that due to background levels; and
- Exposures to PCE concentrations less than 6 $\mu g/m^3$ represent little or no lifetime cancer risk greater than that due to background levels.

Taking into consideration the cancer effects associated with PCE air exposures, ATSDR and the NJDHSS calculated Lifetime Excess Cancer Risks (LECR). While this calculation may not be an indication of a real-life increase in cancer to those who are exposed to PCE, it does indicate a potential added risk, suggesting a difference between the cancer incidence under the exposure conditions and

the background incidence in the absence of exposure. The possibility of any one person (child or adult) getting cancer is probably lower than the calculated risk and is dependent on many factors, *i.e.*, lifestyle, nutritional status, genetics, and other exposures at home and in the workplace. Moreover, the actual exposures to the residents are likely to be much lower than those shown to cause cancer in animals or lower than exposures to workers at dry cleaning establishments.

ATSDR and the NJDHSS consider exposures to PCE at 60 $\mu g/m^3$ and above to be a **"Public Health Hazard"**[See Appendix C for a description of ATSDR's Public Health Hazard categories]. Actions taken by EPA to mitigate these completed pathway exposures are protective of public health. Although exposures between 6 and 60 $\mu g/m^3$ represent a slightly increased risk of cancer beyond the background risk, ATSDR and the NJDHSS consider the actions taken by the NJDEP to reduce or eliminate exposures in this range to also be protective of public health. Taking into consideration typical indoor background levels in U.S. homes and the very low risk of cancer, ATSDR and the NJDHSS consider all exposures to PCE below 6 $\mu g/m^3$ to represent **"No Apparent Public Health Hazard"**.

ATSDR and the NJDHSS have also evaluated the likelihood of an adverse non-cancer effect from the PCE air exposures in the 220 residences that were sampled in Wall Township. All but one sample were below ATSDR's MRLs for long-term non-cancer health effects; therefore, no adverse non-cancer health effects are likely. The one sample that was above the short-term MRL was from a sump at a residence on Laurel Street. Because this sample was taken from an enclosed sump, only short-term intermittent exposures are likely to have occurred. Based on further evaluation of the exposures and health effects from the short-term exposures to the levels of PCE found in the air in the sump area, it is not likely that exposure to any residents would result in any serious non-cancer adverse health effects.

The above conclusions are based on a residential exposure scenario and do not apply to the evaluation of the public health implications of indoor air exposures under non-residential situations (e.g., schools and commercial buildings).

Recommendations

Soil gas and ground water investigations should be continued in order to determine the extent and contribution of site-related contaminants in ground water that infiltrate into the indoor air of homes and businesses.

Public Health Action Plan (PHAP)

The Public Health Action Plan (PHAP) for the (former) White Swan Laundry and Cleaner, Inc. site contains descriptions of the actions to be taken by ATSDR, NJDHSS and other agencies at or in the vicinity of the site. The purpose of a PHAP is to ensure that this Health Consultation not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The environmental sampling data and remedial activities that have been conducted have been evaluated within the context of human exposure pathways and other relevant public health factors. Included is a commitment on the part of ATSDR and NJDHSS to monitor this plan to ensure that the plan is implemented. ATSDR will provide follow-up to this PHAP, outlining the actions which have been completed and those actions that are in progress, as needed. The public health actions to be implemented by ATSDR/NJDHSS are as follow:

Actions Undertaken

(1) EPA and the NJDEP have sampled the indoor air of numerous residences and other structures, including several schools in the vicinity of the site property. In addition, the EPA and NJDEP, collectively, have taken actions to reduce PCE exposures to concentrations that are below levels of public health concern.

(2) ATSDR and the NJDHSS have participated in a public availability session with local residents to provide them with a public health interpretation of their individual air sampling results. In addition, ATSDR and NJDHSS have participated in a public meeting to inform the general public of the public health issues of air exposures.

(3) ATSDR and the NJDHSS have prepared a fact sheet for PCE to accompany individual sampling results sent to the residents by the EPA.

Actions Planned

(1) ATSDR and NJDHSS will provide a copy of this document to all concerned residents in the vicinity of the site.

(2) As additional soil gas and ground water data become available, ATSDR and the NJDHSS will, when requested, evaluate the public health implications of indoor air exposures to other chemicals that may be found to be related to the site and provide assistance to residents to reduce their exposures to chemicals found that are not related to the site.

(3) ATSDR and NJDHSS will coordinate as deemed necessary with the appropriate environmental agencies to develop plans to implement the recommendations contained in this document.

Certification

This Health Consultation was prepared by the Division of Health Assessment and Consultation (DHAC), ATSDR, and the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the ATSDR. It has been produced in accordance with approved methodology and procedures existing at the time the Health Consultation was begun.

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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with its findings.

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Appendices

Appendix A: Fact Sheet on Perchloroethylene (PCE)

Agency for Toxic Substances and Disease Registry (ATSDR) Fact Sheet

Exposure to PCE in Residential Air Near the (former) White Swan Laundry Site Public Health Implications and Interpretation

General Public Health Issues:

- PCE is a solvent that is commonly used in the commercial dry cleaning industry and in some household products.
- Studies have shown that typical background levels in U.S. homes average 3 - 6 $\mu g/m^3$. This range is not a site-specific background level, but is presented to provide perspective.
- Studies of dry cleaning workers suggest a possible link between PCE air exposures and an increased risk of cancer.
- The most consistent cancers shown are esophageal, bladder, cervical, and non-Hodgkin's lymphoma.
- Scientists are uncertain whether these cancers are linked to PCE exposure, exposures from other chemicals used in dry cleaning, or from other risk factors, such as smoking, etc.
- Studies of rats and mice have linked PCE exposure to liver cancer in female mice. As with the human studies, some uncertainty exists, but it appears that the most credible link is with liver cancer in female rodents.
- The scientific community is uncertain whether PCE causes cancer in humans. However, to be protective of public health, ATSDR and the NJDHSS believe it is reasonable to consider PCE a probable human carcinogen.

Perspective on Site-Specific Exposure:

- To be protective of public health, the interpretation of PCE air exposures in the attached table is based on 30 years of exposure. The actual length of exposure to residents is not known, but it is likely to be much shorter than 30 years, so the chance of getting cancer is likely to be lower than stated.
- However, because the actual exposure levels over time are not known, the risk estimates may over- or underestimate the chance of getting cancer.
- The risk of any one person getting cancer is very low and is dependent on many factors, for example, lifestyle, nutritional status, genetics, and other exposures at home and in the workplace.
- The actual exposures to most residents are likely to be much lower than those shown to cause cancer in animal studies or exposure to workers in the dry cleaning business.

Agency for Toxic Substances and Disease Registry (ATSDR)
Public Health Interpretation of Exposure to Tetrachloroethylene (PCE) in Residences Near the (former)White Swan Laundry and Dry Cleaner, Inc. Site

Concentration of PCE in Indoor Air ($\mu g/m^3$)	Public Health Interpretation	Background Concentration of PCE in Indoor Air in U.S. Homes ($\mu g/m^3$)*
Less Than 6	Little to no additional lifetime cancer risk beyond the cancer risk due to background PCE levels (LECR** $<10^{-5}$)	3 - 6
6 - 60	Slightly increased lifetime cancer risk beyond the cancer risk due to background PCE levels (10^{-4} > LECR** > 10^{-5})	
60 and Above	Increased lifetime cancer risk beyond the cancer risk due to background PCE levels (LECR** $>10^{-4}$)	

*Reported values are the ranges of medians for background concentrations found in several U.S. cities, as reported by EPA's TEAM Study, 1987. These are not site-specific background concentrations for the White Swan Laundry and Cleaner site, but are presented to provide perspective. If the concentration of PCE in a household sample is within this range, it does not necessarily indicate that the PCE is entirely due to non-site-related sources.

**LECR - Lifetime Excess Cancer Risk

Note: The EPA Region III Risk Based Concentration (RBC) for PCE of 0.63 $\mu g/m^3$ is equivalent to a LECR of 10^{-6} (1 in 1,000,000). ATSDR currently does not have a health-based cancer comparison value for inhalation of PCE.

Appendix B: Description of Comparison Values

Description of Comparison Values

ATSDR's Comparison Values are media-specific concentrations that are considered to be "safe" under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific chemical substances that the health assessor has selected for further evaluation of potential health effects.

Generally, a chemical is selected for evaluation because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's Comparison Values. However, it cannot be emphasized strongly enough that Comparison Values are not thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a Comparison Value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not solely on environmental concentrations.

Screening values based on non-cancer effects are generally based on the level at which no health adverse health effects (or the lowest level associated with health effects) found in animal or (less often) human studies, and include a cumulative margin of safety (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10-fold to 1,000-fold or more. By contrast, cancer-based screening values are usually derived by linear extrapolation with statistical models from animal data obtained at high exposure doses, because human cancer incidence data for very low levels of exposure are rarely available. Cancer risk estimates are intended to represent the upper limit of risk, based on the available data.

Listed and described below are the types of comparison values that the ATSDR and the NJDHSS used in this Health Consultation:

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations of contaminants in an environmental medium (such as drinking water) that are expected to cause no more than one excess cancer case for every million persons who are continuously exposed to the concentration for an entire lifetime (equaling a risk of 1×10^{-6}). These concentrations are calculated from the EPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are known or suspected of being carcinogenic have CREG Comparison values.

Environmental Media Evaluation Guides (EMEGs) and Reference Dose Media Evaluation Guides (RMEGs) are estimates of chemical concentrations in an environmental medium (such as drinking water) that are not likely to cause an appreciable risk of deleterious, non-cancer health effects, for fixed durations of exposure. These guides may be developed for special sub-populations such as children. EMEGs are based on ATSDR's Minimal Risk Level (MRL) while RMEGs are based on the EPA's Reference Dose (RfD).

Other health-based guides may also be used as Comparison Values, including drinking water Maximum Contaminant Levels (MCLs) established by the EPA or the NJDEP.

Appendix C: ATSDR Public Health Hazard Categories

ATSDR's Interim Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.
C. Indeterminate Public Health Hazard This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.

Category / Definition	Data Sufficiency	Criteria
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

**Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.*

Appendix IV: Indoor Air Contaminants and Background Concentrations

Table 1: Summary of Indoor Air Sampling Data at the White Swan/Sun Cleaner Groundwater Contamination Site

Contaminant	Frequency of Detection ($\mu g/m^3$)	Minimum of Detected Conc. ($\mu g/m^3$)	Maximum of Detected Conc. ($\mu g/m^3$)	Mean of Detected Conc. ($\mu g/m^3$)	Median of Detected Conc. ($\mu g/m^3$)	Standard Deviation ($\mu g/m^3$)
1,1,1-Trichloroethane	130	0.05	48	2.2	0.66	6.3
1,1,2,2-Tetrachloroethane	1	5.5	5.5	5.5	5.5	NA
1,2,4-Trichlorobenzene	32	3.8	34	11	9.6	7.6
1,2,4-Trimethylbenzene	222	0.25	325	6	2.11	23
1,2-Dichlorobenzene	3	3.7	8.4	6.4	7.2	2.4
1,2-Dichloroethane	1	0.16	0.16	0.16	0.16	NA
1,3-Butadiene	78	0.07	7.3	1	0.32	1.6
1,3-Dichlorobenzene	1	6.02	6.02	6.02	6.02	NA
1,4-Dichlorobenzene	46	0.18	938	79	1.8	248
2,2,4-Trimethylpentane	18	2.72	40	10.5	4.7	12.3
2-Chlorotoluene	13	3	12.4	6	5	3.3
3-Chloropropene	2	2.6	3.1	3	3	0.40
4-Ethyltoluene	21	2.5	35	9.5	6.4	9
Acetonitrile	3	1	5.2	2.5	1.2	2.3
Acetylene	206	0.62	301	7	2	30.1

Table 1: (Cont'd.)

Contaminant	Frequency of Detection (μg/m^3)	Minimum of Detected Conc. (μg/m^3)	Maximum of Detected Conc. (μg/m^3)	Mean of Detected Conc. (μg/m^3)	Median of Detected Conc. (μg/m^3)	Standard Deviation (μg/m^3)
Acrylonitrile	3	0.67	5.4	2.3	1	2.61
Benzene	259	0.75	39	3	2	4
Bromodichloromethane	4	1.2	6.7	4.3	4.6	2.4
Bromomethane	3	0.12	0.2	0.2	0.2	0.06
Carbon Tetrachloride	207	0.13	17	0.8	0.6	1.5
Chlorobenzene	1	14.3	14.3	14.3	14.3	NA
Chloroethane	1	7.8	7.8	7.8	7.8	NA
Chloromethane	260	0.64	6	1.35	1.22	0.6
Cyclohexane	24	1.72	30	10	10	7.63
Dibromochloromethane	1	0.34	0.34	0.34	0.34	NA
Dichlorodifluoromethane	259	2.18	62	5.26	3	7.9
Dichlorotetrafluoromethane	14	0.14	35	8	5.3	9.28
Ethylbenzene	227	0.17	52	2.8	0.91	5.88
Hexachloro-1,3-Butadiene	11	5.35	24.6	11.54	8	6.42
Methyl Ethyl Ketone	80	0.74	91	6.78	3.95	11

Table 1: (Cont'd.)

Contaminant	Frequency of Detection (μg/m^3)	Minimum of Detected Conc. (μg/m^3)	Maximum of Detected Conc. (μg/m^3)	Mean of Detected Conc. (μg/m^3)	Median of Detected Conc. (μg/m^3)	Standard Deviation (μg/m^3)
Methyl Isobutyl Ketone	6	1.31	7.21	2.93	2.38	2.16
Methyl tert-Butyl Ether	157	0.69	165	10.45	2.6	23.55
Methylene Chloride	251	0.07	400	10	1.11	40.38
n-Heptane	39	2.15	45.53	7.82	5	8
n-Hexane	27	2.11	77.5	18	11	20
n-Octane	143	0.09	23	1.65	0.75	3
Propylene	203	0.09	16	1.74	1.22	1.9
Styrene	91	0.13	33.67	2.72	0.6	5.75
tert-Amyl Methyl Ether	8	0.13	10	3	2.32	3
Toluene	289	0.90	584	24	7.47	60
Trichlorofluoromethane	225	1.13	38.32	3.19	2.09	4.14
Trichlorotrifluoromethane	206	0.46	7.08	0.91	0.7	0.78
Xylene	268	0.52	231	10.77	3.8	24

NA - Not -applicable

Table 2: Uses and Typical U.S. Background Concentration of Selected Chemicals Detected in Residential Indoor Air Samples at the White Swan Cleaners/Sun Cleaners Groundwater Contamination Site, Wall Township, Monmouth County, NJ

Chemical	Usage[a]	Sources of Common Exposure[b]	Background Concentrations ($\mu g/m^3$)[c]
Acrylonitrile	Plastics; paints and coatings; adhesives; pesticide; dyes; surfactants (in detergents); pharmaceuticals; cotton textile production; acrylics; synthetic wood products; tobacco treatment	Formerly cigarette smoke (use is restricted now); currently, living near a facility involved working with synthetic chemicals	No significant indoor air detection[1,3]
Benzene	Solvents, gasoline, resins and plastics; nylon; paints; adhesives (especially carpet); printing; pesticides; detergents/disinfectants; dyes; photographic processing	Gasoline emissions; cigarette smoke; paints and adhesives; particle board and wood composites; wood smoke	See ATSDR/NJDHSS Fact Sheet for benzene background concentrations
1,3-Butadiene	Intermediate (potential impurity) in many plastics and polymers; fungicides; latex paint; acrylics; fuel formulations	Vehicle emissions; tobacco smoke; wood fires; waste incinerators; electric wire coatings; thermal degradation of plastics	0.38 (indoor) 14 (cigarette smoke)[d]; 2-19
Carbon Tetrachloride	Refrigerants; solvents; fumigants; petroleum additive; perfumes; paint; adhesives	Due to restricted use of the compound in most consumer products in the US, most common exposure is due to environmental contamination. Products from overseas may still contain carbon tetrachloride	0 - 42.41; 2.5 (average)[f] 0.4-1.03
Chloroethane (Ethyl Chloride)	Solvent; refrigerant; dyes; perfume; pharmaceuticals; pesticides; aerosol propellant; paints	Paints, air fresheners, and refrigerants	0.1-0.5[d]; 0.1-0.43
Chloroform	Intermediate in freon production; solvent for fats, oils, etc.; fire extinguishers; plastics; anti-freeze for CCl4; pesticide; pharmaceutical; tobacco treatment; dry cleaning agent; toothpaste; cough syrups; laundry spot remover	Indoor pool chlorination; water chlorination; by-product off-gassing	4.1 (average)[e] 1.0-19.8[f]

Table 2: (Cont'd.)

Chemical	Usage[a]	Sources of Common Exposure[b]	Background Concentrations ($\mu g/m^3$)[c]
Chloromethane (Methyl Chloride)	Silicone products; detergents; pesticides; pharmaceuticals; aerosol propellant; artificial rubber; refrigerants; plastics	Drinking water (as trihalomethanes); plastics; ubiquitous low level contaminant.	14.3[d]; 1.37-6.21[f]
Dichlorodifluoromethane (Freon 12)	Refrigerant; aerosol propellant; pesticides; pharmaceuticals; solvent; plastics	Probably as a refrigerant or aerosol propellant (air fresheners, etc.)	0.5-56.8[d]
Dichlorobenzenes	Deodorant; pesticide; resins and plastics; solvent; dyes; degreaser; wood preservative; motor oils; and paint	Mothballs; toilet deodorants; air fresheners	0-10.22[d]; 24 (average)[e] 0.08-240 [f]
Ethylbenzene	Solvent; gasoline additive; resins and plastics; asphalt; pesticides; and paints	Gasoline emissions; cigarette smoke; paints; cleaners; and spray adhesives	9.3-13.1[d]; 13 (average)[e]; 2.4-28[f]
Hexachlorobutadiene	Solvent for plastics and adhesives; hydraulic and other high heat transfer liquids; intermediate for fluorinated lubricants; pesticide	Source dominated exposure (e.g., used by area plant); fish from contaminated areas.	About 0.4
Methylene Chloride	Paints; solvents; aerosol propellant; pharmaceuticals; plastics; automotive products; pesticides; hair sprays; food additive; and, dental fixtures	Spray paints; spray adhesives; inks; polyurethane; paint strippers; adhesive removers. Hair Spray use was banned in 1989 by the FDA.	2.6-170[d]; 0.2-18,300 [f]
Methyl Ethyl Ketone (2-Butanone)	Solvent for coatings, resins, rubbers, plastics, pharmaceuticals, and rubber cements.	Use of commercially available products such as paints, adhesives, and rubber cements.	27 (average of only 4 samples)[e,f] 2.0-40.9 (office buildings) Levels generally excepted to be low [d]

Table 2: (Cont'd.)

Chemical	Usage[a]	Sources of Common Exposure[b]	Background Concentrations ($\mu g/m^3$)[c]
Methyl T-Butyl Ether (MTBE)	Used as an octane booster in gasoline (gasoline reformulation)	Automobile gasoline refueling; inside automobiles while driving; refueling lawn movers, chain-saws, or other gasoline-powered equipment	No good data for typical indoor air concentrations
Tetrachloroethylene (PCE)	Solvent; degreaser; dry cleaning and textile production; water repellants; pharmaceuticals; pesticides; refrigerants; insulating fluids; correction fluid (e.g., white out) and inks; adhesives	Dry cleaned garments; paint removers; fabric cleaning products (e.g., stain removers, etc.); lubricants; wood products	See ATSDR/NJDHSS Fact Sheet for PCE background concentrations
1,1,2,2-Tetrachloroethane	Solvents for fats, oil, waxes, etc.; paints and paint removers; cleaners and degreasers; moth-proofing treatment for clothing; adhesives; production of bleach; artificial silks and pearls; tobacco; photographic films; pesticides; formulation of other chlorinated organics (e.g., PCE, TCE, etc.); toiletries.	Incineration of chlorinated organics; cement kilns; chemical research laboratories; refineries; hazardous waste sites.	0.1 (average)[e]; 13.0 (average)[f]
Toluene	Gasoline additive; paints; solvents; adhesives; inks and dyes; cleaners and detergents; nylon; cosmetics; pharmaceutical; antifreezes; some leather products	Gasoline emissions; nail polish; cigarette smoke; wood smoke; paint strippers; arts materials; wood and carpet adhesives; hair care products	4.8-10.1[d]; 0.26-31.5[f]

Table 2: (Cont'd.)

Chemical	Usage[a]	Sources of Common Exposure[b]	Background Concentrations ($\mu g/m^3$)[c]
Trichloroethylene (TCE)	Degreaser; solvents; adhesives; textiles; lubricants; paint; pesticides; pharmaceuticals; refrigerant; correction fluids; disinfectants and cleaners; food additive; plastics	Many consumer products in the US removed this compound and the most common exposure is due to environmental contamination. Products from overseas may still contain trichloroethylene, especially Wood Stains and Varnishes; Lubricants; Adhesives; and Correction Fluids/Cleaners. Trichloroethylene is often found associated in the environment with tetrachloroethylene. Trichloroethylene is a contaminant in cigarette smoke	0.2-13[d]; 7.2 9 (average)[e]; 0.7-43 [f]
1,2,4-Trimethylbenzene	Dyes, perfumes, and plastics; solvent and paint thinner; sterilizing agent; degreaser; gasoline additive; synthetic wood products.	Self-serve gasoline fill-ups; indoor painting or printing	10-12[d] 2.8 (average)[e]
1,3,5-Trimethylbenzene	Dyes, inks, and plastics; solvents; gasoline additive	Self-serve gasoline; print and copier machines	0.86-1240[d] 4.5 (average)[e]
Xylenes	Solvents; paints and coatings; pesticides; gasoline and lubricants; resins and plastics; synthetic fabrics; dyes; adhesives; and some leather products	Gasoline emissions; cigarette smoke; paints; pesticide use; model glues; and, cleaning products	1.8-150[d] 12-39 (range of averages of various xylenes)[e]; 3.2-43 [f]

[a]National Library of Medicine's (NLM) Hazardous Substances Data Bank (HSDB) and ATSDR Toxiocological Profile, [b]ATSDR Toxicological Profile, [c]The background concentrations presented are not specific to the Wall Township area and the White Swan Dry Cleaners site in particular, but are presented to provide the homeowner some perspective as to levels typically found in U.S. homes, [d]HSDB, 2002, at www.toxnet.nlm.nih.gov, [e]EPA, 1988, [f]Tox Profile at www.atsdr.cdc.gov

Appendix V: Toxicologic Characteristics

Toxicologic Characteristics of Chemicals of Concern

The toxicological summaries provided below are based on ATSDR's ToxFAQs (http://www.atsdr.cdc.gov/toxfaq.html), except where noted. Health effects are summarized in this section for the chemicals of concern found most frequently above CVs in the White Swan Cleaners/Sun Cleaners Groundwater Contamination site.

The health effects described in the toxicological summaries are typically known to occur at levels of exposure much higher than those that occur from environmental contamination. The chance that a health effect will occur is dependent on the amount, frequency and duration of exposure, and the individual susceptibility of exposed persons. These factors will be considered in the Discussion section.

Chloroform Chloroform is a colorless, volatile, nonflammable liquid. It is slightly soluble in water and is miscible with oils, ethanol, ether, and other organic solvents. Chloroform has a nonirritating odor and a slightly sweet taste. It is unstable when exposed to air, light, and/or heat. When heated to decomposition, chloroform emits toxic fumes of hydrochloric acid and other chlorinated compounds (WHO 1994, HSDB 2001). The major use of Chloroform is in refrigerant (hydrochlorofluorocarbon-22) and fluoropolymers production. Other uses include the extraction and purification of some antibiotics, alkaloids, vitamins, and flavors; as a solvent for lacquers, floor polishes, and adhesives; in artificial silk manufacturing; in resins, fats, greases, gums, waxes, oils, and rubber; as an industrial solvent in photography and dry cleaning; as a heat transfer medium in fire extinguishers; as an intermediate in the preparation of dyes and pesticides; and as a fumigant for stored grain crops (ATSDR 2003).

The primary routes of exposure are ingestion, inhalation, and dermal contact withwater (e.g., while showering, swimming, cleaning, and cooking). Ingestion of contaminated water is expected to be a primary source of exposure. Chloroform was detected in the atmosphere at concentrations ranging from 0.10 to 10.0 $\mu g/m^3$ and in indoor air at 1.0 to 20.0 $\mu g/m^3$ (ATSDR 2003). Exposure via inhalation results in 60% to 80% absorption. Placental transfer of chloroform has also been demonstrated (WHO 1994).

Exposures to high levels of chloroform for long periods of time may damage liver and kidneys. Large amounts of chloroform can cause sores when chloroform touches your skin. Reproductive or birth defects in people is unknown. Animal studies have shown that miscarriages occurred in rats and mice that breathed air containing 30 to 300 ppm chloroform during pregnancy and also in rats that ate chloroform during pregnancy. Offspring of rats and mice that breathed chloroform during pregnancy had birth defects. Abnormal sperm were found in mice that breathed air containing 400 ppm chloroform for a few days.

Chloroform is reasonably anticipated to be a human carcinogen based on sufficient evidence of carcinogenicity in experimental animals (NCI 1976, IARC 1972, 1979, 1982, 1987, 1999). There is inadequate evidence for the carcinogenicity of

chloroform in humans (IARC 1982, 1987, 1999). Several epidemiological and ecological studies indicate that there is an association between cancer of the large intestine, rectum, and/or urinary bladder and the constituents of chlorinated water (EPA 1985).

cis-1,2-DCE cis-1,2-DCE is a highly flammable, colorless liquid with a sharp, harsh odor. It is a volatile organic chemical used in the manufacture of solvents. It is a manmade or synthetic chemical with no natural sources. Release of cis-1,2-DCE to the environment can occur from manufacturing plants. Studies have shown that it may result as a natural degradation product of trichloroethylene (TCE) or of tetrachloroethylene (PCE) in the environment. The other form of cis-1,2-DCE is called trans-1,2-DCE. cis-1,2-DCE is volatile; so it is commonly found as a vapor in the air. Exposure to cis-1,2-DCE occurs by breathing air which has been contaminated with cis-1,2-DCE vapors from shower water or household products, or by drinking, swimming, or showering.

Breathing small amounts of cis-1,2-DCE can irritate nose, throat and the lungs. It may also effect the blood, such as decreased numbers of red blood cells, and the liver. The long-term (365 days or longer) human health effects after exposure to low concentrations of cis-1,2-DCE is unknown. Exposure to cis-1,2-DCE has not been shown to affect fertility in people or animals. One animal study suggested that exposure may impair the growth of fetuses.

The National Toxicology Program has determined that cis-1,2-DCE is “not classifiable” to be a human carcinogen.

TCE TCE is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. TCE dissolves a little in water, and can remain in groundwater for a long time. It quickly evaporates from water, so it is commonly found as a vapor in the air. People can be exposed to TCE by breathing air in and around the home which has been contaminated with TCE vapors from shower water or household products, or by drinking, swimming, or showering in water that has been contaminated with TCE.

Breathing small amounts of TCE may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Breathing large amounts of TCE may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage. Drinking large amounts of TCE may cause nausea, liver damage, unconsciousness, impaired heart function, or death. Drinking small amounts of TCE for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear. Skin contact with TCE for short periods may cause skin rashes.

Some studies with mice and rats have suggested that high levels of TCE may cause liver, kidney, or lung cancer. Some studies of people exposed over long periods to high levels of TCE in drinking water or in workplace air have found evidence of

increased cancer. The National Toxicology Program has determined that TCE is "reasonably anticipated to be a human carcinogen," and the International Agency for Research on Cancer (IARC) has determined that trichloroethylene is "probably carcinogenic to humans."

PCE PCE is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell PCE when it is present in the air at a level of 1 part per million (1 ppm) or more, although some can smell it at even lower levels. People are commonly exposed to PCE when they bring clothes from the dry cleaners.

High concentrations of PCE can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Irritation may result from repeated or extended skin contact with it. These symptoms occur almost entirely in work (or hobby) environments when people have been exposed to high concentrations. In industry, most workers are exposed to levels lower than those causing obvious nervous system effects. The health effects of breathing in air or drinking water with low levels of PCE are not known. Results from some studies suggest that women who work in dry cleaning industries where exposures to PCE can be quite high may have more menstrual problems and spontaneous abortions than women who are not exposed. Results of animal studies, conducted with amounts much higher than those that most people are exposed to, show that PCE can cause liver and kidney damage. Exposure to very high levels of PCE can be toxic to the unborn pups of pregnant rats and mice. Changes in behavior were observed in the offspring of rats that breathed high levels of the chemical while they were pregnant.

The U.S. Department of Health and Human Services (USDHHS) has determined that PCE may reasonably be anticipated to be a carcinogen. PCE has been shown to cause liver tumors in mice and kidney tumors in male rats.

APPENDIX VI

A. Exposure Point Concentration During Lawn and Garden Watering

Stripping of VOCs during lawn and garden watering using sprinklers and their potential impact on ambient air quality was one of the main community concerns during public meetings. This appendix briefly describes the method for estimating the VOC flux, relevant air quality standards and potential impact on a receptor.

VOC Stripping Efficiency of Sprinkler Systems

Sprinklers are used to water crops, lawns, gardens or other plants. They are also used for recreation or as a cooling system. The efficiency of sprinkler systems to remove VOCs from contaminated ground was evaluated in the laboratory and pilot scale systems. Three low-volume mini-sprinklers were tested for their efficiency to remove trichloroethylene (TCE) and tetrachloroethylene (PCE) from water (Berisford et al. 2003). Deionized water spiked with TCE and PCE was pumped through a sprinklers. Water was collected at 2 ft and 4 ft above the ground that were spaced at 2 ft intervals from the riser base. Overall, the sprinklers reduced dissolved concentrations of TCE and PCE by 99.1 to 100 and 96.9 to 100%, respectively, from mean influent dissolved concentrations of 466 to 1675 µg/L TCE and 206 to 940 µg/L PCE. An evaluation of the performance of sprinkler irrigation was conducted by the US Environmental Protection Agency (USEPA) Superfund Innovative Technology Evaluation (SITE) Program (EPA 1998; Richardson and Sahle-Demessie. 1998; Spalding and Exner 2002). Sprinkler irrigation system has been shown to remove greater than 96% of VOCs from a contaminated groundwater source. The air emission risk associated with exposures was also evaluated using an air dispersion model (ISCST3); the results indicated that there were no health risks with the use of the technology at the demonstration site.

The results reported in the literature show that the sprinklers can remove 100% of the PCE from contaminated water. Therefore, as a conservative estimate, we assumed 100% removal for this evaluation.

Sample Calculation for PCE

Inhalation exposure concentration, during lawn and garden watering, was calculated using the following assumptions:

- all of the PCE transfers from the water to air;
- an exposed resident stays in the lawn/garden area for the full watering period.
- watering period 2 hour per day during summer (May to September);
- water flow rate = 3 gallons per minute; and,
- lawn size = 100 ft x 100 ft;

Assuming rapid transfer of VOCs from the liquid to gas phase, the VOC emission rate may be estimated as:

$$3\ \frac{gal}{\min} * 3.78 \frac{L}{gal} * \left(1068\, x10^{-6}\ \frac{gm}{L}\right) * \frac{1}{60 \frac{\sec}{\min}}$$

$$= 2.02 \times 10^{-4} \text{ gm/sec}$$

Assuming the PCE emission was from the entire lawn, the VOC flux may be estimated as:

$$\left(2.02 \times 10^{-4}\ \frac{gm}{\sec}\right) / \left[\ (100\ ft\ x 100\ ft) * 0.093\ \frac{m^2}{ft^2}\ \right]$$

$$= 2.17 \times 10^{-7} \text{ gm/sec-m}^2$$

The Industrial Source Complex Short Term 3 (ISCST3) model[1] was used to estimate the ambient air VOC concentrations in the lawn area. Two years of meteorological data (1991 to 1993) from Atlantic City, NJ weather station, lawn dimensions and VOC flux from the lawn surface were used as the input to the model.

The receptors were placed within the lawn. Ambient air VOC concentrations were estimated using the mean and maximum concentration of PCE detected in the irrigation well.

Results

The method was used to analyze two scenarios:

- Exposure Point Concentration from a single Lawn
- Exposure Point Concentration from multiple Lawns (100 plots)

Contaminant Concentration from a single Lawn During sprinkler use

Contaminant	Groundwater Concentration (µg/L)		Lawn Air Concentration (µg/m^3)		TWA[a] Concentration (µg/m^3)	
	Max.	Mean	Max.	Mean	Max.	Mean
Chloroform	8.7	1.48	0.0038	6.6 x10^{-4}	0.0083	1.1 x10^{-5}
cis-1,2-DCE	657	46	0.3	0.02	0.0018	0.0003

[1]The ISCST3 model is a regulatory guideline dispersion model and is used extensively for air impact analysis. It is based on steady-state three-dimensional Gaussian plume model that can be used to assess pollutant concentrations based on a variety of conditions including emission sources, atmospheric conditions and terrain features.

PCE	1,068	194	0.47	0.08	0.005	0.001
TCE	243	14.3	0.108	0.006	6.7×10^{-5}	0.0001

[a]Time Weighted Average (based on 1 hour per day and 5 months per year)

Contaminant Conc. from a Multiple Lawns During simultaneous use sprinklers

Contaminant	**Mean Groundwater Concentration (μg/L)**	**Lawn Air Concentration ($\mu g/m^3$)**	**TWA[a] Concentration ($\mu g/m^3$)**
Chloroform	1.48	0.001	1.8×10^{-5}
cis-1,2-DCE	46	0.03	0.0005
PCE	194	0.13	0.0023
TCE[c]	14.3	0.01	0.00017

[a]Time Weighted Average (based on 1 hour per day and 5 months per year)

References

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B. VOC Exposures from Swimming Pools

Exposure to VOCs during swimming and their potential impact on ambient air quality was one of the community concerns expressed during public meetings. This appendix briefly describes the method for estimating the VOC flux, relevant air quality and potential health impact on a receptor.

Swimmer Exposure Assessment Model

Exposures from oral, dermal and inhalation routes were evaluated using the SWIMODEL version 3.0, the swimmer exposure assessment model (EPA 2003). The model uses well-accepted screening exposure assessment equations to calculate swimmers' total exposure expressed as a mass-based intake value (mg/event), or lifetime average daily dose (mg/kg/day). SWIMODEL focuses on potential chemical intakes only; it does not take into account metabolism or excretion of the chemical of concern. The ambient air concentration was calculated separately using ISCST3 air dispersion model and was as the input to the SWIMODEL for exposure assessment.

The exposures associated with buccal/sublingual, orbital/nasal and aural routes were not considered in this evaluation.

Oral and Dermal Route

The exposures from oral and dermal route were estimated using average chemical concentration of the pool water, default exposure factors and physical and chemical properties of contaminant of concern.

Inhalation Route: Volatilization of VOC from Swimming Pools

For volatile chemicals, the process of water-to-air exchange can be the most important mechanism of chemical removal from surface water. The overall mass transfer coefficient is a key parameter in predicting the rate of pollutant emissions from aqueous solutions. It is well established that, based on the classic thin film model, the emission rate can be estimated by (Hemond and Fechner-Levy 2000):

$$ER = K_{OL} * \left(C_{L,VOC} - \frac{C_{G,VOC}}{H} \right) * A \qquad (1)$$

where, ER is the emission rate (M/T), K_{OL} is the mass transfer coefficient (L/T), $C_{L,VOC}$ is the VOC concentration in the liquid phase (M/L^3), $C_{G,VOC}$ is the VOC concentration in the gas phase (M/L^3), H is the dimensionless Henry's constant $[(M/L^3)_{air}/(M/L^3)_{water}]$ and A is the source area for pollutant emission (L^2). The overall mass transfer coefficient K_{OL} are defined by the following equation:

$$\frac{1}{K_{OL}} = \frac{1}{k_L} + \frac{1}{Hk_G} \qquad (2)$$

where, k_L and k_G are the are the liquid and gas film mass transfer coefficients (M/L), respectively. The difference between the film mass transfer coefficient (k_L or k_G) and mass transfer coefficient (Ko_L) is that the former considers the mass transfer coefficient in a single phase (either liquid or gas) while the latter considers both phases. In other words, the mass transfer coefficient represents the combined effects of k_L or k_G and H.

Henry's constants are available in the literature for most VOCs of interest. Methods to estimate the liquid or gas film mass transfer coefficient (k_L or k_G) have been thoroughly studied in the ambient environment (oceans, lakes, rivers and waste water treatment facilities). If the dimensionless Henry's constant for a chemical is much greater than 0.01 – as is the case for a large number of VOCs, fuels, and gases – resistance to gas exchange in the stagnant air layer immediately above the water can be neglected (Hemond and Fechner-Levy 2000), i.e.,

$$\frac{1}{K_{OL}} = \frac{1}{k_L}$$

$$\text{or,} \qquad K_{OL} = k_L \qquad (3)$$

The magnitude of liquid phase mass transfer coefficient depends on the nature of mixing (i.e., turbulence) in the stagnant liquid film and characteristics of pollutant. In the case of water side control for slowly flowing water, Schwarzenbach et al. (1993) suggested the following formula:

$$k_L \text{ (cm/sec)} \approx 4 \times 10^{-4} + 4 \times 10^{-5} * U_{10}^{\,2} \qquad (4)$$

where, U_{10} is the wind speed (in m/sec) measured 10 m above the water surface. The profile close to the earth's surface may be represented by logarithmic relationship (Heinsohn and Kabel 1999):

$$U(z) = \left(\frac{U^*}{\kappa}\right) \ln \frac{z}{z_o} \qquad (5)$$

where, U(z) is wind speed at height z, κ is the von Karman constant equal to 0.4, U* is the friction velocity, and z_o is a characteristics roughness height for terrain over which air flows. Typical values of U* and z_o for various surfaces are reported in the literature (Heinsohn and Kabel 1999).

According to thin film theory, the ratio of the mass transfer coefficients of two VOCs is equal to the ratio of their molecular diffusivities in water (Geankoplis 1982); the ratio of molecular diffusivities of two VOCs in turn is approximately equal to the inverse of the ratio of the square roots of their molecular weights.

$$\frac{k_{LA}}{k_{LB}} = \frac{D_{LA}}{D_{LB}} \approx \frac{\sqrt{MW_B}}{\sqrt{MW_A}} \quad (6)$$

where, k_{wA}, D_{LA} and MW_A are the mass transfer coefficient, molecular diffusivity and molecular weight of compound A, respectively and k_{wB}, D_{LB} and MW_B are the mass transfer coefficient, molecular diffusivity and molecular weight of compound B, respectively.

Thus, the measured mass transfer coefficient of a tracer gas can be used to predict the gas exchange coefficient of another chemical. Generally, inert gases (including methane) are used as the tracer gases for estimating mass transfer coefficient from water bodies. A typical value of mass transfer coefficient for methane transfer from small water bodies has been determined to be 12 cm/hr (Hemond and Fechner-Levy 2000).

The surface renewal model also yields a mass transfer coefficient relationship that can be used to calculate VOC flux (Schwarzenbach et al. 1993). The model predicts that the ratio of mass transfer coefficients for two VOCs depends on the square root of the ratio of their molecular diffusivities (and thus approximately the fourth root of the inverse ratio of their molecular weights).

$$\frac{k_{LA}}{k_{LB}} = \sqrt{\frac{D_A}{D_B}} \approx \sqrt{\frac{\sqrt{MW_B}}{\sqrt{MW_A}}} \quad (7)$$

Aqueous Concentration of VOC in the Swimming Pool with Time: Assuming volatilization is the only loss process for the VOCs in the swimming pool and gas phase concentration of VOC is zero, the rate of change of VOC mass in the pool with time may be represented as:

$$\frac{dmass_{VOC}}{dt} = k_{L,VOC} * C_{L,VOC} * A$$

Dividing both sides by pool volume and recognizing the $\left(\frac{mass_{VOC}}{volume}\right)$ equals $C_{L,VOC}$ and $\left(\frac{A}{volume}\right)$ equals $\left(\frac{1}{depth}\right)$, the equation can be written as:

$$\frac{dC_{VOC}}{dt} = k_{L,VOC} * C_{VOC} * \left(\frac{1}{depth}\right)$$
$$= k_{L,VOC}' * C_{VOC} \quad (8)$$

where, $k_{L,VOC}' = \left(\frac{k_{L,VOC}}{depth} \right)$ which is equivalent a first order decay rate constant. Equation (8) is a first-order equation because pool VOC concentration change is proportional to the VOC concentration. In the absence of any other sources of the chemical, first-order kinetics may lead to exponential decay (i.e., first-order decay) of the VOC concentration (i.e., the concentration of the parent compound decreases exponentially with time):

$$C_{t,VOC} = C_{o,VOC} * \exp(-k_{L,VOC} * t) \qquad (9)$$

where $C_{o,VOC}$ and $C_{t,VOC}$ are the initial concentration and concentration at time t of VOC in the pool, respectively.

Using equation (1), the flux of VOC from the pool surface can be calculated. The VOC flux may be used as the input to an air dispersion model (ISCST3) to estimate the ambient air VOC concentration in the pool area.

Finally, the aqueous and ambient air VOC concentration may be used (in the SWIMOFEL) to estimate VOC exposure dose. A brief summary of contaminant dose estimation procedure is also shown in Figure VI-1.

Sample Calculation for PCE

The aqueous and ambient air concentration of groundwater contaminants were calculated using the following typical pool operating parameters (:

- Initial contaminant concentration PCE from previous year = 0;
- Pool size = 40 ft x 16 ft;
- Pool depth: Shallow end = 3 ft, Deep end = 8 ft; Mean depth = 5.5 ft.
- Weekly evaporation loss = 5% of the total pool volume;
- Replenishment rate = once per week (5% of pool volume)

Step 1: Using U* = 0.21 m/sec and z_o = 0.02 cm (Heinsohn and Kabel 1999), the wind-speed at 10 m (i.e., z = 1000 cm) above the surface may be estimated as:

$$\begin{aligned} U(z) &= \left(\frac{U^*}{\kappa} \right) \ln \frac{z}{z_o} \\ &= \left(\frac{0.21}{0.4} \right) \ln \frac{1000}{0.02} \\ &= 5.68 \text{ m/sec} \end{aligned}$$

The calculated wind speed compares well with the mean wind speed (6.6 m/sec) for year 1998 (NCDC 1998).

Step 2: Using equations (4), (6) and (7), molecular weights of methane and PCE and U_{10} calculated in Step 1, the mass transfer coefficients from the pool were calculated as shown below:

Reference	Mass Transfer Coefficient, k_L (cm/sec)
Schwarzenbach et al. (1993)	1.69×10^{-3}
Thin Film Theory	1.04×10^{-3}
Srurface Renewal Theory	1.86×10^{-3}

Since the estimated values are comparable, the mass transfer coefficient using the Schwarzenbach et al. (1993) method was used.

Step 3: Dividing the mass transfer coefficient by pool depth, the first order decay coefficient ($k_{L,VOC}$') may be estimated as:

$$k_{L,VOC}' = \left(\frac{k_{VOC}}{depth} \right)$$

$$= \left(\frac{1.69 \times 10^{-3} \frac{cm}{\sec}}{5.5\, ft * 30.48 \frac{cm}{ft}} \right) * 86400 \ \frac{\sec}{day}$$

$$= 0.87 \text{ day}^{-1}$$

The initial PCE concentration and first order rate constant was used in equation (9) to calculate the aqueous concentration of PCE in the pool water with time:

Day	Aqueous Concentration (μg/L)
0	53.40
1	22.34
2	9.35
3	3.91
4	1.64
5	0.68
6	0.29
Mean = 13.1	

Step 4: The aqueous PCE concentration in the pool water (Step 3) and mass transfer coefficient (Step 2) was used in equation (1) to estimate the flux of PCE from the pool surface:

Day	PCE Emission Flux ($gm/sec\text{-}m^2$)
0	9.03E-13
1	3.78E-13
2	1.58E-13
3	6.61E-14
4	2.77E-14
5	1.16E-14
6	4.84E-15

Step 5: The Industrial Source Complex Short Term 3 (ISCST3) model[2] was used to estimate the ambient air VOC concentrations in the Swimming Pool area. Two years of meteorological data (1991 to 1993) from Atlantic City, NJ weather station, pool dimensions and VOC flux from the swimming pool surface were used as the input to the model.

The receptors were placed within the swimming pool surface. Ambient air PCE concentrations were estimated using the maximum concentration of PCE detected in the irrigation well.

Day	Ambient Air PCE Concentration ($\mu g/m^3$)
0	6.34E-07
1	2.65E-07
2	1.11E-07
3	4.65E-08
4	1.94E-08
5	8.13E-09
6	3.40E-09
Mean = 1.55E-07	

[2]The ISCST3 model is a regulatory guideline dispersion model and is used extensively for air impact analysis. It is based on steady-state three-dimensional Gaussian plume model that can be used to assess pollutant concentrations based on a variety of conditions including emission sources, atmospheric conditions and terrain features.

Step 5: Using mean aqueous (13.09 μg/L) and ambient air concentration (1.55 $x10^{-7}$ $\mu g/m^3$), the SWIMODEL was used to calculate the exposure dose for adults; results are presented as follows:

Maximum Groundwater PCE Concentration = 1,068 μg/L					
Concentration of		**Non-cancer Exposure Dose[1] (mg/kg/day)**	**Annual Exposure dose for Cancer[2] (mg/kg/day)**	**Cancer Slope Factor**	**LECR[3]**
Pool Water (μg/L)	**Ambient Air ($\mu g/m^3$)**				
13.09	$1.55 x10^{-7}$	$4.77 x10^{-5}$	$2.04 x10^{-5}$	0.54	$1.1 x10^{-5}$
Mean Groundwater PCE Concentration = 194 μg/L					
2.38	$2.82 x10^{-8}$	$8.6 x10^{-6}$	$3.7 x10^{-6}$	0.54	$2.0 x10^{-6}$

[1]SWIMODEL results based on default exposure factors; [2]Adult exposure dose from SWIMODEL: 120 event/year for 30 years; [3]Lifetime Excess Cancer Risk

References

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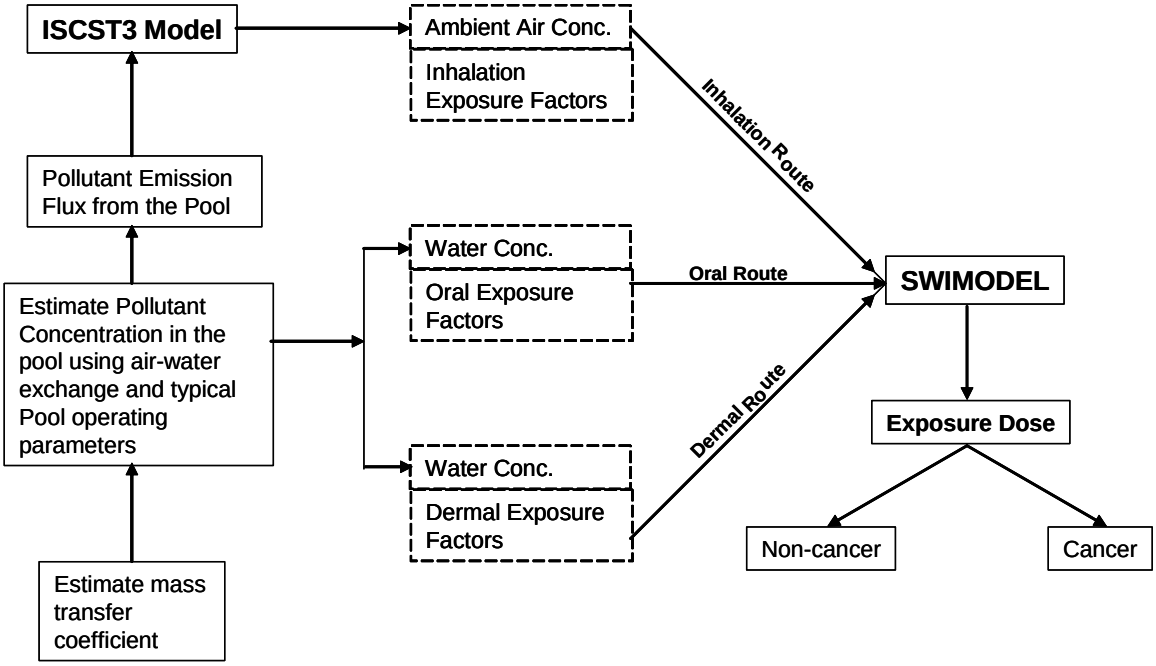

Figure VI-1: Contaminant dose estimation associated with Swimming Pool exposures