ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

LUSHER AVENUE GROUNDWATER CONTAMINATION
ELKHART, ELKHART COUNTY, INDIANA
EPA FACILITY ID: IND982073785
JULY 14, 2009

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

LUSHER AVENUE GROUNDWATER CONTAMINATION
(AKA LUSHER STREET GROUND WATER CONTAMINATION)
ELKART, ELKHART COUNTY, INDIANA

EPA FACILITY ID: IND982073785

Prepared by:

Site and Radiological Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and clean up of the sites.

In 1986, ATSDR was authorized by Superfund to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR may conduct public health assessments when petitioned by concerned individuals or requested by other local, state, or federal agencies. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate possible health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is distributed to the public for their comments. Comments received during the public comment period and that are related to the document are summarized and addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	contaminants of concern
CV	comparison value
DCE	dichloroethylene
ECHD	Elkhart County Health Department
EMEG	environmental media evaluation guide (ATSDR)
EPA	U.S. Environmental Protection Agency
IDEM	Indiana Department of Environmental Management
LAGWC	Lusher Avenue Groundwater Contamination
MCL	EPA's maximum contaminant level
MGD	Million of gallons per day
MRL	ATSDR's minimal risk level
NPL	National Priorities List (EPA)
PCE	tetrachloroethylene
PHA	public health assessment
ppb	parts per billion
ppm	parts per million
RAL	EPA's Removal Action Level
RCRA	Resource Conservation and Recovery Act
RfD	reference dose (EPA)
RMEG	reference media evaluation guide (ATSDR)
SSA	site screening assessment area
TCA	trichloroethane
TCE	trichloroethylene
TOT	time-of-travel
VOC	Volatile Organic Compound

Table of Contents

List of Tables

List of Figures

Summary and Statement of Issues

At the Lusher Avenue Groundwater Contamination site, more than one hundred drinking water wells have been contaminated with chlorinated volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and 1,1,1-trichloroethane (TCA). Private well water has been used for residential, commercial, and industrial purposes. In 1987 and 2006, private well users, whose wells were contaminated above EPA's Removal Action Levels (RAL) or in the migration path of this contamination, were supplied with alternate water (bottled water followed by either municipal water or carbon filtration units).

Although alternate water has been provided to these private well users, exposure to chlorinated VOCs has occurred at this site. ATSDR estimates the population, exposed to levels at or exceeding MCLs, to be approximately 200 people. We estimate that 53 of the 200 people were exposed to hundreds of ppb TCE in the late 1980s and are at greater risk for adverse health effects. ATSDR categorizes the site as a past public health hazard. Due to uncertainties concerning sources, continuing migration of contaminants, and private well use, the site could pose a future public health hazard.

Currently, exposure has been mitigated or reduced through provision of alternate water and filter systems. However, due to the potential for exposure through indoor showering and vapor intrusion, especially for children, we recommend indoor air monitoring in the homes with the highest potential for such exposures. A comprehensive private well survey is needed to identify additional private well users. EPA or IDEM should continue to prevent exposure to VOCs in groundwater through alternate water provision as necessary. Sources of contamination to groundwater at the Lusher site are being identified by EPA.

Background

Introduction and Site Description

The Lusher Avenue Groundwater Contamination (Lusher) site is located in north-central Indiana in the city (southwest sector) and county of Elkhart (Figure 1). It was added to US EPA's Superfund or National Priorities List (NPL) in March 2008. Private wells contaminated with chlorinated solvents, TCE, TCA, dichloroethylene (DCE), and other contaminants define the groundwater plumes and site. The site is bordered to the north by the St. Joseph River, to the south by Hively Avenue, to the east by Oakland Avenue, and to the west by Nappanee Street or State Road 19 (Figure 1) (US EPA 2008a). The Lusher site is located in a mixed residential, commercial, and industrial area with private well use in these sectors. Industrial and commercial activities in Elkhart include the manufacture of pharmaceuticals, recreational vehicles, mobile and modular homes, band instruments (such as woodwinds), tape, corrugated containers, and foam and plastic products (USGS 1991; IDEM 2007). Other activities include metal fabricating and scrapping, auto salvage and repair, plating, lumber yard activities, and a former dump. Many of these businesses are located on Lusher Avenue.

Norfolk Southern Railroad (formerly the Conrail Railroad) divides the site into northern and southern sections. The Conrail Rail Yard Site, a superfund site with two identified groundwater plumes, is adjacent to and west of the Lusher site (ATSDR 2005a). Neither of the Conrail Rail Yard plumes extends onto the Lusher site.

This Public Health Assessment (PHA) focuses on the groundwater and related pathways such as indoor air (volatilization of gases from water during showering and other household uses and vapor intrusion of gases from groundwater or soil gas to indoor air). The groundwater migration pathway was the only pathway scored by EPA. The site was added to the National Priorities List (NPL) on March 19, 2008 (US EPA 2008a). ATSDR evaluates Superfund and other hazardous waste sites for their health implications. ATSDR's health evaluation process was initiated in 2008 based on inclusion of the Lusher site to the EPA's Superfund list.

Site and Well Sampling History

The Lusher site was discovered during an investigation of the K.G. Gemeinhardt Company, Inc., a musical instrument manufacturer on State Road 19. The sources of Lusher groundwater contamination have not been fully identifed. Although contamination was found in the private well of the Walerko Tool & Engineering Corporation at 1935 Lusher Avenue, there are many other potential sources (companies on Lusher Avenue and elsewhere at the Lusher site) that could be contributing chemicals to groundwater in the area (US EPA 2007). Lusher site contamination has not been remediated. Contaminated groundwater in the unconfined aquifer within the Lusher site area is moving northward toward the St. Joseph River.

In 1987, the Elkhart County Health Department (ECHD) began an investigation of the Lusher area (northwest quadrant) after Gemeinhardt indicated that another source of contamination was indicated there. ECHD sampled 145 private drinking water wells and found that 103 of them contained elevated TCE and TCA (US EPA 1989).

In November of 1987, EPA confirmed ECHD findings of elevated VOCs. The EPA installed 13 point-of-use carbon filters at residences and businesses to reduce contaminant concentrations below the safe drinking water standards for public water supplies and provided two residences with municipal water. In 1988, EPA sampled 45 residential and business wells during an Extent

of Contamination Study (US EPA 1989). Five additional residences and businesses were supplied with municipal water.

In the summer of 1989, IDEM conducted water testing and extended municipal water lines to additional homes and businesses. One residence on Avalon Street was not connected to city water because no main was in close proximity (US EPA 2007). A whole-house filter was installed at this residence in 1988. For twenty years, IDEM has continued to provide operation and maintenance of the filter system at this residence. In October 2005, IDEM discovered increased levels of TCE in this residential drinking water well during routine maintenance of their carbon filtration system (5 ppb TCE in 1987 to 700 ppb in 2005) (IDEM 2006) (Tables 1 and 3). This discovery led to the 2006 sampling of nearby private wells.

From June through December 2006, IDEM sampled private wells in five sampling events. One hundred nineteen water samples were analyzed for VOCs. The sampling results indicated that other wells had been impacted by elevated VOCs. Ten additional drinking water wells were contaminated above MCLs; bottled water was initially provided to residents and later some residents were provided with point-of-use carbon filters by EPA Region V. These homes have remained on point-of-use filters maintained by IDEM.

Site and Area Groundwater Contamination

There are four Superfund sites in Elkhart County that are on, or have been on the NPL (National Priorities List): the Himco Landfill and Main Street Well Field north of the St. Joseph River and the Conrail Rail Yard and Lusher Avenue Groundwater Contamination Site (referred to hereafter in this document as the Lusher Site) south of the St. Joseph River. The Main Street Wellfield is discussed briefly because of historical TCE contamination and connection of Lusher residences to the municipal water supply. In addition there are at least eight additional sites in Elkhart County that have been the subject of Time Critical Removal actions. These include: the Accra-Pac Site, the Woodlawn Industrial Site, Sycamore Street, Belmont-Huron Site, Gemeinhardt, Lane Street and others. The vast majority of these additional sites are groundwater related.

There are a number of known sources of groundwater contamination near and on the Lusher Site and suspected unidentified additional sources within the site area. Nearby groundwater plumes that have been identified are the Gemeinhardt plume to the southwest and Conrail plumes to the west. The site was named Lusher because it was originally assumed that the majority of the contamination was coming from businesses on Lusher Avenue.

Main Street Well Field

Groundwater at the Main Street Well Field, north of the Lusher Site and the St. Joseph River, migrates toward the St. Joseph River. The Main Street Wellfield Site is discussed here because of historical TCE contamination and the potential for past exposure of area residents to VOCs in the municipal water supply.

The Main Street Wellfield Site was added to the NPL in December 1982. VOCs were found in the Main Street Well Field in the 1980s. In the 1980s, this well field supplied approximately 75% of the municipal water to area residents. An air stripper was used to remove VOCs beginning in 1985 (ATSDR 1988). The earliest year that Lusher residences were connected to the municipal water supply was 1987. *Based on the sequence of events, it appears that Lusher residents who were connected to municipal water supply because of VOCs in their private wells were not exposed to VOCs in the municipal supply.*

The Gemeinhardt Plume

The K.G. Gemeinhardt Company, Inc. and its predecessors manufactured musical instruments beginning in the 1940s. They used TCA, TCE, and PCE in the manufacturing process and produced approximately 2,500 gallons of wastewater per day (US EPA 1988). The process wastes went to several dry wells, a gravel seepage bed, or to a septic tank at the facility after which they seeped into the ground or the underlying aquifer. After 1985, the wastes went to the Elkhart Municipal Wastewater Treatment Plant (on State Route 19 at the St. Joseph River).

While conducting an extent of contamination study under a 1985 consent order with the EPA, VOCs (primarily TCE and PCE) were detected in private drinking water wells south of Lusher Avenue and to the northeast of Gemeinhardt. Gemeinhardt claimed another unidentified source was deemed responsible for this contamination. The company removed contaminated soil, installed three recovery wells and a treatment facility to recover the contamination that had migrated to the north-northwest of the facility.

ATSDR along with EPA and other agencies visited the air stripper east of Gemeinhardt on an April 21, 2008 site visit. According to Gemeinhardt's consultant, TCE contamination in seepage systems leached into groundwater and was discovered in the late 1980s coming from Gemeinhardt activities. They originally had a soil vapor extraction system in place to remove VOCs. Three groundwater extraction wells were used but currently only one recovery well is in use. An air stripper, used to clean up TCE and other volatile contaminants from the groundwater, has removed approximately 17 pounds of TCE. The recovery effort is nearing completion because of the impracticality of extracting the remaining product. Gemeinhardt consultants and representatives consider the Gemeinhardt plume to be separate from the Lusher Avenue contamination.

Lusher Avenue Contamination

The Walerko Tool & Engineering company is located at 1935 West Lusher Avenue. Their business is machining, tool and die work which commenced in 1952. In 1987, a sample of the drinking water from a well at Walerko contained 38 ppb TCE, 660 ppb TCA, 19 ppb DCE, 82 ppb carbon tetrachloride (CCl_4), and 4 ppb 1,1-dichloroethane (DCA) (US EPA 1988). In 1993, US EPA entered into a consent order with Walerko to recover past costs, of the prior EPA action. Walerko is a potentially responsible party contributing to the Lusher Avenue Groundwater contamination. However, other samples taken in the late 1980s indicated higher contamination (608 and 804 ppb TCE, Table 1) further east in the vicinity of 17th Street and Lusher Avenue. The sources of Lusher groundwater contamination have not been fully identifed. EPA is working to identify other potentially responsible parties.

Conrail Plumes

There are two areas related to the Conrail Rail Yard Superfund site that have contaminated groundwater. The closest area to the Lusher Site is approximately one-half mile west of Nappanee St. and primarily west of Fern Wood Avenue (ATSDR 2005: Figures 4 and 5 of the Conrail PHA). TCE contamination in this area is less than 100 ppb and carbon tetrachloride is less than 30 ppb. Another plume with higher TCE concentrations is much farther west and extends from the Rail Yard toward the St. Joseph River. These areas have been addressed by ATSDR and EPA. Contamination from these areas is not believed to be migrating toward the Lusher site based on groundwater and contaminant flow northward to the River. However, there

may be contaminants from other sources (including sources on the Lusher Site) migrating and mixing with the closest Conrail plume.

ATSDR Involvement

ATSDR is mandated by Congress to conduct an evaluation of sites listed on the EPA's NPL. This PHA is our evaluation of the site and its health implications. ATSDR visited the site and surrounding area on April 21 and 22, 2008. Ken Theisen, an On-Scene Coordinator (OSC) with Region V and who has been involved with the vast majority of the groundwater plumes in Elkhart since the late 1980's**,** gave a drive-by tour of the site and surrounding area on April 21. The tour included the adjacent Conrail Rail Yard and Gemeinhardt Co. (to the southwest) sites and plumes. On April 22, ATSDR and EPA visited the Elkhart County Health Department (ECHD), Planning & Development of the City of Elkhart, and the Mayor's Office. The purpose of these initial meetings was to inform these offices of our upcoming work and to gather information to conduct this work. We were provided with information on neighborhood associations that might assist us with community involvement. Officials with whom we met did not know of any community concerns with respect to water issues.

Open House Meetings

On November 5 and 6, 2008, ATSDR hosted four open house meetings for the community on the Lusher Avenue Groundwater Contamination site at two locations in Elkhart: Calvary United Methodist Church and Canaan Baptist Church. Community members had the opportunity to speak one-on-one with ATSDR staff regarding any site-related concerns and about the Public Health Assessment process. They also had the opportunity to ask questions of EPA, IDEM, and the Elkhart County Health Department, the agencies participating along with ATSDR. Approximately sixty people attended the meetings. Besides the general public, attendees included several reporters, business men, and city officials.

The following concerns were raised at the meetings: the decreased ability to sell property due to the Superfund designation, potential vapor intrusion at rental properties (or the need to show the lack of vapor intrusion), economic considerations of extending city water mains to remote properties, people who still have private well water including the need to determine who's not connected to the municipal water system, the lack of any ordinances against drilling new wells, drainage from pipes near the railroad tracks that might contaminate private property, and some health concerns. Some people lived or worked outside of the Superfund boundary, were on city or bottled water, and had no health concerns. The few health concerns that were expressed by residents related to cancer. One man who had lived there for six years reported that he was diagnosed with renal cell kidney cancer six months after moving to the area. One woman who had lived within the Superfund boundaries and drank well water her whole life died of abdominal cancer at 58 or 59 years of age (as reported by her son). Another woman reported an unspecified cancer concern. Some people were surprised to learn that if they were on city water, their household water was treated and subject to drinking water standards, unlike the groundwater from private wells at the Lusher site.

A draft of the Public Health Assessment (PHA) for the Lusher Avenue Groundwater Contamination site was available to the public for comments in March 2009. ATSDR received comments from Walerko Tool and Engineering Corp. These comments and our responses have been included in Appendix F. Revisions to the text were made and appear in this final version. No other comments from the Lusher community were received. However, ATSDR received comments on the draft Lusher PHA from the U.S. House of Representatives (Subcommittee on Investigation and Oversight of the Committee on Science and Technology) during a review of the agency and some of our sites. The comments pertaining to the Lusher PHA and our responses have been included in Appendix G. This final PHA includes revisions made in response to their concerns.

Demographics

Within the Lusher Site, the population is estimated at 2,597 people (Figure 1). There are estimated to be 286 children who are age six or younger and 520 females aged 15 to 44. We were told by the ECHD that many of the homes at the Lusher Site are rentals and the population is largely transient. Housing in the city of Elkhart is 53.5% owner-occupied with the remainder being apartment or rental housing units (Elkhart County 2007-2008). According to Elkhart vital statistics, the average household/family size is 2.55/3.16 (Elkhart County 2007-2008). Based on these statistics, we have estimated 3 people per residence for use in this assessment where there was no other information available. There are no public schools in the contaminated area or within the site boundaries. However, there may be private schools at local churches.

Community Health Concerns

No community health concerns nor complaints about drinking water quality were identified during our April 21, 2008 site visit—ECHD and the Elkhart City Planning Office had not received any concerns. However, EPA indicated that some families in the Flake Street area had requested whole-house filters rather than the point-of-use kitchen filters they received.

A few cancer concerns were raised at the ATSDR Open House meetings in November 2008. More details on these health and other concerns are presented in the previous section on ATSDR Involvement.

Groundwater

This assessment focuses on the groundwater and related pathways such as indoor air (volatilization of gases from water during showering and other household uses as well as vapor intrusion of gases from groundwater or soil gas to indoor air). ATSDR evaluates Superfund and other hazardous waste sites for their health implications. ATSDR's health evaluation process was initiated in 2008 based on inclusion of the Lusher site to the Superfund list.

Hydrogeology

The St. Joseph River flows from the east to the west near the site and eventually empties into Lake Michigan. Private wells at the Lusher site draw groundwater from the St. Joseph aquifer, a sand and gravel unconfined aquifer of glacial origin. This unconfined surficial aquifer is extremely susceptible to contamination due to high permeability and capacity to transport

contaminants. The sand and gravel deposits may have interbedded lenses of silt and clay. Flow through the aquifers is generally horizontal and toward the St. Joseph River. The area is underlain by shale bedrock. This bedrock confining unit lies at a depth of approximately 150 to 200 feet (depth based on DNR database). In some areas near Lusher, the aquifer is separated into upper and lower zones by a confining layer of silt and clay. The confining layer is not continuous across the Lusher site but is found in some locations as a local and discontinuous layer (US EPA 2007). These local confining layers could trap contamination and be a continuing source in the aquifer. They may also contribute to higher contaminant levels at various depths (the various depths of the layers) above bedrock. Depth to groundwater is approximately 20 feet at the southern site boundary (Hively Street) and decreases northward to zero as groundwater discharges to the St. Joseph River on the northern site boundary). In general, contaminants in groundwater south of the St. Joseph River flow toward the River (north and northeasterly-westerly in the Lusher area; the deepest groundwaters may flow westerly along with decreasing bedrock elevations). The direction of contaminant flow can be changed locally by pumping or groundwater withdrawals and lowering of the groundwater table.

Contaminants

The contaminants in groundwater that routinely exceeded our comparison values were TCE and TCA. The MCL for TCE has been set at 5 ppb because EPA believes, given present technology and resources, this is the lowest level to which water systems can reasonably be required to remove this contaminant should it occur in drinking water. The MCL for TCA has been set at 200 ppb. These drinking water standards and the regulations for ensuring these standards are met are called National Primary Drinking Water Regulations. *Although these standards do not apply to private drinking water wells, they have been used for screening and discussion purposes.*

Trichloroethylene (TCE)

TCE has been used in industry since the early 1940s as a degreasing agent and as a solvent in dry cleaning. It is also present in paint removers, strippers, cosmetics, adhesives, typewriter correction fluids, household cleaners, and spot removers (Collier et al 2003). In 1989, EPA adopted its TCE drinking water standard of 5 ppb. TCE has a sweet odor in water at a concentration of 25,000 to 50,000 ppb; the concentrations at the Lusher Site (less than 1000 ppb in water) are too low for most people to detect by taste or smell. Potential health effects of exposure to TCE in groundwater from the Lusher Site are discussed later in this assessment.

1,1,1-Trichloroethane (TCA)

TCA also called methyl chloroform is used as a degreaser and for cold cleaning, dip-cleaning, and bucket cleaning of metals. It is also used as a dry-cleaning solvent, a vapor degreasing agent and a propellant. It has found wide use as a substitution for carbon tetrachloride (Handbook of Toxic and Hazardous Chemicals and Carcinogens). It is a colorless non-flammable liquid with an odor similar to chloroform at concentrations around 120,000 ppb; the concentrations at the Lusher Site (less than 4000 ppb in water) are too low for most people to detect by taste or smell. EPA categorizes TCA as not classifiable as to human carcinogenicity. This non-carcinogenic VOC can affect the skin, eyes, cardiovascular system and central nervous system. Other symptoms can include dizziness, incoordination, drowsiness, decreased reaction time and

unconsciousness (US EPA 1989). Potential health effects of exposure to TCA in groundwater from the Lusher Site are discussed later in this assessment.

Lusher Private Well Contamination

Within the site boundaries for Lusher, there are several hundred private well locations (30 estimated and 20 known well locations in the Indiana DNR database which primarily do not overlap with the 119 wells sampled by EPA and IDEM during sample events 1-5. There are 145 wells in the northwest quadrant that were sampled by ECHD). No comprehensive private well survey for the Lusher site has yet been conducted.

The well depths and screening intervals are not known for most of the private wells at the Lusher Site; however, those wells for which this information is known and the contaminants found in them are presented in Appendix D. The shallowest screened interval ranges from 20 to 30 feet and the deepest screened interval ranges from 88 to 108 feet. Data in Appendix D indicate that TCA is present in the aquifer from approximately 20 to 100 feet below ground surface (bgs). *Many wells in the northwest quadrant of the site are contaminated with TCA.* In 1987, twelve private wells contained TCA exceeding US EPA's safe drinking water limit of 200 ppb for public water supplies (Table 2). Four of these wells had both TCE and TCA contamination at or above safe drinking water levels or MCLs. Approximately 81 people used well water containing both TCE and TCA (Tables 1 and 2). The highest concentrations of TCA were found in the late 1980s at W. Indiana (1590 ppb) and West Lusher Avenue (660 ppb). In 2006, the most contaminated well for TCA was found on 17th Street near Lusher Avenue (150 ppb).

In 1987, ten wells had TCE concentrations exceeding EPA's safe drinking water limit of 5 ppb for public water supplies (Table 1). The 1987 private well results indicated eight wells with TCE of 106 ppb or less. The estimated exposed population using these wells was 65 people. There were two wells that had maximum TCE concentrations above 500 ppb with an estimated exposed population of 53 people. Historically, the most contaminated residential well was on 17th Street with 804 ppb TCE. Historically, the most contaminated private well used by a business that has been recorded was on West Lusher at 608 ppb TCE (Table 1).

In 2006, ten wells had TCE concentrations exceeding EPA's safe drinking water limit of 5 ppb for public water supplies (Table 3). The estimated exposed population using these ten wells was 44 people. During the 2005/2006 sampling events, the highest concentrations of TCE (320 to 700 ppb) were detected in untreated residential well water on Avalon Street (Table 3). Since a whole-house filter has been in use for 20 years, residents in this household were not exposed to these concentrations. TCE was found at elevated concentrations in the Flake/Albany Street Area. The TCE concentrations in this area are 100 ppb or less (Table 3); however, there are other elevated VOCs. According to EPA, point-of-use (kitchen sink) filters were installed at three Flake Street residences; one household declined installation. There were several children playing in this area during our site tour on April 21, 2008.

In summary, twenty private wells had or have TCE concentrations exceeding EPA's safe drinking water limit of 5 ppb for public water supplies (10 wells in 1987 and 10 wells in 2006, Tables 1 and 3). Twenty-eight private wells have been contaminated with TCE and/or TCA above drinking water standards (MCLs) used for public water supplies (Tables 1 through 3). The total estimated exposed population who used this well water was approximately 200 people.

Table 1. Historical TCE in Private Wells (late 1980s)

	Maximum TCE conc. (ppb) in Private Well		**Estimated Number of People who used these wells***
17th St.	804	1	3
W. Lusher-B	**608**	**1**	**50****
		0	0
Avalon W Lusher-B	106 100	2	18 15+3
Markle-B Fieldhouse	93 71	2	13 10+3
W Indiana **W Lusher-B**	**38.5** **38**	**2**	**28** **25+3**
El Reno Avalon	**19** 5	**2**	**6** 3+**3**

Residences and businesses received alternative water supplies: connection to the municipal water supply or filters. Based on private well water results, a total of 118 people are estimated to have been exposed to TCE above the EPA MCL of 5 ppb in the past (1987 or earlier).

Notes: bold text means TCA contamination also (see Table 2).

Additionally, 1,1-DCE was above the MCL of 7 ppb on 17th Street (13 and 16 ppb).

B=business, others are residences

*Assumes 3 residents per residence based on Elkhart vital statistics; business estimate based on number of employees or size of company if not otherwise documented.

**IDEM 2007b

Source: US EPA 1989

Table 2. Historical TCA in Private Wells (late 1980s)

	Maximum TCA conc. (ppb) in Private Well		Estimated Number of People who used these wells*
W Lusher-B	**3800**	**1**	**50**
W Indiana	**1590**	**1**	**3**
W Indiana	1100	1	3
W. Indiana	754	1	3
W Lusher-B	**660**	**1**	**25**
El Reno El Reno Okema	430 370 330	3	9 3+3+3
El Reno W Indiana Waurika Not listed	**272** 266 263 257	4	12 9+**(3)**

Residences and businesses received alternative water supplies: connection to the municipal water supply or filters. A total of 104 people are estimated to have been exposed to TCA above its MCL in the past (1980s or earlier).

Notes: Bold text means TCE contamination also (see Table 1).

Additionally, 1,1- DCE was above its MCL of 7 ppb on 17th Street (13 and 16 ppb).

B=business, others are residences

*Assumes 3 residents per residence based on Elkhart vital statistics; business estimate based on number of employees or size of company if not otherwise documented.

**IDEM 2007b

Source: US EPA 1989

Table 3. Recent (2005/2006) TCE in Private Wells

TCE Conc. in Water (ppb)		Private well ID, Maximum TCE conc. (ppb) in Private Well		Inhalation and/or ingestion Exposure* Estimated Number of People
500-700	Avalon	700**	1	0***
300-500	Avalon	No maximums	0	0
100-300	Avalon	No maximums	0	0
80-100	Flake	E2P52, 100J	1	8
30-80	Flake Flake Albany Markle Fieldhouse Flake	E2P10, 79 LQ3556, 75 E2NZ2, 64 E2P19, 63 E2P33, 54 LQ3557, 53	6	21 (2+8+3+3+2+3)
5-30	W. Franklin-B Lamar Ct Avalon	LQ3560, 27 E2NX0, 25 E2PO9, 7.9	3	15 (10+2+3) 5 residential 10 business

* municipal water or filters have been installed such that no drinking water exposures are currently occurring at listed residences and businesses.
** raw untreated water, residence has a whole-house filtering system, TCE concentration from 2005 analysis which led to this Superfund determination; 1987 analysis indicated 5 ppb TCE. Concentrations have ranged from 320 to 700 ppb.
***potential vapor intrusion concern; depths of well, the screened interval, and contamination are unknown.
A total of 44 people are estimated to have been exposed to TCE above its MCL in the recent past (2006 or earlier).
B=business
Samples were taken by IDEM in 2006 during 5 sampling events.
Sources: IDEM Key findings list, EPA NPL listing Sept. 2007, IDEM 2007

Public Health Implications

Most of the exposures or the potential for exposures occur under four basic scenarios and could be past, current, or future: 1) during consumption of groundwater as drinking water (for example, while working at facilities within the Lusher area that use(d) private wells as a drinking water source or at residences prior to installation of filters at the tap by EPA) 2) during inhalation of VOCs from showering and other household uses (point of use filters may have been installed so that water at the tap is filtered but other water, such as shower water, remains unfiltered) 3) during both ingestion and inhalation of VOCs from groundwater which combines the first two scenarios and 4) from vapor intrusion into buildings. The scenarios are presented so that a resident or worker in the area could use their water concentration to evaluate their specific exposure scenarios and potential health implications. The four exposures scenarios and their health implications are discussed below. Estimated doses and concentrations are compared to health effect levels in Tables 4 through 6. Potential health effects are summarized in Table 7. Potential cancers are described in Appendix E.

We have discussed exposure to TCE in depth because of its greater toxicity and potential for health implications. The same pathways apply to TCA which is discussed in a more condensed format following the TCE discussions. Historically, there were four private wells that were contaminated with both TCE and TCA. The potential existed for additive joint toxic action based on non-cancerous effects for water use from these wells. Even so, the potential for health implications is driven primarily by TCE.

Exposure to TCE

Many of the human studies for exposure to TCE are limited by the lack of information on individual exposure levels and duration of exposure, small sample size, and the presence of other VOCs. Some studies suggest exposure to TCE may be associated with some types of cancer, primarily leukemia and non-Hodgkin's lymphoma. However, the association between exposure to TCE and cancer has been inconsistent across studies. Some research has correlated TCE exposure to teratological (prenatal) outcomes (Collier et al. 2003; Johnson et al. 2003; Dawson et al.1990; Goldberg et al. 1990). This section summarizes studies of TCE exposures and addresses potential outcomes with respect to the groundwater concentrations at Lusher.

Scenario 1---Drinking water ingestion exposure

This section explores potential health effects from drinking contaminated groundwater [for example, while working at facilities within the Lusher area that use(d) private wells as a drinking water source or at residences prior to installation of filters at the tap by EPA]. However, if a residence did not have a filter at the tap nor a whole house filter, then exposures fall under Scenario 3—ingestion and inhalation exposures. Potential health effects have been discussed as non-cancerous and cancerous.

Noncancerous Effects

The most sensitive effects of TCE exposure for noncancerous health effects are on the developing embryo. The unborn child (as a fetus in utero) is at increased risk of having heart problems (cardiac defects) from maternal exposure to TCE. TCE is capable of placental transfer from mother to fetus (Johnson 2003). TCE exposure is linked with developmental malformations

in numerous animal systems (Collier et al. 2003). Heart defects have been detected in newborn rats that were exposed to TCE during embryo development (Collier et al. 2003, Dawson et al. 1993, Johnson et al. 1998 and 2003). TCE exposure during early cardiac development may alter gene expression and produce cardiac malformations (Collier et al. 2003). TCE contaminated drinking water is associated with increased incidence of congenital cardiac malformations but not general teratogenesis (Johnson et al. 2003).

The Tucson, Arizona epidemiological study of Goldberg et al. (1990) showed a significant association between parental exposure to a contaminated water area and an increased proportion of congenital heart disease among live births as compared with those proportions among live births for parents without contact with the contaminated water area. TCE levels were measured in 1981 and 9 public wells exceeded guidelines with concentrations ranging from 6 to 239 ppb (Goldberg et al. 1990). The primary contaminants in groundwater were TCE, DCE, and chromium.

Other studies have demonstrated a greater than expected number of pediatric patients with congenital heart disease in areas where drinking water was contaminated with TCE, TCA, and DCE (halogenated aliphatic hydrocarbons) (Dawson et al. 1990). In these studies, TCE concentrations were higher (1500 ppb and 1,100,000 ppb) than those found at the Lusher Site (maximum of 804 ppb TCE but for most private wells less than 100 ppb TCE).

Table 4 shows the dose for a woman drinking contaminated water at various TCE concentrations and compares it to the lowest dose (LOAEL of 0.05 mg/kg/day) for developmental and cardiac effects (the most sensitive endpoints) identified in rat studies. The margin of exposure (MOE) is also shown. The margin of exposure is how close the estimated dose is to doses that cause harmful effects. For example, at 500 ppb TCE in private well water, the estimated dose is three times below the dose known to cause cardiac defects in rats. As the estimated dose gets close to the LOAEL, the likelihood of developmental and cardiac effects increases.

Some residents within the Lusher Site boundaries could have been exposed at doses similar to those in rats that caused heart defects. *Base on these studies, pregnant women who used private wells at Lusher with the highest TCE concentrations had an increased risk of having newborns with heart defects.* In the late 1980s, concentrations of 608 and 804 ppb TCE were reported from 2 private wells. The estimated exposed population from these wells was 53 people. Additionally, people in the Lusher Site area are not expected to be at increased risk for non-cancerous gastrointestinal effects.

Table 4. Ingestion: Estimated TCE doses compared to LOAEL for Developmental/Cardiac Effects

TCE Concentration in Water (ppb)	Estimated Dose (mg/kg/day) Women	LOAEL (mg/kg/day) Developmental, Cardiac Effects	Margin of Exposure (MOE)
1000	0.04	0.05	1
700	0.03	0.05	2
500	0.02	0.05	3
300	0.01	0.05	5
100	0.004	0.05	14
30	0.001	0.05	45
5	0.0002	0.05	250

Woman-- 60 kg adult drinking 2.4 liters/day
LOAEL- Lowest Observed Adverse Effect Level
MOE = LOAEL/estimated dose

In addition to being a risk for the developing embryo, at sufficient concentrations, TCE exposed adults could be at an increased risk of heart disease. Workers exposed to solvents have been shown to have an associated increased prevalence of heart disease (Zierlet et al. 1988 in Johnson et al. 2003).

Based on human epidemiological studies, TCE is believed to be harmful to the developing fetus (ATSDR 1997a). A New Jersey study of 75 towns served by 49 water companies examined the association between drinking water contaminants and birth outcome. A monthly estimate of 55 ppb TCE was reported (Bove et al, 1995). Study conclusions were that central nervous system, neural tube, and oral cleft defects were associated with TCE exposure (Bove et al. 1995 in ATSDR 1997a).

A report on the Woburn, Massachusetts population (MDPH 1994 in ATSDR 1997a) indicated an increased prevalence (based on 1 case) in choanal atresia, a rare respiratory effect, and hypospadias/congenital chordee. There was no association between TCE exposure and heart defects and no statistically significant associations between exposure concentrations and birth defects. The study was limited by the small number of cases observed.

At the Lusher Site, there were exposures to water containing hundreds of ppb TCE from two private wells. In the late 1980s, concentrations of 804 and 608 ppb TCE were reported in a residential well on 17th street and a business well on West Lusher, respectively. The estimated exposed population from these wells was 53 people. In 2005, one residential well on Avalon Street had a TCE concentration of 700 ppb; however, the water was filtered and therefore, the residents were not exposed to this contamination.

ATSDR is conducting an epidemiological study at U.S. Marine Corps Base Camp Lejeune, North Carolina. The study will evaluate whether in utero and infant (up to one year of age) exposures to drinking water contaminated with VOCs were associated with specific birth defects and childhood cancers. The study is currently in process.

Cancerous Effects

TCE is considered a carcinogen in animals and a probable carcinogen in humans. (ATSDR 1997a, Johnson et al. 2003). Researchers have shown that TCE binds to DNA and may therefore play a role in inducing cancers (Collier et al. 2003). Some studies suggest exposure to TCE may be associated with some types of cancer, primarily leukemia and non-Hodgkin's lymphoma. However, the association between exposure to TCE and cancer has been inconsistent across studies.

In 1986, a cancer cluster of twenty-one childhood leukemia cases (1969-1986) was investigated in Woburn, Massachusetts (Costas 2002). In 1979, two of eight city-owned public water supply wells were closed after they were found to be contaminated with arsenic (2 ppb), TCE (267 ppb), PCE (21 ppb) and other organic compounds. The number of childhood leukemia over the twenty-seven year period of 1969 through 1997 was 11 expected cases while 24 cases were observed. Cases were generally male and less than 9 years of age. An association between potential for exposure to contaminated water during pregnancy and leukemia diagnosis in the child was identified. The risk of leukemia significantly increased as the amount of contaminated water delivered to the household increased (Costas 2002). In other words, the risk of developing childhood leukemia was greater for a child whose mother drank water from contaminated wells while pregnant with the child and the greater the amount of contaminated water provided to the house and available for use while the mothers were pregnant, the greater the risk of their child developing leukemia (MBEH 1997 in ATSDR 2005).

A 1996 study at Woburn, conducted by the Massachusetts Department of Health, found that the risk of leukemia in the group exposed to TCE in utero was about 8 times higher than that in the unexposed group. Their findings indicate that childhood leukemia in the Woburn population may be related to the mother's exposure to contaminated drinking water during pregnancy (ATSDR 1997a). Several leukemia cases occurred in children with no access to contaminated wells. Based on the Woburn exposure group, children exposed to several hundred ppb TCE while their mother was pregnant with them (some interaction from other contaminants, such as arsenic, may also have been a contributing factor) may be at increased risk of acute lymphocytic leukemia.

A New Jersey study of approximately 1.5 million residents monitored between 1979 and 1987 in 75 towns found a significant elevation of total leukemias, childhood leukemias, acute lymphatic leukemias, and non-Hodgkin's lymphoma in groups of females exposed to greater than 5 ppb TCE. Non-Hodgkin's lymphoma (diffuse large cell/reticulosarcoma) was elevated in males as well. The population in the study was exposed to TCE and other VOCs; the highest exposure category ranged from 37 to 72 ppb (Cohn et al.1994 in ATSDR 1997a). The conclusions are limited by lack of information about the long-term exposure levels to TCE and the confounding influence of other chemicals found in the drinking water (ATSDR 2005).

However, a study of two Finnish villages with drinking water contaminated with up to 220 ppb TCE and/or up to 180 ppb PCE found no significant increase in standardized incidence ratios for total cancer, liver cancer, non-Hodgkin's lymphoma, Hodgkin's disease, multiple myeloma, and leukemia (Rasmussen et al. 1993).

An assessment of mortality of workers at the View-Master factory in Beaverton, Oregon found increases in deaths from kidney cancer in women and two types of digestive cancers in men. The maximum TCE level was 1,600 ppb in contaminated water from the on-site well.

Groundwater is believed to have been contaminated for more than 30 years. Further study is being conducted and this information is preliminary (unpublished).

Based on Indiana Cancer Registry data (1990-1999), leukemia and non-Hodgkins lymphoma were not elevated in the area of the groundwater plume from the Conrail site (ATSDR 2005). No new cases of primary liver cancer, chronic lymphocytic leukemia, or Hodgkin's lymphoma were recorded for this area for the 10-year period. Cancer mortality data were reviewed but they were not in a format that allowed analyses of an exposed versus non-exposed population. The TCE maximum, 4,870 ppb, in a private well was recorded in the 1980s. The plume contained other organic contaminants such as carbon tetrachloride (CCL_4). Nine wells serving an estimated 36 people were contaminated with TCE at 300 ppb or higher. With respect to cancer risk, ATSDR concluded that individuals who used TCE-contaminated well water above 300 ppb may have experienced an increased cancer risk (ATSDR 2005). Exposure to TCE levels below 300 ppb are associated with a greater level of uncertainty and may present a lower cancer risk. The risk of cancer is much lower than the risk of non-cancer effects.

At the Lusher site, there was one residence on 17th Street where the maximum TCE concentration was 804 ppb in the late 1980s. Additionally, there was one business on West Lusher where the maximum TCE concentration was 608 ppb. In 2005, a residence on Avalon Street had a private well water maximum of 700 ppb TCE in untreated water; however, residents were drinking filtered water and were not exposed to the VOC contamination. Lusher residents exposed to the highest TCE levels in water have an increased cancer risk.

Scenario 2- Inhalation of Indoor Air from Showering Exposure

In Scenario 2, inhalation of TCE from showering and other household uses is discussed. Inhalation with skin absorption of TCE may have occurred during showering if a resident did not have a whole house filter (point of use filters may have been installed so that water at the tap is filtered but other water, such as shower water, remains unfiltered).

Assuming a 60% indoor volatilization of TCE from water, the expected air concentration is directly proportional to the water concentration and for simplicity purposes can be estimated at approximately twice the water concentration (Table 5). An estimate of the TCE concentration in air while showering has been presented as a range, the lower end being the estimated concentration for a child and the upper end being for the estimated concentration for an adult (some parameters involved in the calculation are listed in the table).

ATSDR has several comparison values for inhalation of TCE (ATSDR 1997a). The intermediate MRL of 100 ppb is derived from a LOAEL of 50,000 ppb for neurological effects in rats: decreased wakefulness during the exposure and decreased slow wave sleep after the exposures. Disturbed heart rates and sleep patterns have also been seen in people exposed to organic solvents. The acute MRL of 2000 ppb is derived from a LOAEL of 200,000 ppb for mild subjective neurological effects in rats. *The margins of exposure in Table 5 indicate that Lusher residents are at low risk for mild neurological effects due to TCE inhalation exposure.*

If we assume that the Lusher shower air and ingestion doses are comparable (Couch and Andelman, 1984; discussed further under Scenario 3), then the dose from inhalation is estimated at 0.02 mg/kg/day (when the water concentration is 500 ppb, the air concentration is estimated at 1000 ppb).

Table 5. Inhalation TCE concentrations compared to LOAEL for Mild Neurological Effects

TCE Concentration in Water (Cw) (ppb)	Showering Inhalation Concentration Range (ppb) child to adult	Estimated conc. 2*Cw (ppb)	LOAEL Mild Neurological Effects (ppb)	Margin of Exposure (MOE) For 2*Cw
1000	1700-2600	2000	50,000	25
700	1160-1820	1400	50,000	36
500	830-1300	1000	50,000	50
300	500-780	600	50,000	83
100	170-260	200	50,000	250
30	50-80	60	50,000	833
5	8-13	10	50,000	5000

Inhalation concentration includes dermal absorption and is based on the TCE concentration in water, a 10-15 minute shower time and a bathroom after shower exposure time of 15-30 minutes
LOAEL- Lowest Observed Adverse Effect Level
MOE = LOAEL/estimated dose
2*Cw = Two times the concentration in water

Human exposures to TCE have resulted in some neurological symptoms but at much higher concentrations (greater than 27,000 ppb or about 17 times higher than the highest known Lusher exposure of 804 ppb in water with a corresponding estimate of 1608 ppb for inhalation) than estimated for non-occupational inhalation at the Lusher site. Several occupational studies report human neurological effects from TCE exposures. One such study was conducted among 99 Danish metal degreasers (Rasmussen et al. 1993). A significant dose-response relation between solvent exposure and clinical neurological signs of motor dyscoordination was found. Although more cranial nerve dysfunction was reported for workers in the highest exposure group, the authors conclude that no significant cranial nerve dysfunction was found. Based on this study, motor dyscoordination is not anticipated for Lusher residents given their estimated inhalation exposures (Table 5). Additionally, based on ATSDR's MRLs, water concentrations and corresponding inhalation of TCE vapors at the Lusher site are not expected to cause effects to the immune system, lung, or liver.

Scenario 3- Ingestion and Inhalation

Scenario 3 is a combination of the first two scenarios and includes both ingestion of TCE-contaminated drinking water and inhalation of TCE during showering (Table 6). Based on the work of Couch and Andelman (1984), we have conservatively estimated ingestion and inhalation to be equivalent to two times the ingestion dose. In other words, we are assuming that shower air and ingestion doses are comparable.

In 1984, Couch and Andelman investigated the volatilization of TCE into indoor air from well water containing about 40 mg/l (40 ppm or 40,000 ppb) (Andelman1985). Assuming 1 hour per week in the shower and an air breathing volume of 1.2 cubic meters (m^3), they calculated that the shower air (48 mg TCE/week) and ingestion (42 mg TCE/week) doses were comparable. The water concentrations at Lusher (<800 ppb) are approximately 5 times lower than the

concentration monitored by Couch and Andelman. If we assume that the Lusher shower air and ingestion doses are comparable, the estimated combined ingestion and inhalation dose doubles and the margin of exposure is approximately half that of ingestion alone (Table 6, Approach 1). Calculating a combined total dose (Table 6, approach 2) gives us slightly more conservative numbers.

The same health effects are applicable for a combined exposure of ingestion and inhalation as for ingestion or inhalation alone; however, the effect may be applicable at lower water concentrations. *Our analysis suggests that pregnant women who drank and showered with TCE contaminated water containing the highest site concentrations may have been at increased risk of having children with cardiac defects.* The unborn child (as a fetus in utero) was at increased risk of having heart problems (cardiac defects) from maternal exposure to TCE at these levels.

Table 6. Ingestion and Inhalation*: Estimated TCE doses compared to LOAEL for Developmental and Cardiac Effects

TCE Concentration in Water (ppb)	Estimated Dose (mg/kg/day) Ingestion	Approach 1 Estimated Dose (mg/kg/day) Ingestion Inhalation comparable	Approach 1 Margin of Exposure	Approach 2 Combined Total Dose (mg/kg/day)	Approach 2 Margin of Exposure	LOAEL (mg/kg/day) Developmental, Cardiac Effects
1000	0.04	0.08	0.6	0.12	0.4	0.05
700	0.03	0.06	1	0.09	0.6	0.05
500	0.02	0.04	1.3	0.06	0.8	0.05
300	0.01	0.02	2.5	0.04	1.3	0.05
100	0.004	0.008	6	0.01	4	0.05
30	0.001	0.002	25	0.004	13	0.05
5	0.0002	0.0004	125	0.0006	78	0.05

LOAEL- Lowest Observed Adverse Effect Level

* Inhalation concentration includes dermal absorption and is based on the TCE concentration in water, a 10-15 minute shower time and a bathroom after shower exposure time of 15-30 minutes

Scenario 4: Vapor Intrusion

Vapor intrusion refers to the transport of vapors from the subsurface into buildings. The volatile organic contaminants at the Lusher Site (such as TCE and TCA) could pose vapor intrusion problems.

Different building construction techniques and conditions may have different impacts on the ability of vapors to enter indoor space. Basements may have more surface area through which vapors can move inside and may be closer to subsurface sources. Vapors can migrate from soil gas and enter below-grade basements through cracks in walls and floors. Basements usually have lower air pressures then the surrounding soil gas which drives the flow of vapors into residences. Additionally, slabs may impede vapors better. Residences with crawl spaces and dirt floors may have lower levels of indoor VOCs than homes with basements. Typically, indoor air levels from

vapor intrusion are orders of magnitude lower than sub-slab results including basement slabs (for example, sub-slab may be 1,000 ppb of a VOC and indoor air 10 ppb). Soil gas levels are often an order of magnitude higher than groundwater concentrations (ATSDR 2008).

Vapor intrusion is feasible at the Lusher Site. Basements are common within the Lusher Site area. However, TCE and TCA are heavier than water and will tend to sink in the aquifer as they migrate from the source. Thus, homes in the area may not have vapor intrusion concerns even if the groundwater below their homes is contaminated. However, there may be some Lusher Site areas where vapor intrusion is a concern due to proximity to a source and rapid horizontal migration of contamination. Additionally, not all sources may be identified as yet. Intrusion of TCE vapors may increase the cancer risk. Source areas where soil gas is contributing to vapor intrusion should also be monitored.

Businesses at or near source areas may have indoor air quality problems. If product has been spilled or dumped onto the ground surface and trapped in soil gas, it may migrate indoors. Indoor air could also be affected from groundwater contamination off-gassing into soil gas or directly into surface structures. OSHA standards may need to be applied in such circumstances and potentially vapor abatement systems installed. *EPA should consider monitoring for vapor intrusion at businesses that are found to be close to a source of VOC contamination.*

At the Conrail Superfund site adjacent to Lusher, TCE was sampled in indoor air of 15 homes. No levels exceeding the air comparison value were found (ATSDR 2005). However, nine homes were remediated based on carbon tetrachloride levels in indoor air.

At the Lusher site, indoor air samples were collected from three residential locations in August 2006 (US EPA 2007). Summa canisters were used to collect samples for VOC analyses. The TCE concentrations in indoor air ranged from 3.9 to 20 $\mu g/m^3$ but did not exceed a screening value of 40 $\mu g/m^3$. The TCA concentrations in indoor air ranged from approximately 1.0 to 2.1 $\mu g/m^3$. These TCA levels are below our screening values of 4000 and 5000 $\mu g/m^3$. These data suggest that vapor intrusion is unlikely to be at levels that pose a health hazard. Indoor air quality is more likely to be impacted by use of contaminated water in the home than by vapor intrusion. *EPA should consider monitoring indoor air during showering events in select homes to help quantify exposures.*

Exposure to TCA

Historically, the maximum TCA concentration of 3800 ppb was recorded at a business on West Lusher Avenue and 1590 ppb at a residence (Table 2). The reference dose for chronic oral ingestion of TCA is 2 mg/kg/day and the doses from ingestion of 3800 ppb would range from 0.1 to 0.6 mg/kg/day (lower than the reference dose). In 2006, the concentrations were below the MCL of 200 ppb. Drinking water even from the most contaminated well is unlikely to have resulted in adverse health effects. Concerning TCA in the body, nearly all of it quickly leaves in the air you exhale reducing the potential for health effects (ATSDR 2006).

Inhalation during and after showering with water containing 1590 ppb (the highest residential TCA concentration) would result in dermal and inhalation intakes of 2677-4188 $\mu g/m^3$, near or below our screening values of 4000 and 5000 $\mu g/m^3$. An acute inhalation MRL of 2 ppm (10,800 $\mu g/m^3$) is derived from a study based on the lowest level known to cause harmful effects, which is 175 ppm for reduced performance in psychomotor tests (ATSDR 2006). We do not anticipate health effects based on the showering scenario for TCA-exposed residents.

Although TCA in shallow groundwater could have contributed to vapor intrusion, we have no site-specific historical indoor air data on which to assess potential exposure and health effects. The depths of the wells containing the highest concentrations of TCA are unknown such that data are insufficient to determine whether vapors could have entered a building. However, based on EPA's vapor intrusion database, the highest TCA level measured in a residence as a result of vapor intrusion is 150 $\mu g/m^3$ (US EPA 2008b). These results suggest that concentrations of TCA from vapor intrusion at Lusher are unlikely to be harmful.

Table 7. Summary of Potential Health Effects by Route(s) of Exposure for Lusher Private Well Users

Contaminant/Health Effect	Drinking Water (ingestion)	Showering (inhalation and dermal)	Drinking Water plus Showering (ingestion, inhalation, dermal)	Vapor Intrusion (inhalation)
TCE noncancerous	Possible from drinking water from a limited number of private wells having the highest contamination levels *; increased risk of cardiac defects (heart problems) and other developmental effects for the developing embryo	Possible from a limited number of private wells having the highest contamination levels * Mild neurological effects not indicated; possible contribution to risk of cardiac defects and other developmental effects for the developing embryo	Possible from a limited number of private wells having the highest contamination levels *; increased risk of cardiac defects and other developmental effects for the developing embryo	Unknown limited indoor air & no sub-slab, or soil gas data
TCE cancerous	Possible from a limited number of private wells having the highest contamination levels *; increased risk of childhood leukemia or non-Hodgkins lymphoma from maternal exposure** Unlikely, but possibility of adult cancer	Possible from a limited number of private wells having the highest contamination levels *; Possible effects with children being most sensitive (see cancer discussion) Unlikely, but possibility of adult cancer	Possible from a limited number of private wells having the highest contamination levels *; increased risk of childhood leukemia or non-Hodgkins lymphoma from maternal exposure** Unlikely, but possibility of adult cancer	Unknown limited indoor air & no sub-slab, or soil gas data
TCA noncancerous	Unlikely, None indicated	Unlikely, None indicated	Unlikely, None indicated	Unlikely based on data in U.S. EPA's Vapor Intrusion Database.

* In the late 1980s, two private wells had concentrations exceeding 600 ppb TCE with an estimated exposed population of 53 people. The contaminated wells were located at one business on West Lusher Avenue and at one residence on 17th Street. Although one residential well on Avalon Street had a TCE concentration of 700 ppb in 2005, the residents were drinking filtered water and were not exposed to the contamination. Other private wells, which were sampled in the late 1980s and in 2005/2006, contained less than 106 ppb TCE.
**Potential cancers are described in Appendix E.

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. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

Children are the most sensitive group at the Lusher site. The most sensitive effects of TCE exposure for noncancerous health effects are on the developing embryo. Pregnant women who used private wells at the Lusher Site with the highest TCE concentrations for drinking water and showering had an increased risk of having newborns with heart defects (note-- the highest TCE concentrations at the Lusher site exceeded 600 ppb TCE in the late 1980s. These concentrations were found in two private wells: a well at a business on West Lusher Avenue and at a residence on 17th Street. We have estimated the exposed population at 53 people). Children, whose mothers used well water with the highest TCE concentrations while pregnant with that child, had an increased risk of developing cancer such as leukemia or non-hodgkins lymphoma (These cancers are described in Appendix E).

Pregnant women and those planning to become pregnant who drink private well water should be advised about the potential hazards of TCE exposures on their developing child. Currently, wells that have been tested and found to contain TCE exceeding EPA's MCL of 5 ppb are not being used for drinking water.

Developing children may be more susceptible than adults to the toxic effects of VOCs. Babies at the crawling stages or children playing near the floor may be exposed to heavy vapors that could accumulate there. TCE and TCA vapors are heavier than air and tend to lie low near the floor where young children may be playing. There have been delays in developmental milestones and impaired performance in neurobehavioral tests in mouse pups of dams exposed to TCA vapors during later stages of gestation (ATSDR 2006). Teenagers may have greater exposure to vapors from showering if they take prolonged or multiple showers per day.

Conclusions

The unconfined sand and gravel aquifer, which is used for drinking water and other uses at the Lusher Site in Elkhart, currently contains chlorinated volatile organic compounds at levels of public health concern.

Twenty-eight private wells have been contaminated with TCE (5 to 804 ppb) and/or TCA (200 to 3800 ppb) above drinking water standards (MCLs) used for public water supplies. The estimated exposed population, who used these wells, is approximately 200 people. We estimate that 53 of the 200 people were exposed to hundreds of ppb TCE in the late 1980s and are at greater risk for adverse health effects. These exposures to contaminated groundwater came from 2 private wells, one of which was a business location.

Children are the most sensitive group at the Lusher site for exposure to VOCs. Children, whose mothers used well water with hundreds of ppb TCE while pregnant with that child, had an increased risk of developing cancer such as leukemia or non-hodgkins lymphoma. Additionally, they were also at increased risk of adverse birth outcomes such as developmental and cardiac effects. Lusher residents (children and adults) exposed to the highest TCE levels in water have an increased cancer risk. However, we consider the risk of developing adult cancer resulting from TCE exposure to be low.

EPA conducted air monitoring in three residences with the highest VOCs. The results indicated that indoor air concentrations of VOCs were not at levels of health concern.

ATSDR categorizes the site as a past public health hazard. Due to uncertainties concerning sources, continuing migration of contaminants, and private well use, the site could pose a future public health hazard. Currently, exposure has been mitigated or lessened through provision of alternate water and filter systems for private well users with contaminated water above MCLs. Currently, we consider the site to be an indeterminate public health hazard due to data gaps such as a comprehensive private well survey, indoor air testing, and vapor intrusion data.

Recommendations

Residents who are using private well water for drinking water and other uses and are within the Lusher VOC boundary of contamination should have their wells sampled if that has not previously been done.

Although the indoor air of three residences has been monitored, we recommend additional and more extensive indoor air monitoring. Due to the potential exposure to indoor showering and vapor intrusion, especially for children, we recommend monitoring in the homes with the highest potential for such exposures. Specifically, we recommend collecting data to evaluate worst case scenarios for shower exposures in homes without whole-house filters. *EPA should consider monitoring indoor air during showering events in select homes to help quantify exposures.* EPA should also consider sampling hot spot areas or places likely to receive preferential pathway gases (such as along utility, pipe, or other lines) for vapor intrusion.

Exposure to VOCs in indoor air can be minimized with good ventilation and filtering. The use of exhaust fans, during and after showering, is recommended for people still showering with contaminated water. Whole-house fans could also be used to exhaust indoor air. Residents could also install carbon filters for shower water as a preventive measure if they want to minimize exposure to site contaminants.

Businesses that are using private well water for drinking water and are within the Lusher VOC boundary of contamination should have their wells sampled if that has not previously been done. *EPA should consider monitoring for vapor intrusion at businesses that are found to be close to a source of VOC contamination.*

Pregnant women and those planning to become pregnant who drink private well water should be advised about the potential hazards of TCE exposures on their developing child. Currently, wells that have been tested and found to contain TCE exceeding EPA's MCL of 5 ppb are not being used for drinking water.

EPA or IDEM should conduct a comprehensive private well survey to identify additional private well users. They should continue to prevent exposure to VOCs in groundwater through alternate water provision as necessary.

EPA or IDEM should place some monitoring wells near the maximum TCE concentration on Avalon Street to help establish the depth of this contamination and whether or not wells in the vicinity are likely to become contaminated. We recommend that municipal water lines be extended to this Avalon Street residence to eliminate the need for whole-house filter maintenance.

Public Health Action Plan

EPA is conducting a Remedial Investigation/Feasibility Study (RI/FS) for the Lusher Avenue Groundwater Contamination Site and will determine the sources of VOCs as feasible. Most of our recommendations will be conducted by EPA or the potentially responsible parties during their routine RI/FS program. ATSDR has requested that indoor air sampling be conducted early in EPA's remedial process.

EPA plans to place some monitoring wells at the former dump location near Flake and Albany Streets to determine if the dump is a source of VOCs to this area.

EPA and IDEM should continue to connect residences and businesses to city water or provide filters as appropriate.

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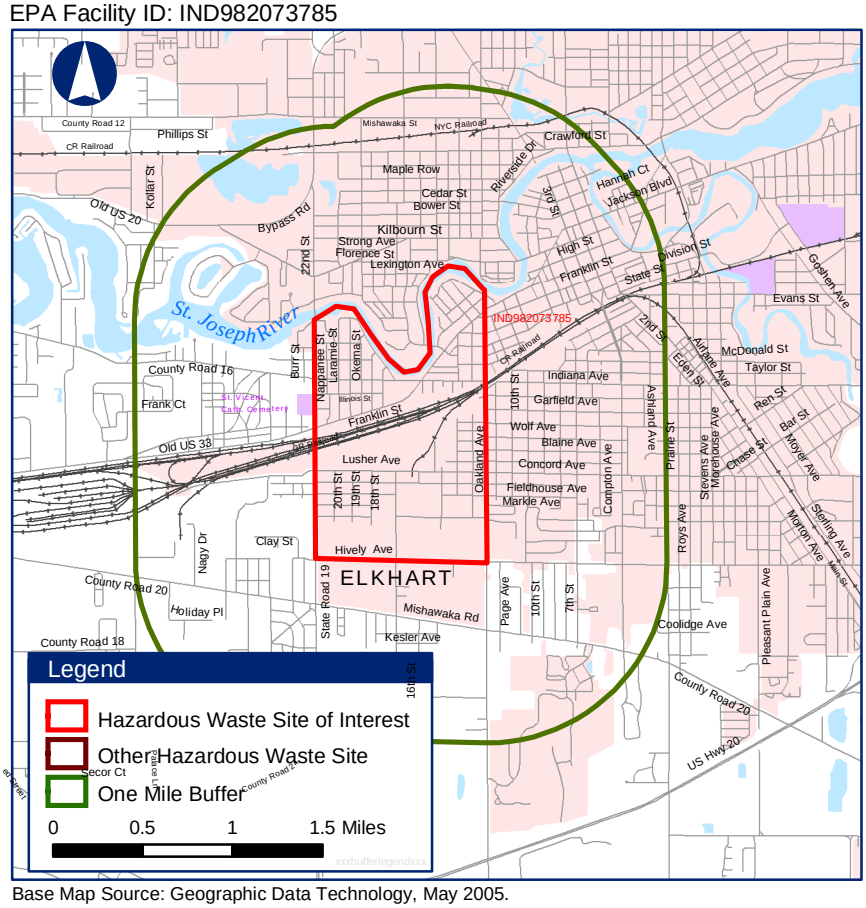
Figure 1

Lusher Street Groundwater Contamination

Elkhart, IN

EPA Facility ID: IND982073785

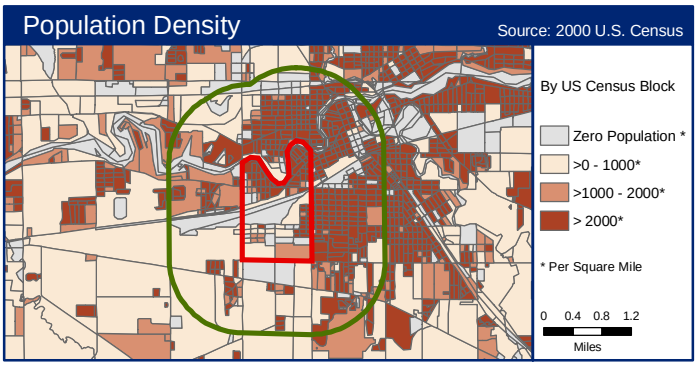


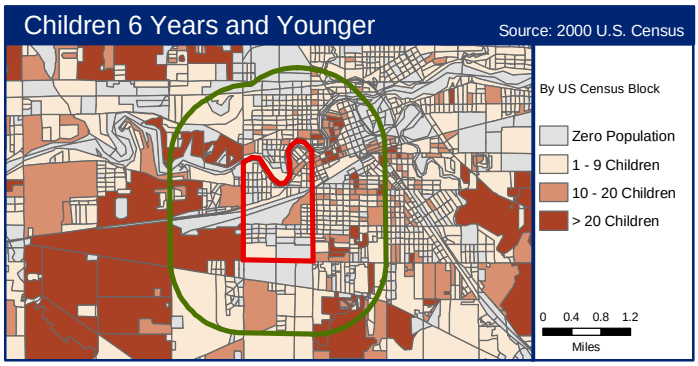
Demographic Statistics
Within Area of Concern*

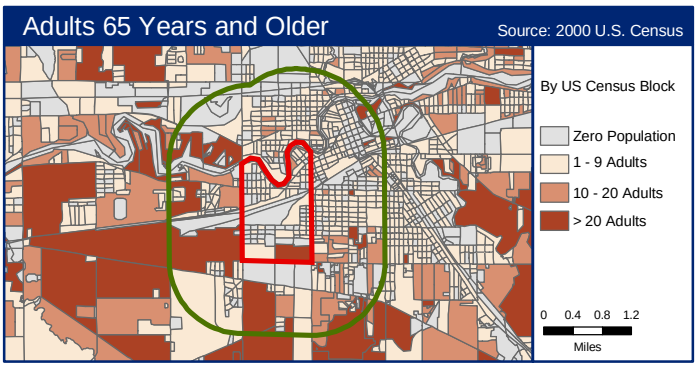
	Within Site Boundary	1mi
Total Population	2,597	24,690
White Alone	1,823	15,819
Black Alone	437	5,005
Am. Ind. & AK Native Alone	10	119
Asian Alone	14	229
Native Hawaiian & Other Pacific Islander Alone	0	29
Some Other Race Alone	207	2,698
Two or More Races	106	790
Hispanic or Latino**	368	4,261
Children Aged 6 & Younger	286	3,068
Adults Aged 65 & Older	337	2,580
Females Aged 15 to 44	520	5,543
Total Housing Units	1,053	9,802

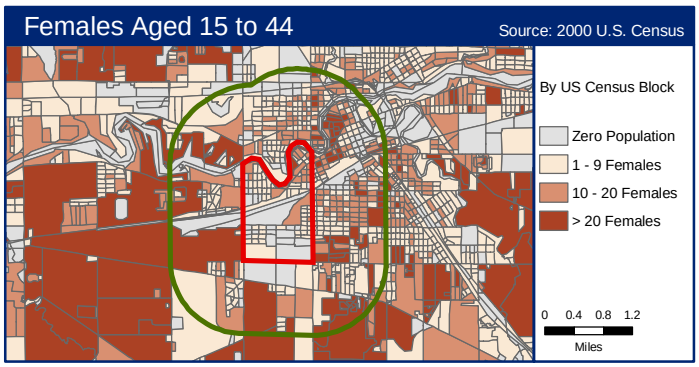
Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Indiana East FIPS 1301 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.





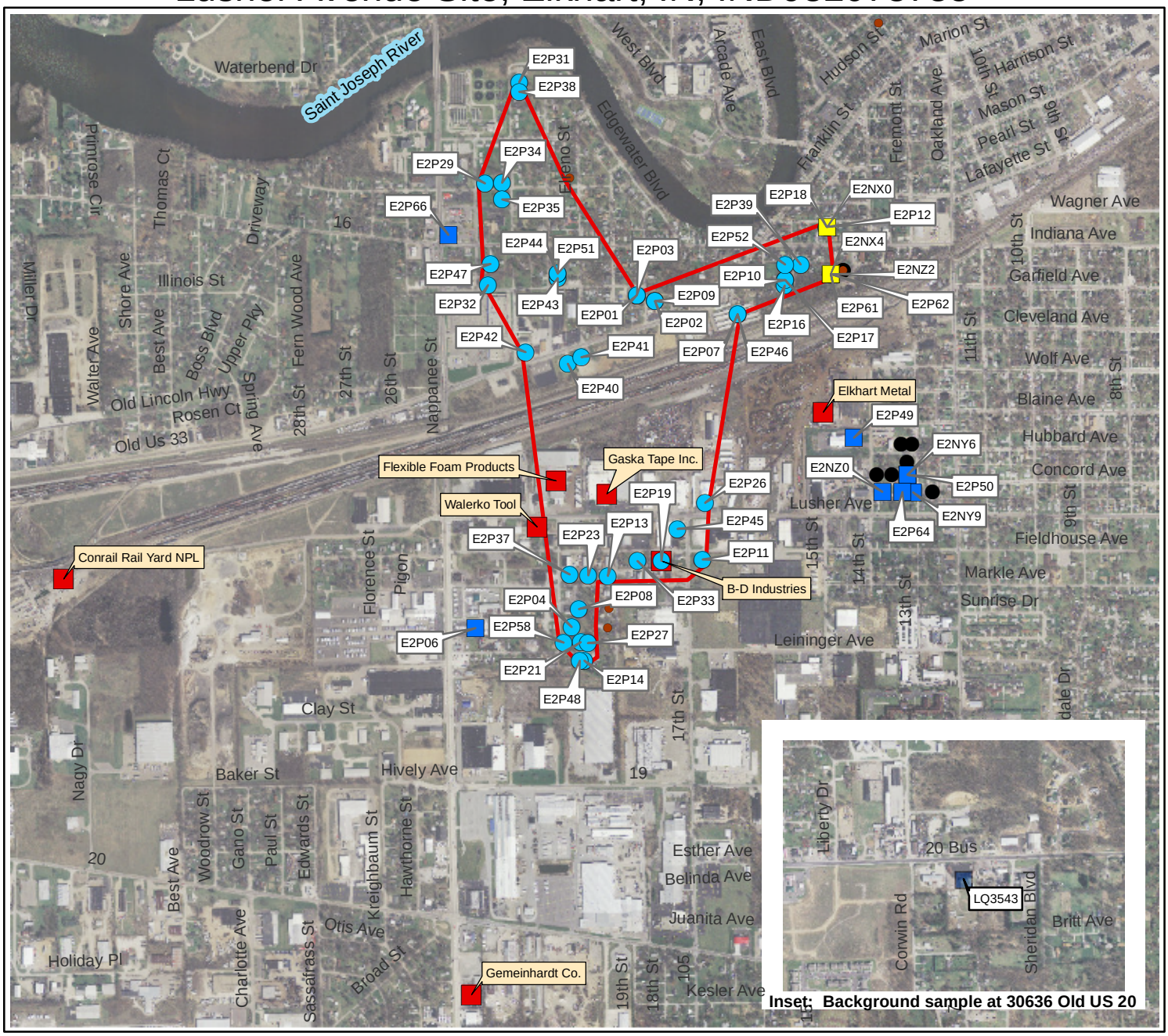




<project=03219><userid=JXA0><geo=Elkhart County, IN><keywords=IND982073785, Lusher, Groundwater>

Figure 2

Ground Water Plume Boundary Map defined by Chlorinated VOCs from Key Findings Lists, Events 3, 4, & 5 including Potential Sources Lusher Avenue Site, Elkhart, IN, IND982073785



Legend

- Sample Location with chlorinated VOCs from Keyfindings List, event 3 - labeled)
- Sample location with chlorinated VOCs (from key findings list, events 4/5 - labeled)
- Potential contamination sources
- Background samples
- Ground water plume
- Sample location from event 4
- Sample location from event 5
- Sample location from event 3

0 500 1,000 2,000 Feet

0 250 500 1,000 Meters

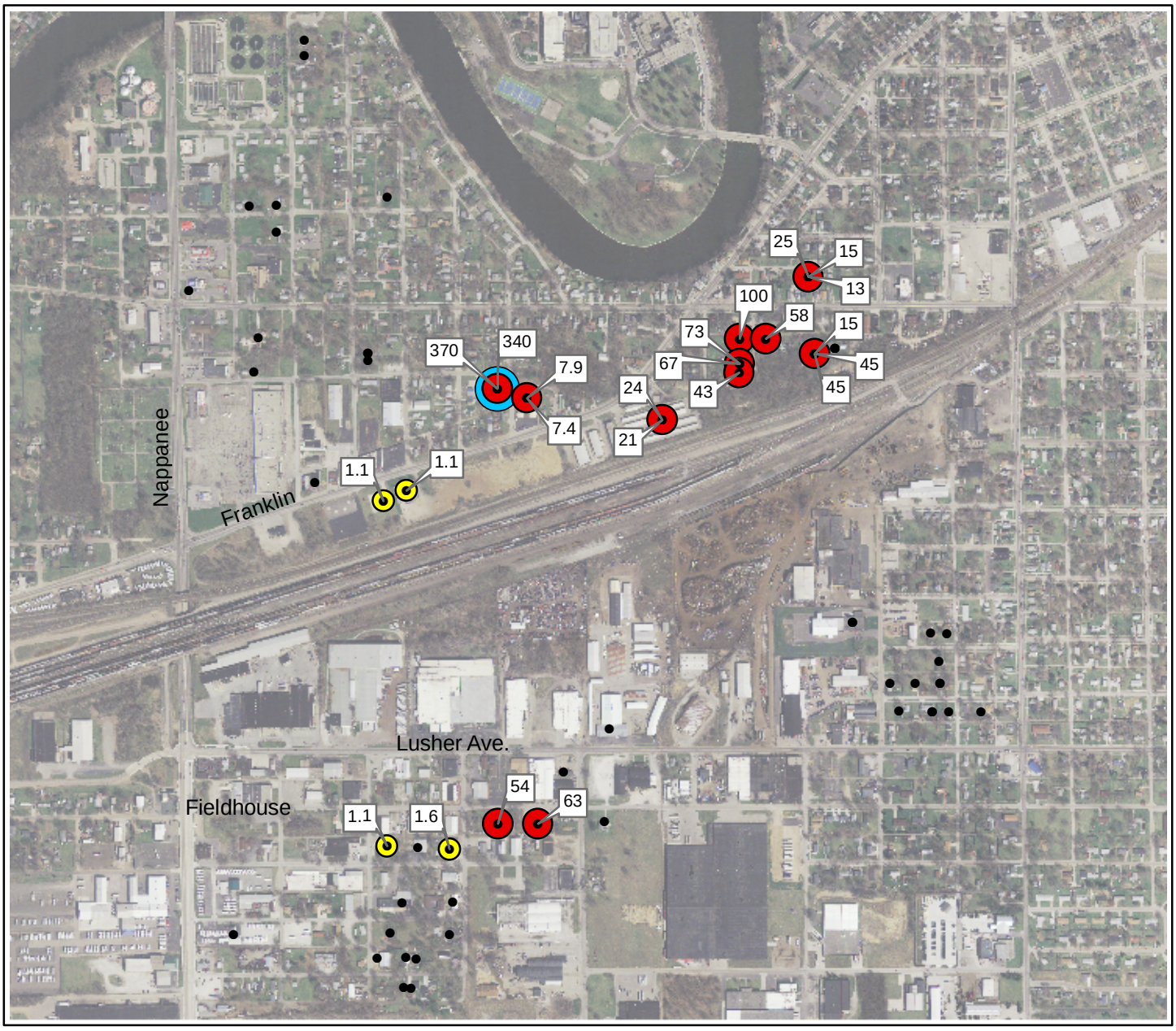
IDEM
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Revised final on July 17, 2007
by Lorraine Wright.
Updated September 16, 2008 by Barry Steward,
Engineering & GIS Services
Office of Land Quality
Indiana Department of Environmental Management

Source:
Road layer from Tele Atlas North America 2007.
2005 Orthophotos - Color aerial imagery collected in Spring 2005, as part of the Indiana Statewide Orthophotography Project. Points for sample locations were located using a combination of digitizing and geodcoding. The geocoding was matched using Elkhart, IN data. Samples that couldn't be located using geocoding where located using google maps and project manger identification. The sample points represent samples collected during sample events 3, 4, and 5. The yellow and blue points represent locations where chlorinated VOCs were detected at concentrations greater than the detection limit. The ground water plume boundary was defined by drawing a line connecting the outter most ground water wells with known detections (greater than detection limit) of chlorinated VOCs based on the Key Findings Lists for events 3, 4, and 5 (level 1 and 2 data). Wells that showed a detection of a chemical without an MCL were not include in the Key Findings Lists.

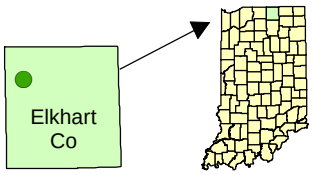
DISCLAIMER:
This map does not represent a legal document. It is intended to serve as an aid in graphic representation only. Information shown on this map is not warranted for accuracy. This map does not contain sensitive or classified information.

Figure 3
Lusher Avenue Site Trichloroethylene (TCE) Detections from Key Findings Lists, Events 3, 4, & 5
Elkhart, IN, IND9820737885



Legend

- Ground water wells sampled
- TCE concentrations greater than or equal to the TCE detection limit 0.5 ug/l and/or below the MCL 5 ug/l
- TCE concentrations greater than or equal to the MCL 5 ug/l
- Highest TCE concentration of 700 ug/l sampled October 2005 - before filter
- Lusher Avenue Site
- Elkhart County



0 262.5 525 1,050 Feet

0 100 200 400 Meters

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Mapped on August 6, 2008
by Lorraine Wright
Reviewed by Barry Steward
Engineering and GIS Services
Science Services Branch
Office of Land Quality
Indiana Department of Environmental Management

Source:
2005 Natural Color Indiana Orthophotography (IndianaMap Framework Data at www.indianamap.org). Projected coordinate system NAD_1983_UTM_Zone_16N. Ground water wells sampled on: 9/12/06 - Event 3; 12/5-6-7/08 - Event 4; and 12/13/06 - Event 5. Points for ground water wells were located using a combination of digitizing and geocoding. The geocoding was matched using Elkhart, IN data. Samples that couldn't be located by geocoding where located using google maps and project manger identification. Wells that showed a detection of a chemical without an MCL were not included in the Key Findings Lists.

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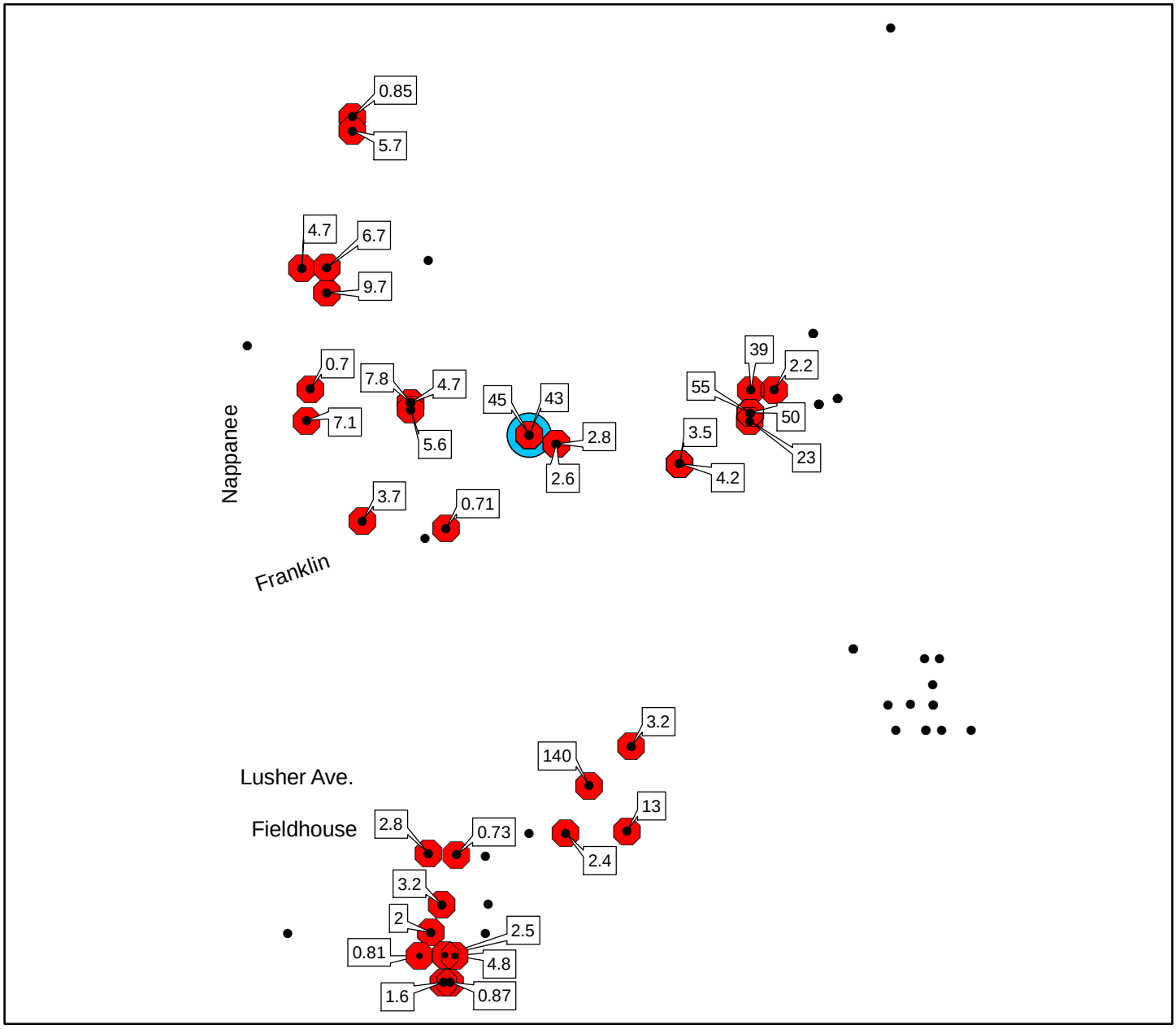
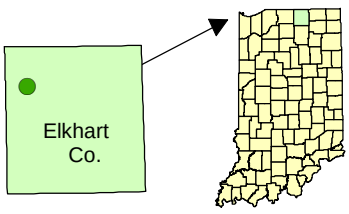
Figure 4

Lusher Avenue Site - 1,1,1 Trichloroethane (TCA) Detections from Key Findings Lists, Events 3, 4, & 5 Elkhart, IN, IND9820737885



Legend

- Ground water wells sampled
- TCA concentrations greater than or equal to the TCA detection limit 0.5 ug/l and/or below MCL 200 ug/l
- Highest TCE concentration of 700 ug/l sampled October 2005 - before filter
- Lusher Avenue Site
- Elkhart County



0 260 520 1,040 Feet

0 100 200 400 Meters

IDEM
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Mapped on August 8, 2008
by Lorraine Wright
Reviewed by Barry Steward
Engineering and GIS Services
Science Services Branch
Office of Land Quality
Indiana Department of Environmental Management

Source:
2005 Natural Color Indiana Orthophotography (IndianaMap Framework Data at www.indianamap.org). Projected coordinate system NAD_1983_UTM_Zone_16N. Ground water wells sampled on: 9/12/06 - Event 3; 12/5-6-7/08 - Event 4; and 12/13/06 - Event 5. Points for ground water wells were located using a combination of digitizing and geocoding. The geocoding was matched using Elkhart, IN data. Samples that couldn't be located by geocoding where located using google maps and project manger identification. Wells that showed a detection of a chemical without an MCL were not included in the Key Findings Lists.

DISCLAIMER:
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APPENDICES

Appendix A. List of Comparison Values Used by ATSDR

Comparison Values

ATSDR 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 "contaminants of concern." The latter term should not be misinterpreted as an implication of "hazard." As ATSDR uses the phrase, a "contaminant of concern" is a chemical substance detected at the site in question and selected by the ATSDR scientist for further evaluation of potential health effects. Generally, a chemical is selected as a "contaminant of concern" because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's comparison values.

Nevertheless, it must be emphasized that comparison values are not thresholds of toxicity. Although concentrations at or below the relevant comparison values could 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. The principal purpose behind conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health hazards before they become actual public health consequences. Thus comparison values are designed to be preventive—rather than predictive—of adverse health effects. The probability that such effects will actually occur does not depend on environmental concentrations alone, but on a unique combination of site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure.

Listed and described below are the various comparison values that ATSDR uses to select chemicals for further evaluation, as well as other non-ATSDR values that are sometimes used to put environmental concentrations into perspective.

CREG	=	Cancer Risk Evaluation Guide
MRL	=	Minimal Risk Level
EMEG	=	Environmental Media Evaluation Guide
IEMEG	=	Intermediate Environmental Media Evaluation Guide
RMEG	=	Reference Dose Media Evaluation Guide
RfD	=	Reference Dose
RfC	=	Reference Dose Concentration
RBC	=	Risk-Based Concentration
MCL	=	Maximum Contaminant Level
LTHA	=	Lifetime Health Advisory

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors, or cancer potency factors, using default values for exposure rates. That said, however, neither CREGs nor cancer slope factors can be used to make realistic predictions of cancer risk. The true risk is always unknown and could be as low as zero.

Minimal Risk Levels (MRL) are estimates of daily human exposure to a chemical (doses expressed in mg/kg/day) that are unlikely to be associated with any appreciable risk of deleterious non-cancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute (those occurring for 14 days or less), intermediate (those occurring for more than 14 days and less than 1 year [15-364] days), and chronic (those occurring for one year [365 days] or greater) exposures. MRLs for specific chemicals are published in ATSDR toxicological profiles.

Environmental Media Evaluation Guides (EMEGs) are concentrations that are calculated from ATSDR minimal risk levels by factoring in default body weights and ingestion rates.

They factor in body weight and ingestion rates for acute exposures (Acute EMEGs — those occurring for 14 days or less), for intermediate exposures (Intermediate EMEGs — those occurring for more than 14 days and less than 1 year), and for chronic exposures (Chronic EMEGs — those occurring for one year [365 days] or greater).

Lifetime Health Advisory is an EPA value used for drinking water.

Reference Dose Media Evaluation Guides (RMEGs) represent the concentration of a contaminant in air, water, or soil that corresponds to EPA's RfD for that contaminant when default values for body weight and intake rates are taken into account.

Reference Dose (RfD) is an estimate of the daily exposure to a contaminant unlikely to cause noncarcinogenic adverse health effects. Like ATSDR's MRL, EPA's RfD is a dose expressed in mg/kg/day.

Reference Concentrations (RfC) is a concentration of a substance in air that EPA considers unlikely to cause noncancer adverse health effects over a lifetime of chronic exposure.

Risk-Based Concentrations (RBC) are media-specific concentrations derived by Region III of the Environmental Protection Agency from RfDs, RfCs, or EPA’s cancer slope factors. They represent concentrations of a contaminant in tap water, ambient air, fish, or soil (industrial or residential) that are considered unlikely to cause adverse health effects over a lifetime of chronic exposure. RBCs are based either on cancer or non-cancer effects.

Maximum Contaminant Levels (MCLs) represent contaminant concentrations in drinking water that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day.

More information about the ATSDR evaluation process can be found in ATSDR’s Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/phamanual/. A hard copy can be obtained by contacting the ATSDR information line toll-free at (888) 422-8737.

Appendix B. ATSDR's Methods

Contaminant Data Evaluation

In public health assessments, ATSDR addresses the likelihood that exposure to contaminants, using the maximum or average concentrations detected, would result in adverse health effects. While the relative toxicity of a chemical is important, the response of the human body to a chemical exposure is determined by several additional factors, including the concentration (how much), the duration of exposure (how long), and the route of exposure (breathing, eating, drinking, or skin contact). Lifestyle factors (i.e., occupation and personal habits) also have a major impact on the likelihood, magnitude, and duration of exposure. Individual characteristics such as age, sex, nutritional status, overall health, and genetic constitution affect how a human body absorbs, distributes, metabolizes, and eliminates a contaminant. A unique combination of all these factors will determine the individual's physiologic response to a chemical contaminant and any adverse health effects the individual could suffer as a result of the chemical exposure.

ATSDR has determined levels of chemicals that can reasonably (and conservatively) be regarded as harmless, based on the scientific data the agency has collected in its toxicological profiles. The resulting comparison values and health guidelines, which include ample safety factors to ensure protection of sensitive populations, are used to screen contaminant concentrations at a site and to select substances ("chemicals of concern") that agency environmental health scientists and toxicologists scrutinize more closely.

It is a point of key importance that ATSDR's (as well as state and federal regulatory agency) comparison values, screening numbers and health guidelines define very conservative and protective levels of environmental contamination and are not thresholds of toxicity. This means that although concentrations at or below a comparison value could reasonably be considered safe, it does not automatically follow that any concentration above a comparison value will necessarily produce toxic effects. To the contrary, ATSDR's comparison values are intentionally designed to be much lower, usually by at least two or three orders of magnitude, than the corresponding no-effect levels (or lowest-effect levels) determined from scientific studies. ATSDR uses comparison values (regardless of source) solely for the purpose of screening individual contaminants. In this highly conservative procedure, ATSDR may decide that a compound warrants further evaluation if the highest single recorded concentration of that contaminant in the medium in question exceeds that compound's lowest available comparison value (e.g., cancer risk evaluation guides or other chronic exposure values) for the most sensitive, potentially exposed individuals (e.g., children or pica children). This conservative process results in the selection of many contaminants as "chemicals of concern" that will not, upon closer scrutiny, be judged to pose any hazard to human health. Still, ATSDR judges it prudent to use a screen that "lets through" many harmless contaminants rather than one that overlooks even a single potential hazard to public health. Even those contaminants of concern that are ultimately labeled in the toxicologic evaluation as potential public health hazards are so identified solely on the basis of the maximum concentration detected. The reader should keep in mind the protective nature of this approach when considering the potential health implications of ATSDR's evaluations.

Because a contaminant must first enter the body before it can produce any effect on the body, adverse or otherwise, the toxicologic discussion in public health assessments focuses primarily

on completed pathways of exposure, i.e., contaminants in media to which people are known to have been, or are reasonably expected to have been, exposed. Examples are water that could be used for drinking, and air in the breathing zone.

To determine whether people were, or continue to be, exposed to contaminants originating from a site, ATSDR evaluates the factors that lead to human exposure. These factors or elements include (1) a source of contamination, (2) transport through an environmental medium, (3) a point of exposure, (4) a route of human exposure, and (5) an exposed population. Exposure pathways fall into one of three categories:

- *Completed Exposure Pathway*. ATSDR calls a pathway "complete" if it is certain that people are exposed to contaminated media. Completed pathways require that the five elements exist and indicate that exposure to the contaminant has occurred, is occurring, or will occur.

- *Potential Exposure Pathway*. Potential pathways are those in which at least one of the five elements is missing but could exist. Potential pathways indicate that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Potential exposure pathways refer to those pathways where (1) exposure is documented, but there is not enough information available to determine whether the environmental medium is contaminated, or (2) an environmental medium has been documented as contaminated, but it is unknown whether people have been, or could be, exposed to the medium.

- *Eliminated Exposure Pathway*. In an eliminated exposure pathway, at least one of the five elements is missing and will never be present. From a human health perspective, pathways can be eliminated from further consideration if ATSDR is able to show that (1) an environmental medium is not contaminated, or (2) no one is exposed to contaminated media.

Appendix C. Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency in Atlanta, Georgia, with 10 regional offices in the United States. ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases from toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. For additional questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

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].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

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

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

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.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

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.

Bioavailability
The degree to which chemicals can be taken up by organisms

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

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

Cancer risk
A theoretical risk 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.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [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]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

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.

Completed exposure pathway [see exposure pathway].

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. The Superfund Amendments and Reauthorization Act (SARA) later amended this law.

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.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

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].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

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

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

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.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

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.

Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

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-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

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.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

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

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

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

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

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].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

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].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

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.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

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].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

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.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

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.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

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).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

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

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human 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].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

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.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

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].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

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 an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

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.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

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

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, 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.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

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].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

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

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

For more information on the work of ATSDR, please contact:
Office of Policy, Planning and Evaluation
Agency for Toxic Substances and Disease Registry
1600 Clifton Road, N.E. (Mail Stop F-61)
Atlanta, GA 30333
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Appendix D- VOCs at known well depths

Sampling ID Location	*Contaminant concentration (ppb)*	*Total well depth and/or screened interval (feet bgs)*
E2P02 Avalon St.	**TCE 7.4*** 1,1,1-TCA 2.6 Cis-1,2-DCE 0.64	22-26
E2P42 W. Franklin St.	1,1,1-TCA 3.7 PCE 0.73	20-30
E2P26 Lusher Ave.	1,1,1-TCA 3.2	38 34-38
E2P04 Borneman Av.	1,1,1-TCA 2.0	40 35-40
E2P41 W. Franklin St.	TCE 1.1 PCE 0.86 1,1,1-TCA 0.71	43 38-43
E2P66 S. Nappanee St. Background well	Non-Detect for VOCs	40-45
E2P64 Concord Ave. Background well	Non-Detect for VOCs	48 43-48
E2P38 Waurika St.	1,1,1-TCA 5.7 1,1-DCA 0.69	50-54
E2P29 Laramie St	1,1,1-TCA 4.7 1,1-DCA 0.56	100
E2P49 14th St. Background well	Non-Detect for VOCs	88-108
Sources: US EPA 2007, IN DNR electronic records. *exceeds the MCL of 5 ppb.		

Appendix E. Description of Potential Cancers

Leukemia

Leukemia is a cancer that originates in the bone marrow. It is characterized by the uncontrolled growth of developing marrow cells. Leukemia actually consists of a group of different cancers of white blood cells. Leukemias are typically categorized based on their cellular origin, myeloid (i.e., myelogenous) or lymphoid (i.e., lymphocytic), and their stage of progression based on the course of the disease if left untreated (i.e., acute or chronic). Acute leukemias (e.g., acute lymphocytic leukemia [ALL] and acute myelogenous leukemia [AML]) often result in internal bleeding, anemia, or infection. Many patients with chronic leukemias (e.g., chronic lymphocytic leukemia [CLL] and chronic myelogenous leukemia [CML]) do not exhibit clinical symptoms (Landis et al. 1999; Wu and Martinez 2000).

The cause of the different forms of leukemia appears to be multi-factorial. Genetic, viral, environmental factors (e.g., ionizing radiation), drugs, and chemicals (e.g., benzene, trichloroethylene) all have been implicated in the development of leukemia. It is believed that the final common pathway is damage to the DNA in one way or another. Patients with an abnormal number of chromosomes (e.g., trisomy 21) and chromosomal translocations are at an increased risk of developing ALL. Of those patients diagnosed with CML, 90% have an acquired chromosomal abnormality (Wu and Martinez 2000).

In 1999, 30,200 newly diagnosed cases of leukemia were reported in the United States. The incidence rates for each of the four primary types of leukemia ranges between 1 and 2.3 cases per 100,000 people per year. Of the leukemias diagnosed in the United States, approximately one-third were classified as AML (incidence = 2.3 cases per 100,000); About 26% were classified as CLL (Incidence rate = 2 cases per 100,000); about 15% were classified as CML (incidence rate = 1.3 cases per year); and about 10% were classified as ALL (incidence rate = 1 case per year). In general, males are diagnosed more often with each of the sub categories of leukemia (i.e., AML, CLL, CML, ALL) than females (Landis et al. 1999; Wu and Martinez 2000). For 1999 through 2002, leukemia ranked 7th for males and 11th for females out of the top 15 most common cancers for all races (Edwards et al. 2005).

Leukemia is the most common type of childhood cancer and accounts for 30% of all cancers diagnosed in children younger than 15 years (Belson et al. 2007). Within this population, ALL accounts for 78% of all childhood leukemia diagnoses. Possible risk factors are genetic, infectious, and environmental. Childhood leukemia and other cancers may stem from a combination of genetic susceptibility factors and environmental exposures. Some cases of childhood leukemia are believed to have originated in utero (Belson et al. 2007).

Non-Hodgkin's Lymphoma

Non-Hodgkin's lymphoma (NHL) is cancer that starts in lymphoid tissue (also called lymphatic tissue). NHL is a collection of more than a dozen different cancers of the lymphatic system. Cancers originating in other organs (e.g., the lung or colon) that then spread to lymphoid tissue are not considered lymphomas. Lymphomas starting in the lymphoid tissue can spread to other organs. Because NHL can develop in the body wherever lymphocytes are found, the cancer can

develop nearly anywhere in the body. Symptoms can vary widely, depending on the cancer site. The most common symptom is a noticeable, usually painless swelling of a lymph node (NCI 2002b; Patlak 1996).

Little is known about exactly what causes NHL. Certain risk factors appear to exist. The likelihood of getting NHL increases with age and is more common in men than in women. NHL is more common among people with inherited immune deficiencies, autoimmune diseases, or HIV/AIDS, and among people taking immunosuppressant drugs following organ transplants. Human T-lymphotropic virus type I (HTLV-1) and Epstein-Barr virus are two infectious agents that may increase the chance of developing NHL. People who work extensively with or are otherwise exposed to certain chemicals, such as pesticides, solvents, or fertilizers, may have a greater chance of developing NHL (NCI 2002b; Patlak 1996). However, most people with these risk factors do not get NHL, and many who do get this disease have none of the suspected risk factors (NCI 2002b).

The incidence of NHL has increased dramatically over the last couple of decades. This disease, which was historically relatively rare, is now the fifth most common cancer in the United States (Patlak 1996; Edwards et al. 2005). According to the National Cancer Institute, NHL has increased by 75% over the last 20 years, making it the most rapidly rising cancer after lung cancer and melanoma. Nationwide, the incidence of NHL increased from 8.5 per 100,000 people in 1973 to 15.1 per 100,000 in 1991, and mortality from the disease increased from 4.8 per 100,000 people in 1973 to 6.5 per 100,000 in 1991 (Patlak 1996).The increase is a result of both better methods of detection and an actual increase in the number of new cases. Although some types of NHL are among the most common childhood cancers, more than 95% of NHL cases occur in adults. The average age at diagnosis is the early 40s. Whites are affected more often than African Americans or Asian Americans (Patlak 1996).

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Appendix F. Public Comments and Responses from the Lusher Community

ATSDR received a letter dated March 30, 2009 from Walerko Tool and Engineering Corp. in response to the draft PHA. The comments and our responses are listed below. Changes were made to pages 2, 3, and 4 of the final document based on Walerko's comments.

Comment 1. On pages 2, 3, and 4 of the Report, mere allegations are stated as factual with respect to the Walerko facility at 1935 West Lusher Avenue. Walerko denies and disputes that it ever used TCE at its facility or that solvents, spent or otherwise, were disposed onto the ground at the facility. Walerko further disputes and denies that it has contributed to any groundwater contamination plume in the area.

Response 1. We have revised the document pertaining to statements on Walerko. The reference to Walerko contamination has been changed to Lusher Avenue contamination. We have added the following for clarification: However, other samples taken in the late 1980s indicated higher contamination (608 and 804 ppb TCE, Table 1) further east in the vicinity of 17th Street and Lusher Avenue. The sources of Lusher groundwater contamination have not been fully identifed. EPA is working to identify other potentially responsible parties.

Comment 2. While Walerko entered into a Consent Order with the U. S. EPA in 1993, it did so as a settlement of disputed issues to avoid prolonged and complex litigation. A settlement as such does not constitute an admission of any fault or liability and is not useable as evidence to prove fault or liability. To suggest otherwise is misleading.

Response 2. Noted. It was not our intent to suggest fault or liability.

Comment 3. Seeking to poison public opinion and jeopardize the legal rights and interest of Walerko is inappropriate and irresponsible. Such efforts are out of place and unnecessary in a public comment document that is supposedly dedicated to being a health assessment.

Response 3. We did not seek to sway public opinion concerning Walerko and have revised the document accordingly.

Comment 4. Walerko may be a potentially responsible party, but it has not been shown to date to be a responsible party as stated in the Report. To state otherwise is erroneous.

Response 4. We have changed the language to indicate that Walerko is a *potentially* responsible party and added that EPA is working to identify other potentially responsible parties.

Appendix G. Comments from the U.S. House of Representatives and our Responses

Report by the Majority Staff of the
Subcommittee on Investigations and Oversight of the
Committee on Science and Technology
U.S. House of Representatives
to Subcommittee Chairman Brad Miller

March 10, 2009

Excerpt from the Report (pages 17-19) on the March 1, 2009 Lusher PHA

Trichloroethylene (TCE) Groundwater Contamination in Elkhart, Indiana

Earlier this month, ATSDR released a draft Public Health Assessment (PHA) on groundwater contamination from trichloroethylene (TCE) and other chemicals at what is known as the Lusher Avenue Site in Elkhart, Indiana. Contamination in the area has stretched back to the mid-1980s and last year EPA designated it a Superfund site and placed it on the National Priorities List (NPL). There are a number of potential sources of environmental pollution in the area including a rail yard, pharmaceutical manufacturer, plastic and metal fabrication plants and a musical instrument fabrication facility. The area has a population of 2,597 people, including 286 children six years old or younger.[46] In 1989, EPA established a drinking water standard or Maximum Contaminant Level (MCL) for TCE of 5 parts-per-billion (5 ppb). Municipal water systems are required to test water for TCE concentrations every three months. If any levels exceed the MCL, they are required to notify the public via newspapers, radio, TV networks and other means and to provide alternative drinking water supplies to the public.[47] In the past, TCE contamination in the drinking water systems in Lusher were discovered in many of the several hundred private wells in the area. Residents were provided with alternative water supplies or filtration systems were installed. A new round of sampling in 2005 and 2006 found some wells had TCE levels of up to 700 ppb, exposing an estimated 200 people to these contaminants.

The recent ATSDR health assessment concluded that: "Most adverse health outcomes are not anticipated at Lusher because the TCE concentration in most private wells is less than 100 ppb."[48] However, ATSDR's own 1997 Toxicological Profile on trichloroethylene cites several studies showing associations between exposures to much lower levels of TCE exposure and health effects, such as neural tube defects, for instance.[49] In addition, it cites another study of residents in Tucson, Arizona that were exposed to TCE levels between 6 and 239 ppb. The study found that the children of mothers who lived in this area in their first trimester of pregnancy were 2 ½ times more likely to develop congenital heart defects than children of mothers not exposed to TCE during pregnancy. [50] Yet, the ATSDR health assessment says that there have been exposures at the Lusher site as high as 700 ppb, *"However, most TCE exposures at Lusher were and are less than 100 ppb and indicate little to no risk for heart defects in newborns."* [Emphasis in the original].[51]

The ATSDR assessment does say: "People drinking well water which contains TCE at levels greater than 300 ppb have an increased risk of developing cancer." It bases this assertion on another ATSDR study that examined a cancer cluster in Woburn, Massachusetts in 1986 and found that there were more than twice as many childhood cases of leukemia as expected while the TCE contamination in the water was only 267 ppb. How ATSDR now justifies asserting that there is no increased risk of cancer below 300 ppb or that there is no risk of heart defects in newborns from the exposures in Lusher appears to be scientifically unfounded and misleading.[52]

The Public Health Assessment also failed to mention a 1994 study cited in ATSDR's own Toxicological Profile of trichloroethylene. The study found that in a review of 1.5 million residents in 75 towns monitored for TCE levels between 1979 and 1987, females exposed to drinking water in excess of the EPA maximum contaminant level (MCL) of 5 ppb had a significant elevation of total leukemias, including childhood leukemias, acute lymphatic leukemias, and non-Hodgkin's lymphoma. The recent ATSDR report also failed to mention that a 1996 study by the Massachusetts Department of Health found that the risk of leukemia in the group of Woburn, Massachusetts women exposed to TCE in utero were 8 times higher than a control group.[53]

While none of these studies in and of themselves are conclusive evidence of clear links between TCE exposures and these specific health problems, they are part of the scientific public health record on these issues. Omitting them from a public health document that is trying to assess the public health threats from TCE to the community in and around the Lusher site appears short-sighted at best and scientifically misleading. In the end, ATSDR's conclusions on the Lusher site seem fuzzy at best. Inconsistencies in other ATSDR reports have been a long standing frustration by both local communities and other federal agencies, particularly EPA. In its conclusions on the Lusher site, for instance, ATSDR wrote: "ATSDR categorizes the site as a past public health hazard. Due to uncertainties concerning sources, continuing migration of contaminants, and private well use, the site could pose a future public health hazard. Currently, exposure has been mitigated or lessened through provision of alternate water and filter systems for private well users with contaminated water. However, there may be private wells that still need to be tested."[54] Until ATSDR begins to focus on the scientific integrity and basic clarity of its public health documents with renewed energy, care and focus the agency will continue to be mired down in problems and garner distrust from the local communities it is supposed to serve.

[46] "Public Health Assessment for Lusher Avenue Groundwater Contamination, Elkhart, Elkhart County, Indiana," Public Comment Release, Prepared by: U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, March 1, 2009, p. 21, (hereafter referred to as ATSDR Lusher Site PHA, available here: http://www.atsdr.cdc.gov/NEWS/lusher_03022009.html.

[47] "Consumer Factsheet on: TRICHLOROETHYLENE," U.S. Environmental Protection Agency, available here: http://www.epa.gov/OGWDW/dwh/c-voc/trichlor.html

[48] ATSDR Lusher Site PHA, p.12.

[49] "Toxicological Profile for Trichloroethylene," U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, September 1997, p. 84, (hereafter referred to as ATSDR TCE Tox Profile) available here: http://www.atsdr.cdc.gov/toxprofiles/tp19.pdf.

[50] ATSDR TCE Tox Profile, p. 85.

[51] ATSDR Lusher Site PHA, p. 13.
[52] ATSDR Lusher Site PHA, pp. 14-15.
[53] ATSDR TCE Tox Profile, pp. 90-91.
[54] "Public Health Assessment for Lusher Avenue Groundwater Contamination, Elkhart, Elkhart County, Indiana," Public Comment Release, Prepared by: U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, March 1, 2009, p. 21, available here: http://www.atsdr.cdc.gov/NEWS/lusher_03022009.html.

ATSDR's Response to House Concerns on the Lusher Avenue Groundwater Contamination PHA

We appreciate the opportunity to review and respond to comments raised in the Majority Staff Report on TCE groundwater contamination in Elkhart, Indiana. Comments and concerns were raised on the draft (public comment version) Public Health Assessment for the Lusher Avenue Groundwater Contamination Site. We hope that the discussions below address these concerns. We have updated and changed the draft document based on these comments and concerns. There are several inaccurate statements and incorrect quotes made about the Lusher Avenue Groundwater site in the House Staff report. In the paragraphs that follow, these inaccuracies are identified and discussed.

Statement. The house panel incorrectly states "A new round of sampling in 2005 and 2006 found some wells had TCE levels of up to 700 ppb, exposing an estimated 200 people to these contaminants".

Response. Although alternate water has been provided to these private well users, exposure to chlorinated VOCs has occurred at this site. ATSDR estimates a total population of approximately 200 people exposed to levels at or exceeding the MCL (5 ppb). The TCE data separate the population into a group of approximately 53 people exposed to levels above 500 ppb at work and at one home in the late 1980s – these people were no longer being exposed when the survey was conducted in 2005/2006. More accurately, there a group of approximately 147 people exposed to levels below 106 ppb in the 1980s and in 2005/2006. In 2005/2006, there was one well where the contamination was recorded at 700 ppb in raw water; however, the residents were drinking filtered water and were not exposed to this contamination (Table 3, p.11 of the Lusher PHA). As shown in Table 3, the other wells had concentrations at or below 100 ppb.

Statement. The House Staff report also mischaracterizes the Lusher PHA by stating "How ATSDR now justifies asserting that there is no increased risk of cancer below 300 ppb or that there is no risk of heart defects in newborns from the exposures in Lusher appears to be scientifically unfounded and misleading".

Response. ATSDR made no such statements in their Lusher PHA. The 300 ppb was not ever used as a break line between cancer risk and no cancer risk, but the PHA reports it as a distinction between wells that were higher from wells that had much lower levels. We did say that people drinking well water which contains TCE at levels greater than 300 ppb have an increased risk of developing cancer. Below 300 ppb would be a lower cancer risk but not "no risk" as the panel states. A group of people with wells containing less than 300 ppb of TCE had

much lower exposures. We also indicated that at the highest exposure levels, there was an increased risk of heart defects in newborns (p.12 and 13 of the March 1, 2009 Lusher PHA). It should be understood that the estimated risk of non-cancer effects is higher than the risk for cancer effects. We estimate that the risk of cancer is much less than the risk of heart defects in newborns. Therefore, ATSDR stressed the higher risks.

We agree with the importance of minimizing all VOC exposures whenever possible; it is equally important to explain exposures and whether there is evidence linking them to health outcomes as well as discussing the strength of evidence. So the question we have to answer is: what about the past exposures? The site specific conditions at Lusher exposed several workers and one household to VOCs above 300 ppb. It's possible that women of child-bearing age may have been exposed in their workplaces in the late 1980s; these potential exposures are a concern because of the potential for in-utero exposure to the fetus. The only known current exposures at Lusher are families showering with TCE-contaminated water at 100 ppb or lower. Because of our concern for these people, we recommended that EPA conduct indoor air monitoring, which we will use to determine exposure doses from showering.

Statement. ATDSR's draft PHA indicates: "Most adverse health outcomes are not anticipated at Lusher because the TCE concentration in most private wells is less than 100 ppb". However, ATSDR's own 1997 toxicological profile on trichloroethylene cites several studies showing associations between exposures to much lower levels of TCE exposure and health effects, such as neural tube defects, for instance.[49] In addition, it cites another study of residents in Tucson, Arizona that were exposed to TCE levels between 6 and 239 ppb. The study found that the children of mothers who lived in this area in their first trimester of pregnancy were 2 ½ times more likely to develop congenital heart defects than children of mothers not exposed to TCE during pregnancy. Yet, the ATSDR health assessment says that there have been exposures at the Lusher site as high as 700 ppb."

Response. The actual information in the Lusher draft PHA was paraphrased in a manner that suggests that we are disagreeing with our own toxicological profile - that is not the case. Our health assessment process requires that we use the information provided in the toxicological profile that is germane to the site situation. It also requires that we use other references that have been published subsequent to the toxicological profile. This procedure is defined in ATSDR's Public Health Assessment Guidance Manual (2005). The house panel identified two studies in our toxicological profile where people were drinking water with TCE below 300 ppb and where adverse effects were found in children. We know these studies well and we understand their implications. The Woburn study was mentioned in the Lusher PHA (p. 14-15). Our staff have added references to the final PHA to provide a more complete picture of all the relevant and available data. We welcome criticisms and comments that can be used to strengthen the science in our documents.

The actual conditions at the Lusher are described in a previous response. Within the community, we estimate that 53 people were exposed to levels above 500 ppb at work and at one home in the

late 1980s, and approximately 147 people were exposed to levels below 106 ppb in the 1980s and in 2005/2006.

Illustrate consistencies and inconsistencies

The panel concluded that Lusher's conclusions were "fuzzy at best" and inconsistent with other sites, but this is not the case. It is consistent with other sites, particularly the Conrail PHA which evaluates the site adjacent to Lusher. Clearly, we called Lusher a past public health hazard. The reason for it also to be a potential future public health hazard is predicated on future findings by the EPA. ATSDR's assessment procedures would also permit the use of an indeterminate health hazard in such a situation, but ATSDR chose a position that is health protective. EPA is working to identify additional sources of TCE and any other private wells that may be contaminated. We support EPA's efforts to minimize exposures and to set standards which are health protective. Our responsibility is to let the public know if we believe any health consequences are likely from their exposures. TCE is a probable human carcinogen and there is a theoretical risk of cancer after any exposure. The agency's mission is to prevent exposure and adverse human health effects and diminished quality of life associated with exposure to hazardous substances in the environment. For the TCE exposure conditions described in the Lusher PHA, children are the most sensitive population and they are at risk for cancer and non-cancer outcomes.

Identify a set of recommendations and next steps

Finally, we would like you to know that our work at this site is continuing. ATSDR has acted to protect public health by advocating several prevention and characterization procedures. Currently, exposure has been mitigated or reduced through provision of alternate water and filter systems. ATSDR's actions at this site have already had an impact: Due to the potential exposure to indoor showering and vapor intrusion vapors, especially for children, ATSDR recommended indoor air monitoring in the homes with the highest potential for such exposures. ATSDR has provided a recommendation to the EPA to conduct additional and more extensive indoor air monitoring. This recommendation will be implemented during EPA's RI/FS process. Also, ATSDR's recommendation for conducting preferential pathway sampling for determining vapor intrusion pathways will be given consideration during EPA's risk assessment process.

EPA is conducting a Remedial Investigation/Feasibility Study for this site and will determine the sources of VOCs at the Lusher site as feasible. EPA may place some monitoring wells at the former dump location near Flake and Albany Streets to determine if the dump is a source of VOCs to this area.

EPA and IDEM should continue to connect residences and businesses to city water or provide filters as appropriate.