Health Consultation

Off-site Groundwater, Surface Water, and Vapor Intrusion

FLASH CLEANERS

POMPANO BEACH, BROWARD COUNTY, FLORIDA

EPA FACILITY ID: FLD83111005

Prepared by
Florida Department of Health

FEBRUARY 8, 2012

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Off-site Groundwater, Surface Water, and Vapor Intrusion

FLASH CLEANERS

POMPANO BEACH, BROWARD COUNTY, FLORIDA

EPA FACILITY ID: FLD83111005

Prepared By:

Florida Department of Health
Division of Environmental Health
Under Cooperative Agreement with
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Table of Contents

Foreword

The Florida Department of Health (DOH) evaluates the public health threat of hazardous waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry in Atlanta, Georgia. This health consultation is part of an ongoing effort to evaluate health effects associated with chlorinated solvents at Flash Cleaners hazardous waste site. The Florida DOH evaluates site-related public health issues through the following processes:

■ Evaluating exposure: Florida DOH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is on the site, and how human exposures might occur. The United States Environmental Protection Agency (US EPA) provided the majority of information for this assessment.

■ Evaluating health effects: If we find evidence that exposures to hazardous substances are occurring or might occur, Florida DOH scientists will determine whether that exposure could be harmful to human health. We focus this report on public health; that is, the health impact on the community as a whole, and base it on existing scientific information.

■ Developing recommendations: In this report, the Florida DOH outlines, in plain language, its conclusions regarding any potential health threat posed by chlorinated solvents, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of the Florida DOH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions for other agencies, including the US Environmental Protection Agency and the Florida Department of Environmental Protection. If, however, an immediate health threat exists or is imminent, Florida DOH will issue a public health advisory warning people of the danger, and will work to resolve the problem.

■ Soliciting community input: The evaluation process is interactive. The Florida DOH starts by soliciting and evaluating information from various government agencies, individuals or organizations responsible for cleaning up the site, and those living in communities near the site. We share any conclusions about the site with the groups and organizations providing the information. Once we prepare an evaluation report, the Florida DOH seeks feedback from the public.

If you have questions or comments about this report, we encourage you to contact us.

Please write to: Bureau of Environmental Public Health Medicine
Florida Department Health
4052 Bald Cypress Way, Bin # A-08
Tallahassee, FL 32399-1712
Or call us at: 850 245-4299 or toll-free in Florida: 1-877-798-2772

Summary

INTRODUCTION

At the Flash Cleaners hazardous waste site, the Florida Department of Health (DOH) and the US Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure nearby residents have the best information to safeguard their health.

The Flash Cleaners hazardous waste site is at 4131 North Federal Highway, Pompano Beach, Florida. Chlorinated solvents were detected beneath the building, in the septic tank, and in the drain field of the facility. Leaks from a dry cleaning machine and improper disposal of solvent waste have resulted in soil and groundwater contamination (primarily bromodichloromethane, tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (*cis*-1,2 DCE), *trans*-1,2-dichloroethene (*trans*-1,2 DCE), and vinyl chloride (VC). The contamination is significant below the dry cleaning facility and has spread beneath nearby commercial buildings, under the nearby residential neighborhood and to a nearby canal. Nearby residents use municipal water but some have irrigation wells.

The Florida DOH produced an earlier report primarily concerning on-site groundwater data for Flash Cleaners on March 17, 2009.

CONCLUSION #1

Breathing indoor air in the on-site building and the building to the south is not likely to harm people's health.

BASIS FOR DECISION #1

The estimated maximum dose of contaminants from exposure by breathing indoor air in the on-site building and the building directly to the south are below levels expected to cause non-cancer illness and would not pose a significant theoretical increased cancer risk to long-term employees in those buildings.

CONCLUSION #2

Incidental ingestion of, and dermal contact with, contaminants in the water, and inhalation of contaminant vapors from future irrigation wells installed in contaminated groundwater near the site is not likely to harm people's health.

BASIS FOR DECISION #2	The estimated maximum dose of contaminants from exposure to future irrigation wells installed in the areas of highest contamination, are below levels expected to cause non-cancer illness and would not pose a significant theoretical increased cancer risk to residents using those wells.
CONCLUSION #3	Exposure to contaminants through incidental ingestion, dermal contact, and absorption through eyes, mouth, nose, and ears while swimming or boating in the North Grand Canal is not likely to cause harm.
BASIS FOR DECISION #3	Based on site observations, swimming in the canal likely occurs on an infrequent basis. The highest detected contaminant concentrations in the canal are below levels expected to cause non-cancer illness and would not pose a significant theoretical increased cancer risk for regular long-time swimmers.
CONCLUSION #4	Incidental ingestion of on-site soils, local fish consumption, drinking from nearby private wells, showering with water from nearby private wells, and vapor intrusion at nearby off-site residential buildings are considered eliminated exposure pathways
BASIS FOR DECISION #4	Levels of site related contaminants associated with these pathways are either below detection limits, below health based comparison values, or below levels that significantly increase the theoretical cancer risk.
FOR MORE INFORMATION	If you have concerns about your health or the health of your children, you should contact your health care provider. You may also call the Florida DOH toll-free at 877-798-2772 and ask for information about the Flash Cleaners hazardous waste site.

Background and Statement of Issues

The purpose of this health consultation report is to use data collected in 2009 and 2010 to assess the public health threat from toxic chemicals in groundwater, surface water, soil, and air associated with the Flash Cleaners Site (FCS). The US Environmental Protection Agency (EPA) requested this assessment. EPA added the FCS to the National Priorities List (NPL) in September 2008. ATSDR published a Health Consultation report on March 17, 2009 covering data collected before 2009 [ATSDR 2009].

The FCS is at 4131 North Federal Highway Pompano Beach, Florida (Figure 1). The FCS is in a densely populated setting adjacent to a busy street and access is unrestricted. Land use surrounding the property is predominately commercial and residential with notable growth within the past 20 years. A school is approximately 1,500 feet southwest of the property and several residential areas are nearby, including one residential area adjacent to the western side of the property. An auto repair and tire business (Banner Tire & Car Care) is to the north and a mattress store (Mattress Comfort Factory Store) is to the south. U.S. 1/ North Federal Highway is to the east of the property (Figure 2).

FCS was a dry cleaning operation between 1977 and 2001. Prior to 1977, the operational history could not be determined. In 2001, the owners of the facility ceased using dry cleaning chemicals but continued to operate as a retail dry cleaning drop off location. Tetrachloroethylene (also known as perchloroethylene or PCE) was the primary cleaning agent used. Past investigations found PCE and its breakdown products, TCE, 1,1-DCE, *cis*-1,2 DCE, *trans*-1,2 DCE, and VC, in groundwater beneath the site above state cleanup goals.

About 220,000 people reside within a 4-mile radius of the site [EPA 2008b]. Four municipal water systems in this area draw from the surficial Biscayne Aquifer. The nearest municipal well field is approximately 0.8 miles northeast of the site. In addition, canals and the Hillsboro River are nearby (Figure 1) [Weston 2005].

Surface water drainage from the site flows toward the North Grand Canal, a residential saltwater canal approximately 1,500 feet east of the site (Figure 1). This canal enters the Hillsboro River, which connects to the Atlantic Ocean through the Hillsboro Inlet. Residents and visitors use the canals in the area and the Hillsboro River for boating and recreational fishing.

The City of Pompano Beach provides drinking water to residential, commercial, and industrial customers near this site and throughout the city. The principle source of municipal water is the sole-source Biscayne aquifer system.

The Biscayne aquifer is composed of limestone, sandstone and sand; however, in Broward County, the aquifer is primarily composed of sand [Weston 2005]. Because the Biscayne aquifer is near land surface, it is susceptible to contamination. Pollutants enter the aquifer by direct infiltration from land surface canals, septic tanks, drain fields,

drainage wells, and solid waste dumps. Most pollutants that enter the aquifer are concentrated in the upper 20 to 30 feet. The ultimate fate of pollutants in this aquifer is the ocean, although some adsorb to the aquifer materials and some are diverted to pumping wells [Klein and Hull 1978]. Groundwater generally flows east toward the coast [PBS&J 2004].

In March 2009, FDOH and ATSDR published a health consultation for Flash Cleaners. Health assessors for this report were limited to evaluating only on-site data. FDOH reported detections of chemicals of concern above ATSDR comparison values in both the subsurface soil and on-site groundwater. FDOH could not fully evaluate the potential pathways of exposure, because critical information was not available [ATSDR 2009].

Between March and November 2009, consultants for EPA sampled five irrigation wells in the neighborhood around the site and analyzed for volatile organic compounds (VOCs). They found carbon disulfide, methyl *tert*-butyl ether, *cis*-1,2-dichloroethene (*cis*-1,2 DCE), and *trans*-1,2-dichloroethene (*trans*-1,2 DCE) below ATSDR screening guidelines for drinking water [Waller 2010].

Health scientists look at what chemicals are present and in what amounts. They compare those amounts to national and state health-based guidelines. These guidelines are set far below known or suspected levels associated with health effects. Florida DOH uses guidelines developed to protect children. If chemicals are not present at levels high enough to harm children, they would not likely harm adults.

This assessment considers health concerns of nearby residents and explores possible associations with site-related contaminants. This assessment requires the use of assumptions, judgments, and incomplete data. These factors contribute to uncertainty in evaluating the health threat. Assumptions and judgments in this assessment err on the side of protecting public health and may overestimate the risk.

This assessment estimates the health risk for individuals exposed to the highest measured level of contamination. This assessment, however, does not apply equally to all nearby residents and employees. Not all nearby residents and employees are exposed to the highest measured level of contamination. The health risk for most nearby residents and employees is less than the health risk estimated in this report. For those residents and employees whose soil, wells, etc. are not contaminated and are not exposed, the health risk is essentially zero.

Site Description

The 0.5-acre Flash Cleaners Site (FCS) is at 4131 North Federal Highway, Pompano Beach, Broward County, Florida 33064 (Figure 1). Land use surrounding the property is predominately commercial and residential with notable growth within the past 20 years. A school is approximately 1,500 feet southwest of the property and several residential areas are nearby, including one residential area adjacent to the western side of the

property. Banner Tire & Car Care currently occupies the building north of the FCS. Mattress Comfort Factory Store currently occupies the building south of the FCS. U.S. 1/ North Federal Highway is to the east of the property (Figure 2).

On January 5, 2011, the Florida DOH staff visited the site. They observed that site access was unrestricted. A wooden fence separates the residential neighborhood from the commercial buildings (including Flash Cleaners). The fence is damaged and missing planks in areas. Much of the site is paved with patches of grass and landscaping. It did not appear that children had been playing in the sand and grassy areas of the site. There did not appear to be any traffic driving through the site except customers of Flash Cleaners. Buildings above the plume of contaminated groundwater, east and northeast of the FCS, consisted primarily of residential condominiums and apartments with some single family homes and a few commercial businesses along U.S. 1/North Federal Highway. The North Grand Canal did not appear to be used for swimming, but primarily recreational boating and fishing.

Demographics

Approximately 15,800 people live within one mile of the site. Seventy-two percent (72%) are white, 7% are African-American, 13% are Hispanic origin, and 8% are other. Seventy-nine percent (79%) are 18 years old or older and 21% are younger than 18. Fifty two percent (52%) have a high school diploma or less and 48% have at least two years of college. Seventy-five percent (75%) speak only English and 59% make less than $50,000 a year [EPA 2010a].

Land Use

Land use to the north and south of the FCS is commercial. To the west is a residential neighborhood and a city park about 400 feet to the northwest. The site is bordered to the east by U.S. 1/North Federal Highway and mixed commercial and residential east of the highway. The North Grand Canal is approximately 0.25 miles to the northeast and east of the FCS.

Community Health Concerns

Florida DOH reviewed previous contamination assessment reports, conducted community meetings, and spoke with county, state, and federal environmental officials but is unaware of any community health concerns. About 19 residents participated in community meetings, but did not express any health concerns. Florida DOH released the report for public comment from September 20, to November 21, 2011. Florida DOH did not receive any health concerns or actionable comments during that time.

Discussion

Pathway Analyses

Chemical contamination in the environment can harm your health but only if you have contact with those contaminants (exposure). Without contact or exposure, there is no harm to health. If there is contact or exposure, how much of the contaminants you contact (concentration), how often you contact them (frequency), for how long you contact them (duration), and the danger of the contaminant (toxicity) all determine the risk of harm.

Knowing or estimating the frequency with which people could have contact with hazardous substances is essential to assessing the public health importance of these contaminants. To decide if people can contact contaminants at or near a site, Florida DOH looks at human exposure pathways. Exposure pathways have five parts. They are:

1. a source of contamination like a hazardous waste site,
2. an environmental medium like air, water, or soil that can hold or move the contamination,
3. a point where people come into contact with a contaminated medium like water at the tap or soil in the yard,
4. an exposure route like ingesting (contaminated soil or water) or breathing (contaminated air),
5. a population who could be exposed to contamination like nearby residents.

Florida DOH eliminates an exposure pathway if at least one of the five parts referenced above is missing and will not occur in the future. Exposure pathways not eliminated are either completed or potential. For completed pathways, all five pathway parts exist and exposure to a contaminant has occurred, is occurring, or will occur. For potential pathways, at least one of the five parts is missing, but could exist. Also for potential pathways, exposure to a contaminant could have occurred, could be occurring, or could occur in the future.

Completed Exposure Pathways:

For this assessment, we evaluated the long-term health threat from three complete exposure pathways: vapor intrusion from contaminated soil/groundwater, swimming in the North Grand Canal, and use of nearby irrigation wells (Table 1).

For the completed vapor intrusion pathway, the FCS is the source. Chlorinated solvents and their breakdown products move vertically down to the groundwater table, where they are transported by groundwater horizontally. Some of the groundwater contaminants may evaporate as vapors (the environmental medium) and travel up underneath, and possibly into, buildings, making indoor air the point of exposure. Breathing the air inside these buildings is the exposure route. Consultants for EPA collected indoor air samples from

the dry cleaning facility and the building directly to the south of the FCS. Consultants for EPA also sampled air beneath the slabs of residential buildings to the east and northeast of the FCS. Workers at Flash Cleaners and in the commercial buildings near the site may be exposed to vapors while in the building (Table 1).

In this assessment we also evaluate the long-term health threat from dermal contact with and incidental ingestion (swallowing) of water from the canal while swimming in the North Grand Canal. Although it appears that swimming is limited, we use this as the worst case scenario for exposure to contaminants in the canal. For this completed pathway, the FCS is the source. Small amounts of chlorinated solvent and its breakdown products are carried by contaminated groundwater that flows into the canal, making it the environmental medium. The North Grand Canal and nearby canal branches are the exposure points. Absorption of contaminants through the skin and incidental ingestion, accidentally swallowing small amounts of water while swimming are the exposure routes. The number of people swimming in the canal is limited due to the steep sides and the availability of swimming pools and the nearby Atlantic Ocean (Table 1).

In this assessment we also evaluate the long-term health threat from incidental ingestion of contaminated water and inhalation (breathing) of vapors created while irrigating landscaping with water from contaminated irrigation wells. For this completed pathway the FCS is the source. Chlorinated solvents and their breakdown products have contaminated groundwater beneath the mixed commercial and residential area east and northeast of the FCS and west of the North Grand Canal. Water and vapors from existing and potential irrigation wells installed in the contaminated groundwater are the environmental medium. Landscape areas watered by the irrigation wells are the exposure points. Incidental ingestion of the water and breathing vapors when irrigating systems are operating are the exposure routes. Children may be exposed while playing in water sprinklers, and adults may be exposed while gardening or working in the yard (Table 1).

Eliminated Exposure Pathways:

DOH concludes that incidental ingestion (swallowing) of on-site surface soil, fish consumption, nearby private drinking water wells, and vapor intrusion in nearby homes or apartments are eliminated exposure pathways (Table 2).

None of the14 on-site surface (0-12 inches) soil samples exceeded ATSDR screening guidelines and there is no evidence of incidental ingestion (swallowing) of the soil on the site [Weston 2005, Waller 2010]. The site is covered with asphalt and a commercial building with few grassy areas. No one is being exposed to subsurface soil. Therefore, Florida DOH does not consider soil at the FCS to be a public health concern.

Consumption of fish from the North Grand Canal is an eliminated exposure pathway. Although fish were not sampled during site investigations, chlorinated solvents and their breakdown products do not accumulate significantly in fish [ATSDR 1997].

Drinking and showering with water from private wells is an eliminated exposure pathway. There are no known private drinking water wells near the FCS. Residents in this area get their drinking water from the municipal supply.

Off-site residential vapor intrusion from contaminated groundwater is an eliminated pathway. No contaminants were detected in any of the 15 air samples collected from beneath the slabs of residences above shallow contaminated groundwater [Waller 2010].

Environmental Data

Between 2000 and 2005, the Florida Department of Environmental Protection (FDEP), the EPA, and consultants for the property owners conducted on-site environmental assessments. Florida DOH evaluated these data in a 2009 report [ATSDR 2009]. From November 2009 to April 2010, J.M. Waller Associates Inc conducted a comprehensive Remedial Investigation (RI) of both on- and off-site contamination on behalf of the EPA. Florida DOH bases this health consultation on the 2009/2010 data.

Groundwater

In a previous report, Florida DOH evaluated on-site groundwater testing prior to 2009 [ATSDR 2009]. In 2009 and 2010, consultants for EPA collected 37 groundwater samples from 18 on-site locations and 175 groundwater samples from 44 off-site locations [Waller 2010]. They found contaminants, including benzene, bromodichloromethane, PCE and its breakdown products (1,1-DCE, *cis*-1,2 DCE, *trans*-1,2 DCE, TCE, and vinyl chloride) above screening guidelines in some off-site monitoring wells, east and northeast of the FCS (Table 3)[Waller 2010]. Figure 3 shows the general shape of the plume [Waller 2010]. Wells and direct push points on the edge of the plume in Figure 3 represent points where groundwater samples were below groundwater concentration target levels. Figure 3 does not show the additional sample locations outside of the plume that are below detection limits or state groundwater standards.

Florida DOH considers the extent of the groundwater contamination to be adequately determined. The contaminated groundwater plume extends outward from the site primarily in a northeasterly direction (Figure 3). The plume is bounded to the east slightly past NE 22nd Ave and to the north by the North Grand Canal [Waller 2010].

In June 2011 the EPA began groundwater treatment activities. Groundwater treatment includes the in-situ injection of emulsified oil into multiple injection wells on the Flash Cleaners property and on the median and east side of Federal Highway. After the initial groundwater injection, EPA will continue to conduct periodic groundwater monitoring. Groundwater monitoring will include analysis of groundwater samples from 20 monitoring wells for chlorinated VOCs, groundwater geochemistry, and select analytes to evaluate the potential of natural attenuation of chlorinated VOCs [EPA 2010d].

Surface Water

In November 2009 and April 2010, consultants for the EPA collected nine surface water samples from the North Grand Canal (Figure 3). *Cis*-1,2-DCE and vinyl chloride (VC) were the only contaminants detected. *Cis*-1,2-DCE was detected below ATSDR screening guidelines. Two of the samples had detections of VC above the screening guidelines, with a maximum concentration of 0.29 micrograms per liter (µg/L) (Table 4). This concentration was reported as an estimated value by the laboratory [Waller 2010].

Because a treatment system is being installed and active drycleaning has ceased, contaminant levels should decrease with time. Florida DOH considers the extent of the surface water contamination to be adequately determined.

Soil Vapor

Contaminated groundwater is closest to ground surface at the site and along the North Grand Canal. The contaminated groundwater appears to sink a short distance from the site and as it gets close to the North Grand Canal appears to rise again near the surface.

In 2009 and 2010, contractors for the EPA conducted sub-slab and near-slab soil vapor sampling in three areas; beneath the Flash Cleaners building, beneath condominiums east of the site, and beneath single family homes along the North Grand Canal. Soil vapor was analyzed for VOCs. There were no detections beneath the condominiums or single family homes. *Cis*-1,2-DCE, PCE, and TCE were detected beneath the slab of the Flash Cleaners facility. PCE was detected (330 $\mu g/m^3$) above the screening guideline (300 $\mu g/m^3$) in one of the four samples (Table 5).

During March and April 2011 the EPA conducted soil remediation activities. Soil remediation included digging up contaminated soils around the dry cleaner building and installing a soil vapor extraction (SVE) system to treat soils beneath the building. The SVE system will continuously remove contaminated soil vapors beneath the Flash Cleaners building, thus minimizing the potential for on-site vapor intrusion.

Because a groundwater treatment system is being installed, a soil vapor extraction system has already been installed, and active drycleaning has ceased, contaminant levels should decrease with time. Florida DOH considers the extent of the soil vapor intrusion to be adequately determined.

Indoor Air

In April 2010, contractors for the EPA collected 8-hour composite VOC ambient air samples inside the Flash Cleaners building and the building directly south of the site. Samples were collected after business hours, with windows and doors shut. They detected benzene, ethyl benzene, toluene, PCE, TCE, *cis*-1,2-DCE, and xylenes in the indoor air. Only benzene, which is not associated with dry cleaning operations, was detected above the ATSDR screening guidelines. The maximum indoor air concentration of benzene was

0.35 µg/m^3. Benzene, which was not detected in the soil vapor, was detected in the outdoor background air sample at 0.32 µg/m^3, approximately the same concentration as the indoor samples. FDEP and their consultants did not detect contaminants in soil vapor in off-site areas with shallow groundwater contamination. It is likely that benzene measured inside the building is from outdoor ambient air and not directly related to the Flash Cleaners site. Thus, there was no need to sample off-site indoor air.

Florida DOH considers the extent of the indoor air contamination to be adequately determined.

Identifying Contaminants of Concern

Florida DOH compares the maximum concentrations of contaminants found at a site to ATSDR and other comparison values. Comparison values are specific for the medium contaminated (soil, water, air, etc.). We screen the environmental data using these comparison values:

- ATSDR Environmental Media Evaluation Guides (EMEGs)
- ATSDR Reference Media Evaluation Guides (RMEGs)
- Florida DEP Soil Cleanup Target Levels (SCTLs)
- EPA Maximum Contaminant Levels (MCLs)
- Other guidelines

When determining which comparison value to use, Florida DOH follows ATSDR's general hierarchy. To error on the side of human health, Florida DOH chooses the lowest comparison value within the general hierarchy in which data is available.

We select for further evaluation contaminants with maximum concentrations above a comparison value. Comparison values, however, are not thresholds of toxicity. They are not used to predict health effects or establish clean-up levels. A concentration above a comparison value does not necessarily mean harm will occur. It does, however, indicate the need for further evaluation.

Maximum contaminant concentrations below comparison values are safe because they do not pose a significant risk of adverse health effects and are not evaluated further.

Comparing the highest measured concentrations in soil, air, and groundwater to ATSDR and EPA screening guidelines, Florida DOH selected benzene, PCE, TCE, 1,1-DCE, *cis*-1,2 DCE, *trans*-1,2 DCE, VC, and bromodichloromethane as contaminants of concern. Selection of these contaminants does not necessarily mean they pose a public health risk. Rather, Florida DOH selected these contaminants for closer scrutiny. Concentrations of other contaminants were below screening guidelines, are not likely to cause illness, and are not evaluated further.

Public Health Implications

Methods and Assumptions

Florida DOH provides site-specific public health recommendations on the basis of toxicological literature, levels of environmental contaminants, evaluation of potential exposure pathways, duration of exposure, and characteristics of the exposed population. Whether a person will be harmed depends on the type and amount of each contaminant, how they are exposed, how long they are exposed, how much contaminant is absorbed, genetics, and individual lifestyles.

After identifying contaminants of concern, Florida DOH evaluates exposures by estimating daily doses for children and adults. Karmin [1988] explains the concept of dose as follows:

> "…all chemicals, no matter what their characteristics, are toxic in large enough quantities. Thus, the amount of a chemical a person is exposed to is crucial in deciding the extent of toxicity that will occur. In attempting to place an exact number on the amount of a particular compound that is harmful, scientists recognize they must consider the size of an organism. It is unlikely, for example, that the same amount of a particular chemical that will cause toxic effects in a 1-pound rat will also cause toxicity in a 1-ton elephant.
>
> Thus instead of using the amount that is administered or to which an organism is exposed, it is more realistic to use the amount per weight of the organism. Thus, 1 ounce administered to a 1-pound rat is equivalent to 2,000 ounces to a 2,000-pound (1-ton) elephant. In each case, the amount per weight is the same; 1 ounce for each pound of animal."

This amount per weight is the *dose*. Toxicology uses dose to compare toxicity of different chemicals in different animals. We use the units of milligrams (mg) of contaminant per kilogram (kg) of body weight per day (mg/kg/day) to express doses in this assessment. A milligram is 1/1,000 of a gram; a kilogram is approximately 2 pounds.

To calculate the daily doses of each contaminant, Florida DOH uses standard and other factors needed for dose calculation [ATSDR 2005; EPA 1997]. We assume that people are exposed daily to the maximum concentration measured. We also make the health protective assumption that 100% of the ingested chemical is absorbed into the body. The percent actually absorbed into the body is likely less. The general formula for estimating a dose is:

Dose = (concentration X ingestion rate) / body weight

ATSDR groups health effects by duration (length) of exposure. Acute exposures are those with duration of 14 days or less; intermediate exposures are those with duration of 15 – 364 days; and chronic exposures are those that occur for 365 days or more (or an

equivalent period for animal exposures). ATSDR Toxicological Profiles also provide information on the environmental transport and regulatory status of contaminants.

To estimate exposure from contaminated water, Florida DOH uses the following standard assumptions:

1) children ingest about 1 liter of water per day and adults ingest about 2 liters of water per day from all sources including tap water, drinks prepared with tap water, purchased drinks, and water intrinsic to purchased foods,
2) children weigh an average of 10 kilograms (kg) or about 22 pounds,
3) adults weigh an average of 70 kg, or about 155 pounds,
4) children and adults ingest (swallow) contaminated water at the maximum concentration measured for each contaminant,
5) while swimming children take water in and out of their mouth at a rate of 5.27 liters per hour [Dang 1996],
6) while swimming adults take water in and out of their mouth at a rate of 2.5 liters per hour [Dang 1996],
7) the rate of incidental ingestion while swimming for children is 0.05 liters per hour [EPA 2003],
8) the rate of incidental ingestion while swimming for adults is 0.025 liters per hour [EPA 2003],
9) an area of 1.04 m^2 is used as the total body surface area of a child's skin,
10) an area of 1.94 m^2 is used as the total body surface area of an adult's skin.

Florida DOH uses the EPA's SWIMODEL swimming screening tool Version 3.0 to calculate the exposure doses for adults and children swimming in the North Grand Canal. The SWIMODEL combines exposure calculations for incidental ingestion, dermal contact, buccal/sublingual route (absorption while water is temporarily in the mouth), orbital/nasal route (absorption through the eyes and nose), and aural (absorption through the ears).

We compare estimated exposure doses to ATSDR chemical-specific minimal risk levels (MRLs). MRLs are values that establish exposure levels many times lower than levels where no effects were observed in animals or human studies. The MRL is designed to protect the most sensitive, vulnerable individuals in a population. The MRL is an exposure level below which non-cancerous harmful effects are unlikely, even after daily exposure over a lifetime. Although we consider concentrations at or below the relevant MRL not likely to harm people's health, exceeding a MRL does not imply that we expect adverse health effects. If contaminant concentrations are above MRLs, we further analyze exposure variables (for example, duration and frequency), toxicology of the contaminants, epidemiology studies, and the weight of evidence for health effects. We use chronic MRLs where possible because exposures are usually longer than a year. If chronic MRLs are not available we use intermediate (longer than 2 weeks but less than a year) length MRLs [ATSDR 2005].

For cancer, we quantify the increased theoretical risk by multiplying the estimated dose by the EPA cancer potency slope factor. This is a conservative (high) estimated increased cancer risk. The actual increased cancer risk is likely lower. Because of large uncertainties in the way scientists estimate cancer risks, the actual cancer risk may be as low as zero. If there is no cancer slope (potency) factor for a particular chemical of concern, we can not quantify the risk.

We usually estimate the cancer risk from lifetime (70 year) exposure. Or we may estimate the cancer risk from exposure over a significant portion of the lifetime (at least 35 years). Studies of animals exposed over their entire lifetime are the basis for calculating most cancer slope factors. Usually, little is known about the cancer risk in animals from less than lifetime exposures. Therefore, it is more appropriate to estimate the cancer risk in people from lifetime exposure. Florida DOH considers it generally not appropriate to estimate the cancer risk for children, or from less than 35 years exposure.

Mixtures

Because people are often exposed to several chemicals at the same time, health scientists are often asked to evaluate exposure to a mixture of chemicals. There is evidence of additive toxicity from exposure to certain chemical mixtures when the individual chemicals are administered at doses that are near the individual toxic thresholds. Due to the low estimated contaminant doses (individual contaminant doses were below one tenth of the no-observed-adverse-effect level (NOAEL)) at this site, it is highly unlikely that significant additive or toxic interactions would occur at this site (Table 6). Therefore, this report assesses the health threat based on exposure to individual contaminants.

Exposure Factors

The cancer risk evaluation for indoor air is based on employees of the Flash Cleaners facility and adjacent building to the south, working 8 hour days, 5 days/week for 50 weeks (250 days) a year for 35 years, resulting in a unit-less exposure factor of 0.114.

The estimated maximum dose while swimming in the North Grand Canal was calculated based on a child or adult swimming 181 minutes/month. The swimming time per month was based on EPA's exposure factor recommendations (the 95^{th} percentile) [EPA 2009]. The actual amount of swimming in the canal is probably much less.

Incidental ingestion (swallowing), inhalation (breathing vapors), and dermal absorption (skin contact) are three possible exposure pathways from use of contaminated irrigation well water. In order to determine the risk of illness from use of irrigation wells, Florida DOH used an exposure model developed by toxicologists at the University of Florida [Roberts 2008]. This model uses conservative assumptions that are protective of the most sensitive individuals: children and the elderly. The model calculates exposure for non-potable (non-drinking) uses of contaminated irrigation well water. The model considers

the potential intake of contaminants in groundwater through inhalation, dermal contact, and incidental ingestion. The model also considers exposures resulting from eating fruits and vegetables grown with water from these wells. Inhalation rates for children and adults were combined with exposure frequency, exposure duration, and air concentration values to estimate inhalation exposures [Roberts 2008]. When using the irrigation model, no additional exposure factors are used to calculate a dose. The risk of cancer and non-cancer illness associated with the levels of chemicals potentially found in irrigation wells was calculated (Table 9).

To estimate exposure from contaminated irrigation wells, the University of Florida model uses a residential aggregate composed of an average for children and adults instead of making separate calculations for either. The following are standard assumptions used:

1) the residential aggregate for a person's weight is of 51.9 kilograms (kg) or about 114 pounds,
2) the residential aggregate for a person's surface area is 15,158 square centimeters (cm^2),
3) the residential aggregate for a person's inhalation rate is 1.04 cubic meters per hour (m^3/h),
4) the residential aggregate for a person's rate of eating irrigated vegetables is 0.298 kg per day (kg/d),
5) the residential aggregate for a person's incidental water ingestion rate is 0.01 liters per day (L/d),
6) the irrigation exposure frequency is 52 days per year (d/y),
7) the irrigation time per exposure is 0.483 hours per day (h/d),
8) the maximum detected contaminate levels are used.

Since the Flash Cleaners dry cleaning facility has been open for approximately 33 years, and the EPA recommends a minimum of 35 years when calculating cancer risk, an exposure factor of 0.5 (35 years/ 70 years) is used when calculating cancer risk for surface-water and irrigation wells.

Contaminants of Concern (On-Site)

Benzene

Non-cancer illness - Benzene was detected in the air of the on-site building and adjacent building to the south above the ATSDR screening guideline (Table 7). Adults working in the on-site building or the adjacent building to the south would be subject to breathing small amounts of benzene. Nearby automotive traffic may be the source since benzene is a component of gasoline and the outdoor air concentration of benzene was similar to the indoor air concentration. The maximum benzene concentration (0.35 $\mu g/m^3$) is less than the ATSDR chronic inhalation MRL of 10 $\mu g/m^3$ and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - Benzene is a known human carcinogen. For calculating the theoretical cancer risk of workers breathing indoor air contaminated with benzene, the maximum concentration is multiplied by the exposure factor and the EPA inhalation cancer unit risk factor (0.35 $\mu g/m^3$ × 0.114 × 7.8×10^{-6} per $\mu g/m^3$ = 3×10^{-7}) [ATSDR 2010b]. Florida DOH interprets this as no increased theoretical cancer risk.

cis-1,2-Dichloroethene (cis-1,2-DCE)

Non-cancer illness – Not enough is known about *cis*-1,2 DCE in order to calculate non-cancer inhalation health risk.

Cancer - EPA has not classified *cis*-1,2 DCE as to human carcinogenicity. Therefore, it is not possible to calculate a theoretical increased cancer risk [ATSDR 1996].

Tetrachloroethylene (Perchloroethylene or PCE)

Non-cancer illness - Workers in the on-site building and adjacent building are not likely to suffer any non-cancer illnesses. The maximum PCE concentration in indoor air (51 $\mu g/m^3$) is less than the ATSDR chronic inhalation MRL of 300 $\mu g/m^3$ [ATSDR 2010a] and thus is not likely to cause any non-cancer illnesses (Table 7).

Cancer - The EPA has proposed the range of cancer inhalation unit risk factors 2×10^{-6} to 2×10^{-5} per $\mu g/m^3$ [EPA 2008a]. To calculate the theoretical risk of cancer from inhalation of air inside the on-site building, the maximum air concentration of PCE is multiplied by the exposure factor and then the range of inhalation unit risk factors (51 $\mu g/m^3$ × 0.114 × 2×10^{-6} to 2×10^{-5} $\mu g/m^3$ = 1×10^{-5} to 1×10^{-4}). This is interpreted as an increased theoretical risk of 1 to 10 people in every 100,000 people or a very low to low increased risk of cancer.

Trichloroethylene (TCE)

Non-cancer illness - Workers in the on-site building and adjacent building exposed to the maximum detected concentrations of TCE in air are not likely to suffer any non-cancer illnesses. The maximum TCE concentration in indoor air (2.5 $\mu g/m^3$) is less than the ATSDR intermediate inhalation MRL of 500 $\mu g/m^3$ [ATSDR 2010a] and thus is not likely to cause any non-cancer illnesses (Table 7). The intermediate inhalation MRL was used because a chronic MRL value has not been calculated.

Cancer - In a draft report on the health risk assessment of TCE, EPA proposed the range of cancer inhalation slope factors to be 5.7×10^{-6} to 1.1×10^{-4} risk per $\mu g/m^3$ [EPA 2001]. To calculate the theoretical risk of cancer from the inhalation of air in the Flash Cleaners facility the maximum concentration of TCE is multiplied by the exposure factor and then the EPA highest inhalation slope factor (2.5 $\mu g/m^3$ × 0.114 × 5.7×10^{-6} to 1.1×10^{-4} $\mu g/m^3$ = 2×10^{-6} to 3×10^{-5}). Florida DOH interprets this as an increased risk of 2 to 30 people among every 1,000,000 people or an extremely low to very low increased risk of cancer.

Contaminants of Concern (Off-Site)

Benzene

Non-cancer illness - Residents exposed to irrigation well water with the maximum concentration of benzene are not likely to suffer any non-cancer illnesses (Table 8). The maximum benzene dose for residents using irrigation wells (1.1×10^{-5} mg/kg/day) is less than the ATSDR chronic oral MRL of 5×10^{-4} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - The EPA has calculated a range for the cancer oral slope factors to be 0.015 to 0.055 per mg/kg/day. For calculating cancer risk from exposure to contaminated irrigation wells we use the oral slope factor since the irrigation well exposure model estimates a dose. The dose is multiplied by the exposure factor then the EPA oral slope factor in order to calculate the theoretical risk of cancer from using irrigation wells with benzene at 260 µg/L (1.1×10^{-5} (mg/kg/day) × 0.5 × 0.015 to 0.055 $(mg/kg/day)^{-1} = 8\times10^{-8}$ to 3×10^{-7}) [ATSDR 2010b]. Florida DOH interprets this as no increased cancer risk.

Bromodichloromethane

Non-cancer illness - Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of bromodichloromethane are not likely to suffer any non-cancer illnesses (Table 8). The maximum bromodichloromethane dose for residents using these irrigation wells (2.9×10^{-8} mg/kg/day) is less than the ATSDR chronic oral MRL of 2×10^{-2} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - Bromodichloromethane is reasonably anticipated to be a human carcinogen and EPA has calculated the oral slope factor to be 0.062 $(mg/kg/day)^{-1}$ [ATSDR 1989]. The exposure dose is multiplied by the exposure factor then the EPA oral slope factor in order to calculate the theoretical risk of cancer from incidental ingestion and inhalation while using irrigation wells with bromodichloromethane at 0.95 µg/L (2.9×10^{-8} (mg/kg/day) × 0.5 × 0.062 $(mg/kg/day)^{-1} = 9\times10^{-10}$). Florida DOH interprets this as no increased cancer risk.

1,1-Dichloroethylene (1,1-DCE)

Non-cancer illness - Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of 1,1-DCE are not likely to suffer any non-cancer illnesses (Table 8). 1,1-DCE was detected above screening guidelines in only one of 175 samples and was not detected in surface water, soil, or soil vapor. The maximum 1,1-DCE dose for residents using these irrigation wells (9.4×10^{-5} mg/kg/day) is less than the ATSDR chronic oral MRL of 9×10^{-3} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - There is suggestive evidence of carcinogenicity for 1,1-DCE but not enough information is available to calculate a theoretical increased cancer risk [ATSDR 1994].

cis-1,2-Dichloroethene (cis-1,2-DCE)

Non-cancer illness - Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of *cis*-1,2 DCE or swimming in the North Grand Canal are not likely to suffer any non-cancer illnesses (Tables 8 & 9). The maximum *cis*-1,2 DCE dose for children swimming in the canal (6.7×10^{-7} mg/kg/day) or residents using contaminated irrigation wells (1.8×10^{-3} mg/kg/day) are less than the EPA reference dose (RfD) for chronic oral exposure of 2×10^{-3} mg/kg/day and thus is not likely to cause any non-cancer illnesses [EPA 2010b].

Cancer - EPA has not classified *cis*-1,2 DCE as to human carcinogenicity. Therefore, it is not possible to calculate a theoretical increased cancer risk [ATSDR 1996].

trans-1,2-Dichloroethene (trans-1,2-DCE)

Non-cancer illness - Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of *trans*-1,2 DCE are not likely to suffer any non-cancer illnesses (Table 8). The maximum *trans*-1,2 DCE dose for residents using these irrigation wells (2.6×10^{-4} mg/kg/day) is less than the EPA RfD for chronic oral exposure of 2×10^{-2} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - EPA has not classified *trans*-1,2 DCE as to human carcinogenicity. Therefore, it is not possible to calculate a theoretical increased cancer risk [ATSDR 1996].

Tetrachloroethylene (Perchloroethylene or PCE)

Non-cancer illness - Residents exposed to irrigation well water with the maximum concentrations of PCE are not likely to suffer any non-cancer illnesses (Table 8). The maximum PCE dose for residents using these irrigation wells (1.6×10^{-3} mg/kg/day) is less than the EPA chronic oral RfD of 1×10^{-2} mg/kg/day and thus is not likely to cause any non-cancer illnesses [EPA 1988].

Cancer - In a draft report on the health risk assessment of PCE, EPA proposed the range of cancer oral slope factors to be 0.01 to 0.1 per mg/kg/day [EPA 2008a]. To calculate the theoretical risk of cancer from incidental ingestion and inhalation while using irrigation wells with PCE at 27,000 µg/L, the non-cancer exposure dose is multiplied by the exposure factor and then the EPA highest oral slope factor (1.6×10^{-3} (mg/kg/day) × 0.5 × 0.01 to 0.1 $(mg/kg/day)^{-1} = 8\times10^{-6}$ to 8×10^{-5}). Florida DOH interprets this as an increased risk of 8 to 80 people among every 1,000,000 people or a very low to low theoretical increased risk of cancer.

Trichloroethylene (TCE)

Non-cancer illness - In a draft report on the health risk assessment of TCE, EPA proposed the chronic oral RfD to be 3×10^{-4} mg/kg/day [EPA 2001]. Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of TCE are not likely to suffer any non-cancer illnesses (Table 8). The maximum TCE dose for residents using these irrigation wells (2.7×10^{-4} mg/kg/day) is less than the proposed EPA chronic oral RfD of 3×10^{-4} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a]. Although the estimated maximum TCE dose is close to the proposed chronic oral RfD this exposure scenario is theoretical and not likely to occur. The estimated maximum dose is still almost two hundred times less than the NOAEL for TCE.

Cancer - In a draft report on the health risk assessment of TCE, EPA proposed the range of cancer oral slope factors to be 0.02 to 0.4 per mg/kg/day [EPA 2001]. To calculate the theoretical risk of cancer from incidental ingestion and inhalation while using irrigation wells, the non-cancer exposure dose is multiplied by the exposure factor then the EPA highest oral slope factor (2.7×10^{-4} (mg/kg/day) × 0.5 × 0.02 to 0.4 mg/kg/day)$^{-1}$ = 3×10^{-6} to 5×10^{-5}). Florida DOH interprets this as an increased risk of 3 to 50 people in every 1,000,000 people or a very low to low theoretical increased risk of cancer.

Vinyl Chloride (VC)

Non-cancer illness - Residents exposed to irrigation wells installed in the groundwater with maximum detected concentrations of vinyl chloride or swimming in the North Grand Canal are not likely to suffer any non-cancer illnesses (Tables 8 & 9). The maximum vinyl chloride dose for swimmers and boaters in the North Grand canal (1.6×10^{-5} mg/kg/day) and for residents using these irrigation wells (1.2×10^{-5} mg/kg/day) are less than the ATSDR chronic oral MRL of 3×10^{-3} mg/kg/day and thus is not likely to cause any non-cancer illnesses [ATSDR 2010a].

Cancer - Vinyl chloride is a known human carcinogen and EPA has calculated an oral slope factor and an inhalation unit risk factor. In order to calculate the theoretical risk of cancer from exposure to water contaminated with VC while swimming or boating in the North Grand Canal, the adult non-cancer exposure dose is multiplied by the exposure factor then the EPA oral slope factor ((6.5×10^{-6} (mg/kg/day) × 0.5 × 1.4 (mg/kg/day)$^{-1}$) = 5×10^{-6}) [ATSDR 2006]. Florida DOH interprets this as an increased risk of 5 people in every 1,000,000 people or a very low to extremely low theoretical increased risk of cancer.

In order to calculate the theoretical risk of cancer from incidental ingestion and inhalation while using irrigation wells with vinyl chloride, the exposure dose is multiplied by the exposure factor then the EPA oral slope factor ((1.2×10^{-5} (mg/kg/day) × 0.5 × 1.4 (mg/kg/day)$^{-1}$) = 8×10^{-6}) [ATSDR 2006]. Florida DOH interprets this as an increased risk of 8 people in every 1,000,000 people or an extremely low increased risk.

Health Outcome Data

Florida DOH epidemiologists did not evaluate area cancer rates for two reasons. First, the maximum theoretical increased cancer risk for exposure to chlorinated solvents in the air associated with vapor intrusion at this site is "low" to "very low." In order to be conservative, the theoretical risks are calculated using the maximum detected values. Second, because the exposed population is relatively small, it is statistically unlikely that exposure to chlorinated solvents in the air or water at this site would result in an observable difference in cancer area rates compared to other communities in the state.

Child Health Considerations

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

This assessment takes into account the special vulnerabilities of children. It specifically assesses the health risk for children exposed to water from irrigation wells contaminated as a result of activities at the FCS. It also assesses the health risk for children swimming the contaminated water in the North Grand Canal. The contaminants found thus far are not at levels likely to cause harm in children.

Conclusions

1. Breathing indoor air in the on-site building and the building to the south is not likely to harm people's health. Florida DOH interprets the current theoretical increased risk of cancer for long-term building employees from vapor intrusion into these buildings as "low" to "very low."
2. Incidental ingestion, dermal contact, and inhalation of vapors from water from future irrigation wells installed in contaminated groundwater near the site are not likely to harm people's health. Florida DOH interprets the current theoretical increased risk of cancer for residents with these irrigation wells as "low" to "very low."
3. Exposure to contaminants through incidental ingestion, dermal contact, and absorption by eyes, mouth, nose, and ears while swimming or boating in the North Grand Canal is not likely to cause harm. Florida DOH interprets the current

theoretical increased risk of cancer for regular long time swimmers in the canal is "very low" to "extremely low."

4. Incidental ingestion of on-site soils, local fish consumption, drinking from nearby private wells, showering with water from nearby private wells, and vapor intrusion at nearby off-site residential buildings are considered eliminated exposure pathways.

Public Health Action Plan

Actions Undertaken

In February 2009 and August 2010, the EPA sponsored open house meetings at the Broward County Library in the Lighthouse community. In September 2010, the EPA completed the remedial investigation and feasibility study for Flash Cleaners. During March and April 2011 the EPA conducted soil remediation activities. Soil remediation included digging up contaminated soils around the dry cleaner building and installing a soil vapor extraction system to treat soils beneath the building. In June 2011 the EPA began groundwater treatment activities. Groundwater treatment includes the in-situ injection of emulsified oil into multiple injection wells on the Flash Cleaners property and on the median and east side of Federal Highway [EPA 2010d].

Actions Planned

The EPA is continuing site remediation activities. Soil remediation using the soil vapor extraction system will be on-going until it has effectively removed chemicals of concern to the applicable cleanup criteria. After the initial groundwater injection, EPA will continue to conduct periodic groundwater monitoring. Groundwater monitoring will include analysis of groundwater samples from 20 monitoring wells for chlorinated VOCs, groundwater geochemistry, and select analytes to evaluate the potential of natural attenuation of chlorinated VOCs [EPA 2010d].

Florida DOH will review additional site monitoring and remediation data and respond as necessary.

References

[ATSDR 1989] Agency for Toxic Substance and Disease Registry. Toxicological Profile for Bromodichloromethane. U.S. Department of Health and Human Services, Atlanta, GA. December 1989.

[ATSDR 1994] Agency for Toxic Substance and Disease Registry. Toxicological Profile for 1,1-dichloroethene. U.S. Department of Health and Human Services, Atlanta, GA. May 1994.

[ATSDR 1996] Agency for Toxic Substance and Disease Registry. Toxicological Profile for 1,2-dichloroethene. U.S. Department of Health and Human Services, Atlanta, GA. August 1996.

[ATSDR 1997] Agency for Toxic Substance and Disease Registry. Toxicological Profile for Tetrachloroethylene. U.S. Department of Health and Human Services, Atlanta, GA. September 1997.

[ATSDR 2005] Agency for Toxic Substance and Disease Registry. Public Health Assessment Guidance Manual (Update). U.S. Department of Health and Human Services, Atlanta, GA. January 2005.

[ATSDR 2006] Agency for Toxic Substance and Disease Registry. Toxicological Profile for Vinyl Chloride. U.S. Department of Health and Human Services, Atlanta, GA. July 2006.

[ATSDR 2007] Agency for Toxic Substance and Disease Registry. Toxicological Profile for Benzene. U.S. Department of Health and Human Services, Atlanta, GA. August 2007.

[ATSDR 2009] Agency for Toxic Substances and Disease Registry. Health Consultation, Flash Cleaners, Pompano Beach, Broward County, Florida EPA Facility ID: FLD8311105. March 17, 2009.

[ATSDR 2010a] Agency for Toxic Substances and Disease Registry. Minimal Risk Levels (MRLs) for Hazardous Substances. Atlanta: US Department of Health and Human Services; March 2010.

[ATSDR 2010b] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Benzene (Update). Atlanta: US Department of Health and Human Services; August 2010.

[Dang 1996] Dang, W. The Swimmer Exposure Assessment Model (SWIMODEL) and its use in estimating risks of chemical use in swimming pools. EPA Internal Guidance Document. 1996

[EPA 1988] US Environmental Protection Agency, Integrated Risk Information System. March 1988 Available online at http://www.epa.gov/iris/index.html

[EPA 1997] US Environmental Protection Agency, Office of Research and Development. Exposure Factors Handbook. Volumes I, II, and III. August 1997.

[EPA 2001] US Environmental Protection Agency, Office of Research and Development. Trichloroethylene Health Risk Assessment: Synthesis and Characterization. External Review Draft. EPA/600/P-01/002A. August 2001

[EPA 2003] US Environmental Protection Agency, Office of Pesticide Programs Antimicrobials Division. User's Manual Swimmer Exposure Assessment Model (SWIMODEL) Version 3.0. November 2003

[EPA 2005] US Environmental Protection Agency, Trichloroethylene Inhalation Toxicity Values and Corresponding Risk Based Indoor Air Concentrations. Technical Publication. US EPA Region 8 January 26, 2005

[EPA 2008a] US Environmental Protection Agency. IRIS Toxicological Review of Tetrachloroethylene (Perchloroethylene) (External Review Draft). U.S. Environmental Protection Agency, Washington, DC. EPA/635/R-08/011A, 2008.

[EPA 2008b] US Environmental Protection Agency. Narrative Summary, National Priorities List (NPL). Flash Cleaners, Pompano Beach, Florida. September 2008 http://www.epa.gov/superfund/sites/narr/nar1775.pdf

[EPA 2009]. US Environmental Protection Agency. Exposure Factors Handbook: 2009 Update—External Review Draft, July 2009. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/R-09/052A. Available online at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209866

[EPA 2010a] US Environmental Protection Agency. Environmental Justice Geographic Assessment tool. Washington, DC. [Updated May 27, 2010; accessed January 4, 2010]. Available from http://epamap14.epa.gov/ejmap/entry.html

[EPA 2010b] US Environmental Protection Agency, Integrated Risk Information System. March 1988 Available online at http://www.epa.gov/iris/index.html

[EPA 2010c] US Environmental Protection Agency, Superfund Proposed Plan Fact Sheet, Flash Cleaners Site. August 2010

[EPA 2010d] US Environmental Protection Agency, Record of Decision, Summary of Remedial Alternative Selection, Flash Cleaners Superfund Site. September 2010

[EPA 2011] US Environmental Protection Agency. Flash Cleaners Superfund Site, Fact Sheet No. 6. March 2011

[Karmin 1988] Toxicology – A Primer on Toxicology Principles and Applications. Lewis Publishers. Chelsea MI.

[Klein and Hull 1978] H. Klein and J.E. Hull, USGS. Biscayne Aquifer, Southeast Florida. Water-Resources Investigation 78-107. September 1978. 59 pages

[PBS&J 2004] Post, Buckley, Schuh & Jernigan (PBS&J). Site Inspection Report for Flash Cleaners, FLD083111005. February 2004. 83 pages.

[Roberts 2008] Roberts, S. (University of Florida). Irrigation well dosing model for Florida Department of Health.

[Waller 2010] J.M. Waller Associates, Inc. Remedial Investigation Report of Flash Cleaners Site Pompano Beach, Florida. September 2010.

[Weston 2005] Roy F. Weston, Inc Expanded Site Inspection Report Flash Cleaners. November 4, 2005

Appendices

Tables and Figures

Table 1. Completed Human Exposure Pathways at the Flash Cleaners Superfund Site

COMPLETED PATHWAY NAME	COMPLETED EXPOSURE PATHWAY ELEMENTS					TIME
	SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	
Vapor intrusion into air of commercial buildings	Dry cleaner solvents from Flash Cleaners	Groundwater	Indoor air of commercial buildings above and adjacent to the site	Inhalation	About 20 workers in the dry cleaner facility and adjacent commercial buildings	Past, Current, Future
North Grand Canal	Dry cleaner solvents from Flash Cleaners	Groundwater	Swimming in the North Grand Canal	Ingestion, and absorption by skin, eyes, mouth, nose, and ears	About 100 local swimmers	Past, Current, Future
Irrigation wells	Dry cleaner solvents from Flash Cleaners	Groundwater	Lawn and garden irrigation	Ingestion of water and inhalation of vapors	About 20 users of 5 nearby irrigation wells	Past, Current, and Future

Table 2. Eliminated Human Exposure Pathways at the Flash Cleaners Superfund Site

ELIMINATED PATHWAY NAME	ELIMINATED EXPOSURE PATHWAY ELEMENTS					TIME
	SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	
Incidental ingestion (swallowing) of on-site soil	Dry cleaner solvents	Soil	None	Ingestion	None	None
Fish consumption	Dry cleaner solvents	Fish	None	Ingestion	None	None
Drinking water from nearby private wells	Dry cleaner solvents	Groundwater	None	Ingestion	None	None
Showering with water from nearby private wells	Dry cleaner solvents	Groundwater	None	Inhalation	None	None
Off-site residential vapor intrusion from contaminated groundwater	Dry cleaner solvents	Indoor air	None	Inhalation	None	None

Table 3. Maximum Contaminant Concentrations in Off-Site Groundwater (March to November 2009)

Contaminants	Maximum Concentration (µg/L)	Screening Guideline * (µg/L)	# of samples above screening guideline/total # samples	Source of Screening Guideline
Benzene	260	0.6	14/175	CREG
Bromodichloromethane	0.95	0.6	1/42	CREG
1,1-DCE	270	90	1/175	Chronic EMEG, child
cis-1,2 DCE	5,000	20	52/175	RMEG, child
trans-1,2 DCE	840	100	5/175	LTHA
PCE	27,000	10	2/175	LTHA
TCE	6,800	5	4/175	MCL
Vinyl Chloride	340	0.02	28/175	CREG

µg/L = micrograms per liter
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
CREG = ATSDR cancer risk evaluation guide for 10^{-6} excess cancer risk
LTHA = Lifetime Health Advisory
RMEG = Reference Dose Media Evaluation Guide
MCL = Maximum Contaminant Level (EPA)
BDL = below detection limit
NA = Not analyzed
* Screening guidelines only used to select chemicals for further scrutiny, not to the judge the risk of illness.
Source of data: [Waller 2010]

Table 4. Maximum Contaminant Concentrations in Water of the North Grand Canal (November 2009 to April 2010)

Contaminants	Maximum Concentration (µg/L)	Screening Guideline * (µg/L)	# of samples above screening guideline/ total # samples	Source of Screening Guideline
Benzene	BDL	--	--	--
Bromodichloromethane	BDL	--	--	--
1,1-DCE	BDL	--	--	--
cis-1,2 DCE	0.26[a]	20	0/9	RMEG, child
trans-1,2 DCE	BDL	--	--	--
PCE	BDL	--	--	--
TCE	BDL	--	--	--
Vinyl Chloride	0.29[a]	0.02	2/9	CREG

µg/L = micrograms per liter
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
CREG = ATSDR cancer risk evaluation guide for 10^{-6} excess cancer risk
RMEG = Reference Dose Media Evaluation Guide
BDL = below detection limit
NA = Not analyzed
* Screening guidelines only used to select chemicals for further scrutiny, not to the judge the risk of illness.
Source of data: [Waller 2010]
[a] laboratory estimated value

Table 5. Maximum Contaminant Concentrations of Indoor Air Samples from Flash Cleaners Facility and Adjacent Commercial Building (April 2010)

Contaminants	Maximum Concentration ($\mu g/m^3$)	Screening Guideline * ($\mu g/m^3$)	# of samples above screening guideline/ total # samples	Source of Screening Guideline
Benzene	0.35	0.1	4/4	CREG
Bromodichloromethane	NA	--	--	--
1,1-DCE	BDL	--	0/4	--
cis-1,2 DCE	7.5	None	--	--
trans-1,2 DCE	BDL	--	0/4	--
PCE	51	300	0/4	Chronic EMEG/MRL
TCE	2.5	500	0/4	Intermediate EMEG/MRL
Vinyl Chloride	BDL	--	0/4	--

$\mu g/m^3$ = micrograms per cubic meter
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
CREG = ATSDR cancer risk evaluation guide for 10^{-6} excess cancer risk
EMEG = ATSDR environmental media evaluation guide
MRL = Agency for Toxic Substances and Disease Registry Minimal Risk Level
BDL = below detection limit
NA = Not analyzed
* Screening guidelines only used to select chemicals for further scrutiny, not to the judge the risk of illness.
Source of data: [Waller 2010]

Table 6. Oral Hazard Quotient and Hazard Index Values

Contaminant	Maximum Concentration (µg/L)	Estimated Maximum Dose (mg/kg/day)	ATSDR MRL or EPA RfD (mg/kg/day)	NOAEL (mg/kg/day)	NOAEL Source	H.Q.
Benzene	260	1.1×10^{-5}	5×10^{-4}	1	[ATSDR 2007] lowest of several studies	2×10^{-2}
Bromodichloromethane	0.95	2.9×10^{-8}	2×10^{-2}	11.6	[ATSDR 1989] lowest of several studies	1×10^{-6}
1,1-DCE	270	9.4×10^{-5}	9×10^{-3}	9	EPA IRIS	1×10^{-2}
cis-1,2 DCE	5,000	1.8×10^{-3}	2×10^{-3}	17	[ATSDR 1996] lowest of several studies	9×10^{-1}
trans-1,2 DCE	840	2.6×10^{-4}	2×10^{-2}	17	[ATSDR 1996] lowest of several studies	1×10^{-2}
PCE	27,000	1.6×10^{-3}	1×10^{-2}	20	EPA IRIS	2×10^{-1}
TCE	6,800	2.7×10^{-4}	3×10^{-4} [a]	0.05	[EPA 2001] lowest of several studies	9×10^{-1}
Vinyl Chloride	340	1.2×10^{-5}	3×10^{-3}	0.09	EPA IRIS	4×10^{-3}
H.I.						2.0

µg/L = micrograms per liter
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
MRL = Agency for Toxic Substances and Disease Registry's Minimal Risk Level
RfD = US Environmental Protection Agency's Reference Dose
mg/kg/day = milligrams per kilogram per day
NC = not calculated
[a] = value from [EPA 2001]
NOAEL = No Observed Adverse Effect Level
H.I. = Hazard Index
H.Q. = Hazard Quotient

Table 7. Estimated Maximum Dose and Increased Lifetime Cancer Risk: Vapor Intrusion in Commercial Buildings.

Contaminant	Maximum Concentration ($\mu g/m^3$)	ATSDR MRL or EPA RfC ($\mu g/m^3$)	Inhalation Cancer Slope Factor (risk per $\mu g/m^3$)	Source of Inhalation Cancer Slope Factor	Theoretical Increased Lifetime Cancer
Benzene	0.35	10	2.2×10^{-6} to 7.8×10^{-6}	EPA IRIS	3×10^{-7}
Bromodichloromethane	NA	--	--	--	--
1,1-DCE	BDL	--	--	--	--
cis-1,2 DCE	7.5	None	*	--	--
trans-1,2 DCE	BDL	--	--	--	--
PCE	51	300	2×10^{-6} to 2×10^{-5}	EPA 2008a	1×10^{-5} to 1×10^{-4}
TCE	2.5	500	5.7×10^{-6} to 1.1×10^{-4}	EPA 2005	2×10^{-6} to 3×10^{-5}
Vinyl Chloride	BDL	--	--	--	--

$\mu g/m^3$ = micrograms per cubic meter
Theoretical Increased Lifetime Cancer risk based on adults working 8 hour days 261 days a year for 35 years
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
EPA = US Environmental Protection Agency
IRIS = Integrated Risk Information System
MRL = Agency for Toxic Substances and Disease Registry's Minimal Risk Level
RfC = US Environmental Protection Agency's Reference Concentration
BDL = below detection limit
NA = Not analyzed
* = EPA has not determined a cancer slope factor

Table 8. Estimated Maximum Dose and Increased Lifetime Cancer Risk: Nearby Irrigation Wells

Contaminant	Maximum Concentration (µg/L)	Estimated Maximum Dose (mg/kg/day)	ATSDR MRL or EPA RfD (mg/kg/day)	Oral Cancer Slope Factor (mg/kg-day)	Source of Oral Cancer Slope Factor	Theoretical Increased Lifetime Cancer
Benzene	260	1.1×10^{-5}	5×10^{-4}	0.015 to 0.055	EPA IRIS	8×10^{-8} to 3×10^{-7}
Bromodichloromethane	0.95	2.9×10^{-8}	2×10^{-2}	0.062	EPA IRIS	9×10^{-10}
1,1-DCE	270	9.4×10^{-5}	9×10^{-3}	NC	--	--
cis-1,2 DCE	5,000	1.8×10^{-3}	2×10^{-3}	NC	--	--
trans-1,2 DCE	840	2.6×10^{-4}	2×10^{-2}	NC	--	--
PCE	27,000	1.6×10^{-3}	1×10^{-2}	0.01 to 0.1	EPA 2008a	8×10^{-6} to 8×10^{-5}
TCE	6,800	2.7×10^{-4}	3×10^{-4a}	0.02 to 0.4	EPA 2001	3×10^{-6} to 5×10^{-5}
Vinyl Chloride	340	1.2×10^{-5}	3×10^{-3}	1.4	EPA IRIS	8×10^{-6}

µg/L = micrograms per liter
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
BDL = below detection limit
MRL = Agency for Toxic Substances and Disease Registry's Minimal Risk Level
RfD = US Environmental Protection Agency's Reference Dose
EPA IRIS = US Environmental Protection Agency Integrated Risk Information System
mg/kg/day = milligrams per kilogram per day
NC = not calculated
[a] = value from [EPA 2001]

Table 9. Estimated Maximum Dose and Increased Lifetime Cancer Risk: Swimming in the North Grand Canal.

Contaminant	Maximum Concentration (µg/L)	Estimated Maximum Dose (adult)[1] (mg/kg/day)	Estimated Maximum Dose (child)[1] (mg/kg/day)	ATSDR MRL or EPA RfD (mg/kg/day)	Oral Cancer Slope Factor (mg/kg-day)	Source of Oral Cancer Slope Factor	Theoretical Increased Lifetime Cancer[2]
Benzene	BDL	--	--	--	--	--	--
Bromodichloromethane	BDL	--	--	--	--	--	--
1,1-DCE	BDL	--	--	--	--	--	--
cis-1,2 DCE	0.26[a]	9.9×10^{-8}	6.7×10^{-7}	2×10^{-3}	*	--	--
trans-1,2 DCE	BDL	--	--	--	--	--	--
PCE	BDL	--	--	--	--	--	--
TCE	BDL	--	--	--	--	--	--
Vinyl Chloride	0.29[a]	6.5×10^{-6}	1.6×10^{-5}	3×10^{-3}	1.4	EPA IRIS	5×10^{-6}

µg/L = micrograms per liter
[1] Estimated max dose based calculated using EPA's SWIMODEL Swimming Screening Tool Version 3.0
[2] Theoretical Increased Lifetime Cancer Risk based on Estimated Maximum Dose for Adults
DCE = dichloroethene
TCE = trichloroethylene
PCE = tetrachloroethylene
MRL = Agency for Toxic Substances and Disease Registry's Minimal Risk Level
RfD = US Environmental Protection Agency's Reference Dose
EPA IRIS = US Environmental Protection Agency Integrated Risk Information System
BDL = below detection limit
mg/kg/day = milligrams per kilogram per day
* EPA has not determined a cancer slope factor
[a] lab reported concentration to be an estimated value

Figure 1. Location of Flash Cleaners Site in Broward County

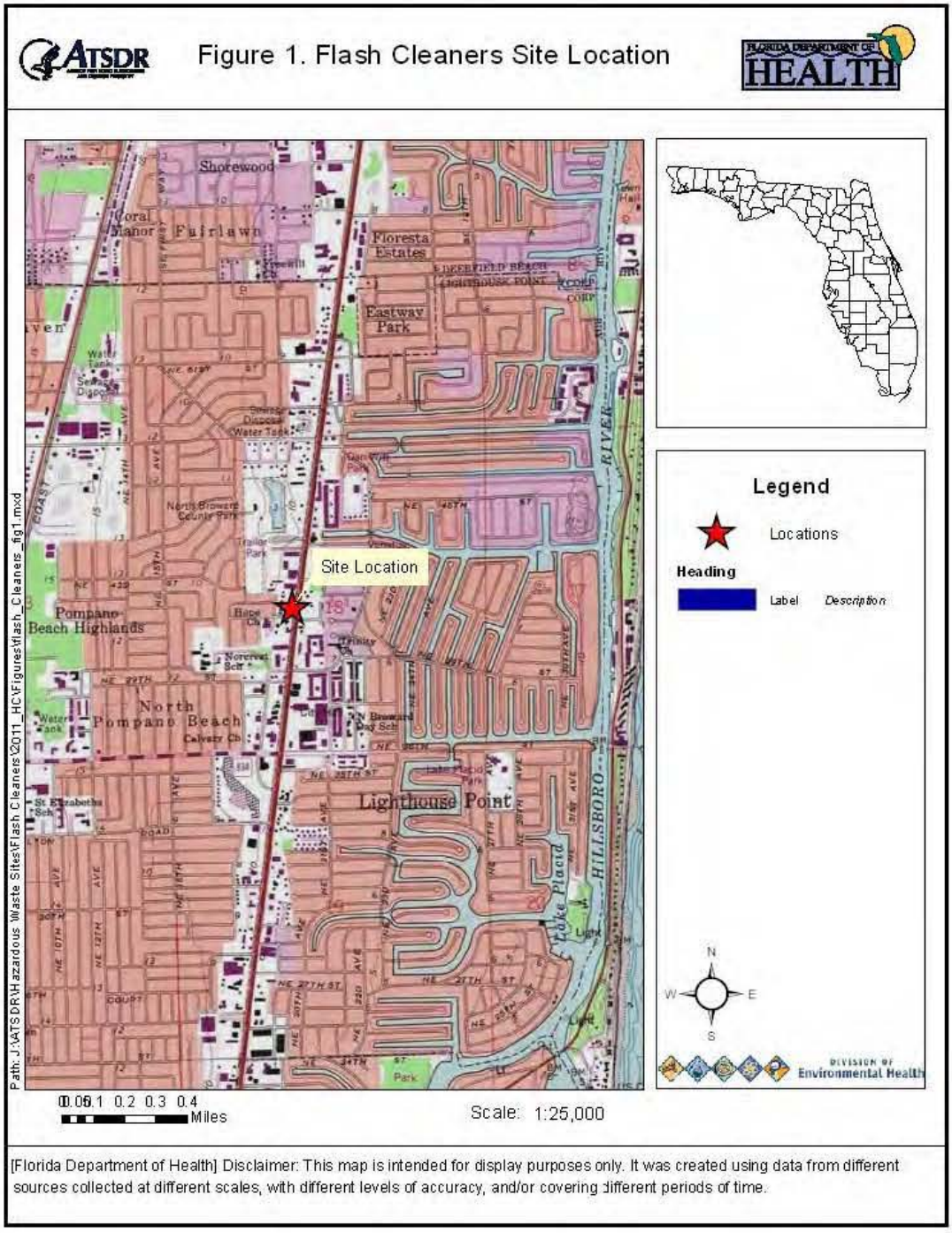

Figure 2. Property Boundary

Figure 3. Flash Cleaners Total VOC Plume [Waller 2010]

Selected Glossary Terms

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure]**.

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, *ambient* air).

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see **route of exposure**].

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Environmental media
Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA

United States Environmental Protection Agency.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with **public health assessment**].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

mg/kg
Milligram per kilogram.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Public health action
A list of steps to protect public health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see **population**]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an **exposure pathway**.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

REPORT PREPARATION

This Health Consultation for the Flash Cleaners Site was prepared by the Florida Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

Author

Spencer Mitchell
Bureau of Environmental Public Health Medicine
Division of Environmental Health
Florida DOH
850 245-4299

Florida DOH Designated Reviewer
Randy Merchant
Bureau of Environmental Public Health Medicine
Division of Environmental Health
850 245-4299

Technical Advisor

Jennifer Freed
Technical Project Officer
ATSDR/DHAC/CAPEB