AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

FARIBAULT MUNICIPAL WELL FIELD
FARIBAULT, RICE COUNTY, MINNESOTA
EPA FACILITY ID: MND982074569
MARCH 21, 2005

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

FARIBAULT MUNICIPAL WELL FIELD

FARIBAULT, RICE COUNTY, MINNESOTA

EPA FACILITY ID: MND982074569

Prepared by:

Minnesota Department of Health

Under a Cooperative Agreement with
The U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Atlanta, Georgia

FOREWORD

This public health assessment report summarizes the results of an evaluation, conducted by the Minnesota Department of Health (MDH), of possible exposure to hazardous substances and possible public health implications of such exposure to residents living near the Faribault Municipal Well Field site in Faribault, Rice County, Minnesota. The conclusions and recommendations contained in this document are based this site evaluation. Site evaluations include the following activities:

- *Evaluating exposure:* MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. The department relies on information provided by the Minnesota Pollution Control Agency (MPCA), the U.S. Environmental Protection Agency (EPA), other governmental agencies, private-sector businesses, and the public.

- *Evaluating health effects:* If there is evidence that people are being exposed—or could be exposed in the future—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. This report focuses on public health; that is, the health impact on the community as a whole, and is based on existing scientific information.

- *Developing recommendations:* In the public health assessment document report, MDH outlines its conclusions regarding any potential health threat posed by site contaminants and offers recommendations for reducing or eliminating human exposure to the contaminants. The role of MDH in dealing with hazardous waste sites is primarily advisory. For that reason, this evaluation report will typically recommend actions to be taken by other agencies (EPA and MPCA). If, however, an immediate health threat exists, MDH will issue a public health advisory warning people of the danger, and will work to resolve the problem.

- *Soliciting community input*: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals and/or organizations responsible for cleaning up the site, and community members living near the site. Any conclusions reached about the site are shared with the individuals, groups, and organizations that provided the information. Once a public health assessment report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, you are encouraged to contact us. The MDH address and telephone numbers listed on the following page.*

Address:	Community Relations Coordinator Site Assessment and Consultation Unit Minnesota Department of Health 121 East Seventh Place/Suite 220 Box 64975 St. Paul, MN 55164-0975
Phone numbers:	(651) 215-0916 *or* 1-800-657-3908 (Toll-free call – Press "4" on your touch-tone phone)
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Summary

Trichloroethene (TCE) contamination in the municipal water supply of Faribault was first discovered in 1982. The disposal or spillage of a large quantity of TCE (and possibly other volatile organic compounds or solvents), from an unknown source or sources in the city has resulted in a large area of groundwater contamination affecting several major groundwater aquifers. Two private water-supply wells, and four of five active municipal-supply wells in the city have been affected by the contamination. Concentrations of TCE in the water supply itself have not exceeded either a regulatory or a health-based criteria since 1992. However, exposures to TCE through the city water supply at levels above the regulatory and health-based criteria are currently being prevented by careful management of the water supply system. Thus, the site currently represents *no apparent public health hazard*. In the past, the concentration of TCE in the water supply system and possibly in private wells exceeded the maximum contaminant levels and/or current interim recommended exposure limit for TCE, requiring intervention. At this time, however, no conclusive evidence exists of an unusual incidence of adverse health effects as a result of this exposure to TCE.

Introduction

Trichloroethene (TCE) is the main contaminant at the Faribault Municipal Well Field site. In 1997, the Minnesota Department of Health (MDH) released its first health consultation report for the Faribault Municipal Well Field site (MDH 1997). Since then, studies of the site have been conducted by the Minnesota Pollution Control Agency (MPCA), MDH, the city of Faribault, and private parties. These studies investigate potential sources of contamination in the city, evaluate potential remedial actions, and identify activities necessary to protect the city wells from additional contamination. The site continues to be addressed by MPCA under the Minnesota State Superfund Program, and the site is listed on the state's Permanent List of Priorities. In 2002, MDH established an interim recommended exposure limit of 5 micrograms per liter (µg/L) for TCE in private wells; this is substantially lower than the previous standard (Health Risk Limit [HRL]) of 30 µg/L. Several private wells that were known to remain in the city were recently sampled by MDH to determine if they had concentrations of TCE in excess of the new interim recommended exposure limit. The U.S. Environmental Protection Agency (EPA) maximum contaminant limit (MCL) of 5 µg/L continues to be the applicable regulatory standard for the municipal water supply system.

MDH has recently completed health consultations for two other TCE sites in Faribault, the Nutting Truck and Caster Company site and the AAF-McQuay, Inc., site (MDH 2000, MDH 2003a). A groundwater pump-and-treat system operates to control the TCE plume in the groundwater beneath the Nutting Truck and Caster Company site. Monitoring of the small TCE plume at the AAF-McQuay site has been discontinued, and the site was issued a No Further Action letter by the MPCA in May 2004.

MDH has prepared this report to summarize current site conditions, to evaluate the potential health risks associated with the use of drinking water from the city distribution system, and to make recommendations to protect public health. MDH has consulted with staff from MPCA and the city of Faribault to gather information and to determine the focus of this report.

Background

<u>Site Description and History</u>

Much of the information in this section has been presented in previous MDH documents (MDH 1997; MDH 1998), and it is included in this document for completeness.

The Faribault Municipal Well Field site is in the central area of the city of Faribault, Minnesota, as shown in Figure 1. The well field consists of six wells, the locations of which are shown in Figure 2. Wells #1 through #4 are on the south side of the Cannon River, and wells #5 and #6 are on the north side of the river. Municipal well #2 is no longer used because of heavy sand infiltration. TCE has been detected in all wells except well #6. Detailed information on the construction of the wells is as follows:

Table 1. Well Number, Year Completed, Depth, Pumping Capacity, and Diameter

Well ID	Unique Well Number	Year Completed	Depth (feet)	Pumping Capacity (gpm†)	Diameter (inches)
MuW-1	217737	1936	750	1,660	12
MuW-2*	217736	1938	450	2,000	24
MuW-3	217741	1912	410	1,000	16/12
MuW-4	217745	1963	407	1,650	24
MuW-5	217746	1968	405	2,000	24
MuW-6	541549	1996	403	1,800	18

*Well number MuW-2 was taken out of service during the 1980s.
†gpm = Gallons of water per minute.

Well #1 is the deepest well, and it draws water from multiple geological formations. Wells #2 through #5 are multi-aquifer open-hole wells, drawing water from both the Prairie du Chien and Jordan Aquifers (see below). Well #6 is the only well with an extensive casing (steel liner); its casing extends to 327 feet below grade, into the Jordan sandstone formation. Well #6, therefore, only draws water from the Jordan formation.

TCE contamination was first detected in the Faribault Municipal Well Field in October 1982. Although other related volatile organic compounds (VOCs; e.g., 1,1-dichloroethane and 1,2-dichloroethene) have been detected at low levels in the municipal wells, TCE is the main contaminant of health concern. Monitoring for TCE began in October 1982, but it probably existed in the municipal wells for an unknown period before October 1982.

The municipal wells were sampled on a monthly or bimonthly basis from 1983 through 1989. From 1990 to the present, the wells and distribution system have been sampled approximately once per quarter; some years only an annual sample was required because of low TCE concentrations. Since the late 1980s (with a few exceptions), levels of contaminants in city drinking water have been maintained below federal standards and below state health-based guidelines for TCE by 1) blending water from multiple wells before distribution, and 2) limiting water use from the most contaminated wells to periods of heavy demand. No treatment is currently being used to remove the TCE.

Geology / Hydrogeology

Four aquifers lie beneath the site. The uppermost layer is composed of intermixed sand and silty sand that was deposited during the last glacial period. Below this is the St. Peter Sandstone Aquifer, which is composed of fine-to-medium-grained sandstone. Near the base of the St. Peter Sandstone Aquifer, there is often a clayey zone. When present, it can impede, but not prevent, vertical movement of groundwater. Below the St. Peter Aquifer are the Prairie du Chien Dolomite (limestone) Aquifer and the Jordan Sandstone Aquifer. Together, these two aquifers make up the important regional aquifer. On the basis of the static water-level results from monitoring wells near the site, groundwater flow in the Prairie du Chien Aquifer is generally north and towards the Cannon River. However, groundwater flow on a more localized scale may vary significantly because of the karstic nature (cave-like openings) and fracture systems of the aquifer.

All of the municipal wells are in the Prairie du Chien Aquifer that contains significant karstic zones and fractured bedrock. These fractures and karstic openings tend to concentrate groundwater flow into narrow openings that can be both vertically and horizontally extensive. As a result, the groundwater flow can be concentrated in narrow openings at unknown locations, causing unpredictable flow rates and directions. The concentrated groundwater flow in these narrow openings can make it extremely difficult to identify the source of the TCE detected in the municipal wells based on data from the monitoring wells. Unless the monitoring well is properly placed, the contaminant plume may sidestep an otherwise well-placed monitoring-well network through a narrow flow channel.

In addition, the uncertainty surrounding groundwater flow in karstic areas makes it difficult to determine if a component of the TCE contamination detected in the municipal wells is from the Nutting site. The Nutting site once may have contributed to the TCE contamination that is currently being detected in the municipal wells, before the construction of the groundwater pump-out system. However, current data from the Nutting site, the AAF-McQuay site, the municipal wells, other residential wells, and monitoring wells in the area suggest that another as-yet-unidentified source, or sources, is responsible for the majority of TCE contamination in the city wells.

TCE in the Municipal Wells and System

TCE concentrations in the five affected municipal wells (Wells #1 through #5) have varied widely since monitoring began in 1982 (see Figures 3 and 4). TCE concentrations of up to 50 µg/L were common in the early 1980s. In the mid-1980s, TCE concentrations as high as 160 to 180 µg/L were observed in Wells #2, #3, and #4. Since that time, TCE concentrations in the individual wells generally have declined. Since 1986, TCE concentrations in any individual well exceeded 20 µg/L only once (Well #4 in March, 1999). Since 1990, Wells #3 and #4 have been the only wells that have typically had TCE concentrations in excess of the MCL. Well #4 has consistently had the highest TCE concentrations.

The city of Faribault generally has maintained TCE concentrations in the water-distribution system itself below the MCLs through careful management of the water-supply system. This includes blending water from multiple wells before distribution and limiting water usage from the most-contaminated wells to periods of heavy demand. Figures 5 and 6 show the TCE concentrations in the water distribution system from 1982 through 2003. Although the MCL was frequently exceeded in the early 1980s, the TCE concentration has matched or exceeded the MCL only three times since 1986, most recently in late 1992.

Well #6 was installed and entered into service in 1996, and the average concentration of TCE in the water distribution system declined noticeably in 1997. Well #6, the northernmost city well, is a high-capacity well that draws water exclusively from the Jordan Aquifer that historically has been uncontaminated. As well #6 came into use, the city was able to rely less and less on contaminated wells #3 and #4, and the concentrations of TCE in the water supply dropped correspondingly. This can be observed by comparing Figure 7, which shows the pumping rates of each well, to Figure 6. As the pumping rates of wells #5 and #6 increased in the late 1990s, and as the pumping rate of well #4 decreased, the average concentration of TCE in the city water supply also dropped.

Total water use in the city has increased in recent years to more than 1 billion gallons per year, and per capita water use has increased accordingly. Per capita water use in 1999, was estimated at 177.6 gallons per person per day (PCE 2001). Residential use accounted for approximately 31% of total water use in 1998, and commercial uses accounted for 54% of total water use. Approximately 15% of water could not be attributed to any specific use. Because of the potential for continued population growth, additional water capacity may be needed in the future.

Private Well Monitoring Results

Most homes and businesses within the city of Faribault are served by the municipal water supply. However, in Faribault, as in many Minnesota cities both large and small, a number of homes and businesses are still served by individual, private water-supply wells. In 1997, MDH identified contaminated groundwater beneath parts of the city and determined that the contamination was of potential health concern (MDH 1997). The 1997 public health assessment identified a specific area (i.e., between several potential contamination sources and the city wells) within the city as a candidate for a detailed private-well search. This area and the potential sources of contamination are shown in Figure 8.

To address this concern, MDH reviewed a recent report analyzing the city’s water distribution system (PCE 2001). The analysis showed no major gaps in the system or areas that were clearly not served by the water supply. In 2003, MDH staff worked with city staff to query the city's computerized utility-billing system for those properties billed for sanitary sewer service, but *not* billed for municipal water service. Presumably, such properties are served by a water source other than the municipal system, such as private wells. The city identified 18 such properties within the city that were billed for sanitary sewer service, but *not* for water. MDH staff reviewed the list and selected 11 wells that were within or near the area of concern outlined in 1997, or near the AAF-McQuay facility on the north side of the city. The TCE plume in the Prairie du Chien formation at the AAF-McQuay site was never fully defined, and MDH was concerned about the potential for nearby wells to be affected. MDH also considered the AAF-McQuay site as a possible source of the TCE found in municipal well #5 (MDH 1997, MDH 2003a).

In August 2003, MDH sent each property owner a letter outlining the concerns regarding potential groundwater contamination and requesting permission to collect a water sample from their residential well. MDH eventually received permission to collect samples from seven of the 11 wells; two of the remaining four were subsequently found to be wells serving commercial businesses that were unlikely to be used extensively for potable purposes. The locations of the seven wells are shown in Figure 8. Unfortunately, no information regarding the depths of the wells or their construction could be located. Given their ages and locations, the wells are likely to be completed in the glacial till or upper Prairie du Chien formation.

MDH staff collected water samples from the seven wells on October 3, 2003. The samples were analyzed at the MDH lab for VOCs, including TCE. TCE was detected in water samples from two of the seven wells at concentrations less than 1 microgram per liter (µg/L). Both of these wells are south of the Cannon River. Low levels of two other VOCs, 1,2-dichloropropane and tetrachloroethene (PCE), were found separately in two wells located just south of the AAF-McQuay site. It is not clear whether these low-level VOC detections are related to the TCE contamination found at the AAF-McQuay site, or other potential sources in the area. The concentrations of VOCs in all four wells were well below their respective Health Risk Limits (HRLs) and the recommended interim exposure limit for TCE. The well owners were mailed letters containing the results of the analysis of their water samples. The results of the sampling are provided in Figure 8.

Additional Site Investigations

In 1998, the MPCA conducted a field investigation in the city to attempt to determine the potential source(s) of TCE contamination and to evaluate the flow patterns of TCE in the affected aquifers (MPCA 1999). Twenty borings were drilled in the area southwest of the municipal wells, and soil and groundwater samples were collected from multiple depths in the glacial drift/St. Peter formations in each boring. Several potential source areas were targeted on the basis of historical information. The source areas included the current Crown Cork & Seal facility (the original location of AAF-McQuay; see MDH 2003a), the K & G Manufacturing facility, and the Mercury Minnesota facility. A series of borings also were placed between the potential source areas and the municipal wells in order to track the contamination plume. The general locations of the borings and the potential source areas are shown in Figure 9. Low levels of PCE were found in groundwater at the Crown Cork & Seal property, and low levels of TCE and PCE were found in groundwater at the K & G Manufacturing and Mercury Minnesota facilities.

Analysis of groundwater samples from the borings placed between the potential source areas and the municipal wells confirmed that at least some of the TCE contamination must have originated southwest of the wells, but the source-area investigations did not pinpoint a potential contamination source in soil (MPCA 1999). This is not necessarily surprising because little or no contaminated soil may remain at the source. A recent study of the behavior of TCE when it is injected into the unsaturated zone (the zone between the ground surface and the groundwater surface) indicates that approximately 95% of the injected TCE will evaporate and discharge into the atmosphere, leaving only a small amount to contaminate the groundwater through simple diffusion (Jellali et al. 2003). The researchers in this study attempted to prevent the TCE from migrating directly from the injection site to the groundwater surface, but they were not successful. TCE is heavier than water, and it will form a dense, non-aqueous phase liquid (often known by its acronym, "DNAPL") that can easily migrate downward from a concentrated source until it reaches an impermeable layer, such as bedrock. It will stop at the impermeable layer and then serve as a continuing source of groundwater contamination.

MPCA investigation indicated that a narrow plume of VOC contamination is present and moving in a northeastward direction between borings B803 and B805 (see Figure 9). The investigation work confirms that a widespread plume of VOC contamination exists at depth below the center of the city, affecting the glacial till/St. Peter and Prairie du Chien formations. Because of the lack of a defined source area, the extent of the VOC contamination, and the nature of the geology, MPCA deemed potential remediation of the groundwater to be impractical as a method of reducing or eliminating human exposure through the water supply (MPCA 1999).

Because the TCE contamination is most severe in municipal well #4, MPCA and MDH conducted several investigations at the well from 1998 to 2000. These investigations are documented in a previous health consultation (MDH 1998) and in an MPCA staff memorandum (MPCA 2000). When the city removed the pump for maintenance in 1998, a detailed examination (including sampling for VOCs) of the well was conducted at selected intervals. In1999, a series of five permanent monitoring wells were installed around well #4 to monitor water quality and water levels during pumping tests. In 1999 and 2000, a series of pumping tests were conducted to determine from which formation(s) the well drew the most water and to determine the depths at which the highest levels of TCE contamination were found. The results of the tests showed that 1) a relatively small vertical segment of the Prairie du Chien formation (at 110–120 feet below ground surface) was contributing the majority of the TCE contamination, and 2) the underlying Jordan sandstone was likely not affected, or only affected as a result of cross-contamination.

Proposed Response Actions

Because well #4 has consistently had the highest level of TCE contamination, and the investigations conducted at the well by MDH and others showed at what depths the contamination was greatest, the city and various agencies have explored various options for addressing the situation. These options have included reconstructing well #4 so that it would not draw water from the most contaminated regions of the aquifers (i.e., in the

Prairie du Chien formation), pumping and treating the water prior to use, or simply using the well to pump contaminated water from the aquifer and disposing of the water in the Cannon River. The goal of the latter plan would be to remove the TCE contamination from the aquifers, thereby reducing TCE concentrations in the other affected wells and eventually lead to clean up of the aquifers.

In 2004, the city of Faribault developed a final response action plan to abandon the existing well #4 properly and to construct a replacement well (Bolton & Menck 2004). A replacement well is needed to meet current demand and the anticipated increased future demand from residential and commercial growth. This will allow the city to have three uncontaminated (or minimally contaminated in the case of well #5), high-capacity wells in place to meet current and future demands. Wells #1 and #3 would still be used as needed to meet peak demands. In a letter dated December 22, 2003, MPCA agreed to provide significant financial assistance to the city of Faribault to implement the then-proposed response action. Implementation of the final plan is scheduled for completion in late 2004.

The city also is working with the MDH Drinking Water Protection Section on the development of a wellhead protection plan. Wellhead protection is designed to protect public water supply wells. States are required to have wellhead protection programs under the provisions of the 1986 amendments to the federal Safe Drinking Water Act. A capture zone for the wells (called the wellhead protection area) is designated, and a plan is developed and implemented for managing potential contamination sources within the wellhead protection area.

Staff of the Source Water Protection Unit of MDH typically assists public water suppliers in preparing and implementing wellhead protection plans. The wellhead protection planning process itself is a two-part program. Part 1 involves delineation of the wellhead protection area and drinking water supply management area, and an assessment of the vulnerability of the wells. Part 2 involves the creation of the wellhead protection plan itself, including goals, objectives, plan of action, evaluation program, and contingency plan. MDH staff has assisted the city in developing Part 1 of the wellhead protection plan (MDH 2003b). Figure 10, from Part 1 of the plan, represent the city’s delineated drinking water supply management area and wellhead protection area. Given the current contamination in the city’s municipal water supply system, protecting the wells from future contamination is critical to protect the water supply and preserve the city’s investment.

<u>Site Visits</u>

MDH staff has conducted numerous visits (most recently in October 2003) to the site during the past 10 years to observe MPCA well drilling and sampling, conduct private well searches and well water sampling, and attend community and public meetings. Because a groundwater plume with an undefined source underlies the site, few noteworthy surface features exist except as described elsewhere in this report. No risks from physical hazards, contaminated soils, or other environmental media at the surface have been identified.

Demographics, Land Use, and Natural Resources

The estimated population for the city of Faribault in 2002 was 21,476 people, living in 7,689 households (Minnesota Department of Administration 2004). The city is a typical Midwestern mix of residential, commercial, and industrial areas, and it is experiencing significant growth (approximately 22% from 1990–2000). A large minority population (in excess of 20%) is present as well.

The Cannon River bisects the site. Shallow TCE-contaminated groundwater may discharge into the river. Because of the relatively low concentration of TCE in the shallow aquifers at the river, this discharge is not considered a threat to the aquatic environment or to recreational users, although it has not been monitored or formally assessed. The contaminants are assumed to be quickly diluted and either degraded biologically or volatilized into the air.

General Regional Issues

This region of the state, located approximately a 1 hour drive from the Minneapolis/Saint Paul metropolitan area, will likely continue to experience substantial population growth in the coming years. Because this continued growth may present a strain on area resources such as the city water supply, the potential need for expansion of the system will have to be evaluated by the city.

Community Concerns

From time to time, MDH staff has received phone calls from citizens living in the city of Faribault expressing concern about TCE in the city water supply. A community meeting was held by MDH in July of 2000, and approximately a dozen people attended. MDH also has held other informal meetings.

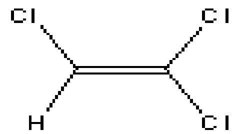
Some area residents expressed concern about the following: cancer rates in the area may be higher than normal, the health implications of children who may have been exposed to contaminated water (both before and after birth), and the health of domestic animals that may be drinking contaminated water. Residents also had questions about multiple exposure pathways to volatile contaminants and the various regulatory criteria for TCE in water. MDH has made every effort to address the health issues and has produced several information sheets for area residents, including one entitled "TCE in Drinking Water," which is provided as Appendix II. The city also has provided annual updates for local residents in their water quality reports.

Public Comment Period

A draft of this document was released for public comment on November 23, 2004. The public comment period ended on December 17, 2004. A press release regarding the availability of the document for review was issued by MDH, and a story subsequently appeared in the local newspaper, the *Faribault Daily News*. The document was made available for review in a variety of formats. No comments from the public were received.

Evaluation of Environmental Fate, Toxicity, and Exposure

TCE is a nonflammable, colorless liquid with a slightly sweet odor and taste (ATSDR 1997). TCE is extremely volatile, and most TCE released into the environment will evaporate into the air. It can persist in groundwater, however, because of the limited contact between groundwater and air. The TCE chemical structure consists of two carbon atoms linked by a double bond, with three chlorine atoms and one hydrogen atom attached, as shown below:



TCE was marketed under a variety of trade names (Triclene, Vitran, Triad, and others.) and was used extensively as a degreasing solvent in a variety of industries. Although the use of TCE a solvent has been declining, it also is used in the manufacture of other chemical products (ATSDR 1997). Because of its extensive use, TCE is one of the most common contaminants found at Superfund sites across the United States, especially in groundwater. It has been listed as a hazardous pollutant, hazardous waste, or hazardous substance under a variety of federal and state environmental regulations (EPA 2001). TCE can be found throughout the environment, and most people are likely to be exposed to it at low levels through ingestion of drinking water, inhalation of ambient air, and ingestion of food (Wu and Schaum 2000).

Under certain conditions, TCE will degrade in the subsurface environment, following predictable pathways (ATSDR 1997). Many factors determine the rate at which TCE will degrade, such as the amount of oxygen in the groundwater, the pH of the water, or the concentrations of other substances that microorganisms need to break down the TCE. Low levels of the common break down products of TCE (such as cis-1,2-dichloroethylene) have been observed in water samples collected at the site. This indicates that up until this point TCE is being biologically degraded in the aquifers, but not significantly so. The reasons for this are not clear, but likely include the geochemical conditions of the site (such as the presence of oxygen in the shallow groundwater, which inhibits degradation of TCE), a possible lack of nutrients needed by microorganisms, and the speed at which the groundwater is moving through the relatively porous formations. The lack of biological degradation is in and of itself not a cause for concern, because several of the environmental breakdown products of TCE, such as vinyl chloride, are more toxic than TCE itself.

Dermal contact with concentrated solutions of TCE can produce skin rashes, dermatitis, or other skin problems. Exposure to high concentrations of TCE in air can affect the central nervous system, producing headaches, dizziness, or even unconsciousness. These concentrations typically have been found only in occupational settings, or cases of intentional exposure (i.e., intoxication or suicide attempts). In rare instances, however, people living in communities near facilities using and releasing very large amounts of TCE into the air and groundwater, thus exposing people through multiple exposure pathways, have had neurologic symptoms (Kilburn 2002). The concentrations of TCE reported to have produced these effects were as high as 10,000 µg/L in groundwater, and releases to the ambient air were significant enough to produce reportable odors near the source. The odor threshold of TCE in air is approximately 100 parts per million (ppm).

The most common environmental/community exposure pathway for TCE is through ingestion of contaminated drinking water. Ingestion of TCE in drinking water results in internal exposure to a mixture of TCE and its metabolites (much of the toxicity attributed to TCE is likely due to its metabolites) (EPA 2001). Many of these metabolites are formed through the action of enzymatic pathways in the liver and kidney that also metabolize other substances such as alcohol, pain relievers (e.g., acetominophen), and other drugs and environmental contaminants. Exposure to these other common substances or contaminants at the same time may therefore affect (reduce or enhance) the metabolism of TCE.

Animal studies show that the ingestion of TCE at very high doses (e.g., hundreds to thousands of times above what is found at this site) can cause nerve damage, liver and kidney damage, and can be associated with reproductive or development effects. Some studies also suggest an association between exposure to solvents, such as TCE, and autoimmune disorders (Hess 2002; Garabrant et al. 2003). The neurologic effects of exposure to TCE may occur only after inhalation exposure and *not* after ingestion of TCE-contaminated water, according to some animal studies (Waseem et al. 2001). Although animal studies have shown that high doses of TCE can cause tumors of the liver, kidney, and lymphatic system in rats and mice, scientists are less certain whether people who are exposed to lower doses of TCE have an increased risk of these or other types of cancer. Differences in how TCE is metabolized at different doses by different species may be related to the different mechanisms by which TCE causes disease (EPA 2001). For instance, kidney tumors in rats that have been exposed to high doses of TCE may result from direct toxicity to kidney cells, whereas kidney tumors in rats exposed to lower doses may result from mutations in kidney cells induced by metabolites of TCE.

Occupational exposure to high levels of TCE in air has been associated with an increased risk of kidney cancer in some studies; however, the estimates of exposure in these studies have been uncertain, and other studies have failed to demonstrate a relation between kidney cancer and TCE exposure (Bruning et al. 2003; Cherrie et al. 2001). TCE is classified as a “probable human carcinogen” under current EPA cancer guidelines that are based on “limited” human evidence and “sufficient” animal evidence of carcinogenicity. TCE would be characterized as “highly likely to produce cancer in humans” under the cancer guidelines proposed for adoption by EPA in 1999 (EPA 2001).

Maternal exposure to high levels of TCE during pregnancy may be associated with an increased risk of birth defects, including heart and eye defects (ATSDR 1997). Studies in rats have demonstrated an association between TCE exposure (and its metabolites) and cardiac birth defects, but the amount of TCE exposure needed to produce this increased risk is unclear (Johnson et al. 1998). One study in rats suggested that the concentration of TCE in drinking water that resulted in an increased risk of cardiac birth defects was approximately 250 µg/L. An exact comparison between exposure levels in rats and humans cannot be made due to cross-species differences in intake rates, metabolism, development, and mechanisms of action (Johnson et al. 2003).

One epidemiology study suggested a relation between maternal exposure to TCE in drinking water (up to 107 µg/L of TCE) and very low birth weight (less than 1,501 grams [3.3 pounds]) (Rodenbeck et al. 2000). Other studies have suggested that maternal exposure to TCE could be related to a variety of birth defects, including neurologic defects, cleft palate, and childhood leukemia (Bove et al. 2002, Costas et al. 2002). A common problem with these studies, however, is the typically small size of the exposed populations, and the lack of adequate exposure information. ATSDR is conducting a large-scale epidemiology study of birth outcomes of women exposed to high levels of TCE and other VOCs (up to 1,400 µg/L of TCE) while living at Camp Lejeune, North Carolina from 1968 to 1985 (ATSDR 2003). Preliminary findings suggest that maternal exposure to high levels of TCE in drinking water at Camp Lejeune may be associated, in some cases, with low birth weights and various birth defects, e.g., spina bifida, cleft palate, and cleft lip.

In almost every study cited, the exposure concentrations of TCE in drinking water have been tens to hundreds of times above the highest concentrations observed in the Faribault municipal water supply. For this reason, the various adverse health effects that these studies suggest are potentially associated with environmental exposure to TCE would not be expected to occur in persons exposed to the relatively low levels of TCE at the Fairbault Municipal Well site. An epidemiology study of the population of a California community exposed to similar or higher concentrations of TCE in a public water supply during a similar period showed no difference between the expected and the observed numbers of all cancers in area residents (Morgan and Cassady 2002).

<u>Effects on Private Wells</u>

TCE was detected in two of seven private water-supply wells within the city that were sampled by MDH in October 2003 (Figure 9). Concentrations of TCE in both wells were below 1 µg/L, and well below the MDH recommended interim exposure limit of 5 µg/L. The owners of the private wells were provided with the results.

Low levels of two other VOCs were found in two other wells near the AAF-McQuay site on the north end of the city. It is unclear, however, whether these detections were related to the AAF-McQuay site or to another source in the area

<u>Effects on the Various Aquifers</u>

Investigations conducted by MDH, MPCA, and the city suggest that TCE and other VOC contamination in Faribault appears to be concentrated in the glacial drift/St. Peter and Prairie du Chien formations. The Jordan Sandstone aquifer appears to be uncontaminated north of the Cannon River, as evidenced by the studies of well #4, and the lack of detections of TCE in well #6, which is completed solely in the Jordan formation. The contamination does not appear to be degrading an appreciable amount, and is likely to be present for some time. The source(s) of the TCE contamination remains unclear. It is possible that the Nutting Truck and Caster site contributed some TCE contamination at one time, before the groundwater remediation system was installed. The lack of detections of TCE in the private wells sampled near the AAF-McQuay site suggests that the AAF-McQuay site is not the source of TCE contamination that has been sporadically detected in municipal well #5.

Effects on Public Water Supplies

Because of careful management of the system and the installation of well #6 in an uncontaminated aquifer, the levels of TCE detected in the water supply system have steadily declined (Figures 5 and 6). The concentration of TCE has not exceeded the federal MCL of 5 µg/L since late 1992. The city generally relies on wells #5 and #6 to supply the vast majority of its water needs. The three remaining wells are used to meet peak demands or to allow the two main wells to recharge for a period. The city wells and the distribution system typically are monitored on a quarterly basis, and the results of monitoring are reported annually to citizens in a water quality report. The proposed construction of a new city well to replace current well #4 should allow the city to supply the system using uncontaminated water for the vast majority of the time and to rely less and less on the two remaining contaminated wells (wells #1 and #3).

Exposure to Volatile Organic Compounds

Residents of Faribault have been exposed to TCE through the public water supply at least since 1982. At times in the past, especially during the early-to-mid-1980s, levels of contamination in the system exceeded the MCL and the current interim recommended exposure limit for TCE in private wells. Some residents also have been exposed to low levels of TCE through drinking water from contaminated private wells. When contaminants first reached any individual well and at what levels are not known; therefore, the length of time users may have been exposed to contaminants in the system cannot be known. Some wells could have been contaminated as early as the 1960s or 1970s.

MCLs are based on protection of human health; however, other factors are considered, such as cost, technical feasibility, and analytical method sensitivity. HRLs are based solely on protection of human health. Both are based on a measure of the potency of a contaminant known as a “reference dose” for noncarcinogens, and as a “cancer slope factor” for carcinogens. The reference dose is the amount of a substance or chemical that is unlikely to cause toxic effects in humans exposed to this dose over a lifetime (70 years). The slope factor is a similar measure of potency for carcinogens. HRLs for carcinogens (such as TCE) are levels that would be expected to result in a negligible excess lifetime cancer risk if the contaminated water is ingested for a lifetime (70 years). MDH currently defines a risk as negligible if the expected excess lifetime risk of cancer is no greater than one additional cancer case in 100,000 exposed people.

The previous HRL for TCE (30 µg/L) was based on cancer as the adverse health effect of concern, using a cancer slope factor of 0.011 per milligram per kilogram of body weight per day $(mg/kg/day)^{-1}$. A recently published EPA draft health risk assessment document for TCE proposed a range of cancer slope factors from 0.02 to 0.4 $(mg/kg/day)^{-1}$ (EPA 2001; the higher the cancer slope factor, the more potent the carcinogen is considered to be). EPA also proposed a reference dose of 0.0003 mg/kg/day based on critical effects on the liver, kidney, and developing fetus.

In response to this new toxicological criteria for TCE, MDH developed an interim exposure limit of 5 μg/L for TCE to be used in place of the existing HRL of 30 μg/L for drinking water from private wells. Once again, an HRL is the highest concentration of a groundwater contaminant that can be safely consumed for an average lifetime of 70 years, with a daily consumption of 2 liters of water. If a person drinks less water, or drinks it for a shorter period, the risk is correspondingly lower.

This exposure limit should be considered an interim value. Although the EPA health risk assessment is still in draft form, MDH considers the document to represent the best available toxicology information on TCE. Changes to the draft assessment may yet be proposed because the assessment incorporates a number of newer risk-assessment techniques. The recommended interim exposure limit is conservative because it limits exposures in accordance with the lower end of the range of toxicity values proposed by EPA; and it is consistent with the current EPA MCL for public drinking water supplies. MDH is revising the HRL rule. As a part of the rule-revision process, the department will consider any new information as well as public comments when it updates the HRL for TCE. This process is expected to be complete within the next year or two. The final HRL for TCE may differ from the recommended exposure limit.

Currently, HRLs for drinking-water contaminants that are not carcinogens are calculated using a formula that includes a “relative source contribution factor” that directly accounts for exposures that do *not* result from drinking contaminated water. Other environmental exposure pathways (for example, inhalation, skin contact, or ingestion) containing the contaminant also can contribute to the amount of individual exposure. HRLs for contaminants that may be associated with an increased cancer risk in humans (including TCE) do not include this factor directly in the calculation. However, the conservative calculation of the EPA cancer slope factor accounts for this indirectly.

Some studies have suggested that exposure to VOCs in drinking water through inhalation or skin contact during activities (such as, showering, bathing or washing dishes) could be significant in certain situations. The ratio of inhalation uptake versus direct ingestion (drinking, eating) of contaminated water has been estimated to be as high as 6:1 (McKone 1989) or as low as less than 1:1 (Lindstrom and Pleil 1996). A more recent study (Kerger et al. 2000) using water and air measurements taken in actual home bathrooms estimated that the exposure through inhalation of VOCs (such as TCE) from showering and bathing in contaminated water is less than the ingestion exposure by a factor of three to four. Previous studies typically used laboratory or simulated shower facilities that tend to be smaller than standard home showers and less well ventilated, resulting in higher estimates of exposure through inhalation.

A large number of variables are involved in assessing inhalation exposure, making accurate estimates very difficult. These variables include such things as water temperature, size of the shower enclosure, the type of shower head used, length of time spent in the shower, and the ventilation rate. One study identified the contaminant level and the time spent in the shower as the key variables that determine the level of exposure (Lee et al. 2002). Several studies have demonstrated that simply ventilating the shower stall can greatly reduce the estimated exposure to VOCs in shower air (McKone and Knezovich 1991; Aggarwal 1994).

Estimates of additional exposure through skin contact with contaminated water are generally thought to be less than for inhalation exposure and have been estimated to be in the range of 1:1 or less (McKone 1989). One study (Lee et al. 2002) estimated that intake through dermal absorption would account for only about 2% of the total intake through inhalation and dermal contact while showering, but an older study done using measurements of human volunteers showed that dermal absorption of TCE contributes as much to the total body exposure as inhalation (Weisel and Jo 1996). Thus, the best recent estimates of TCE exposures through inhalation and dermal absorption indicate at most a doubling of exposure over exposure from drinking-water ingestion alone.

The route of exposure, however, affects the rate at which TCE is absorbed and metabolized by the body; even if the same dose is received through different routes (i.e., ingestion, inhalation, or dermal contact), the resulting toxicity may be different (Weisel and Jo 1996). A compilation of studies summarized by ATSDR in it's *Toxicological Profile for TCE* suggest that absorption of TCE in the gastrointestinal tract as a result of oral exposure is "extensive," whereas the absorption rate in the lungs from inhalation exposure ranges from 37% to 64% (ATSDR 1997). Pharmacokinetic models developed by EPA also suggest that levels of some TCE metabolites formed by the body may be significantly higher from oral exposure than from inhalation exposure (EPA 2001). For example, small amounts of TCE that are ingested are often quickly metabolized by the liver; however, small amounts of TCE that are inhaled or absorbed through the skin are typically distributed throughout the body before metabolism by the liver, and are therefore metabolized more slowly. The toxic effects of exposure to TCE are mainly thought to be due to the action of its metabolites. Thus, for equal (but low) doses, the ingestion of TCE in water may be of greater consequence within the body than inhalation or dermal absorption (EPA 2001).

Health Outcome Data Review

MDH staff has reviewed available sources of health outcome data for the city of Faribault, including the state cancer registry and other sources of vital statistics. The Minnesota Cancer Surveillance System (MCSS) is the state's cancer registry. It is an ongoing program within the Chronic Disease and Environmental Epidemiology section at MDH. The MCSS systematically collects demographic and diagnostic information on all Minnesota residents with newly diagnosed cancers, and produces biennial reports describing the occurrence of cancer. The primary objectives of the MCSS are to

1. Monitor the occurrence of cancer in Minnesota and describe the risks of developing cancer,
2. Inform health professionals and educate citizens regarding specific cancer risks,
3. Answer the public's questions and concerns about cancer,

4. Promote cancer research; and
5. Guide decisions about how to target cancer-control resources.

MCSS has data available from its inception in 1988 through 2001. Because the city of Faribault experienced significant growth (in excess of 20%) during 1990–2000, the analysis was limited to the years 1997–2001 to more accurately reflect the current population as measured in the 2000 U.S. Census. The MCSS system was searched for records of all cancers diagnosed among residents of the city of Faribault (Zip code 55021) 1997–2001; the search results are provided in the following table.

Cancer Incidence, City of Faribault (Zip Code 55021) 1997–2001						
Cancer Site	Males			Females		
	Observed	Expected	SIR*	Observed	Expected	SIR*
Colon (excluding rectum)	36	26.42	1.4	35	29.82	1.2
Rectum and rectosigmoid	18	11.21	1.6	13	7.98	1.6
Liver	1	2.63	0.4	4	1.29	3.1
Lung and bronchus	55	44.79	1.2	43	31.95	1.3
Breast	2	0.64	3.1	83	98.82	0.8
Corpus uteri	--	--	--	18	19.3	0.9
Ovary	--	--	--	7	12.71	0.6
Prostate gland	96	104.49	0.9	--	--	--
Urinary bladder	20	22.04	0.9	8	7.75	1.0
Kidney and renal Pelvis	9	9.87	0.9	6	5.97	1.0
Non-Hodgkin lymphoma	9	15.56	0.6	8	13.23	0.6
Leukemias	14	11.11	1.3	11	8.09	1.4
All cancers	339	331.54	1.0	293	302.68	1.0

* SIRs = Standardized incidence rates. SIRs are based on 2000 Census Bureau population data, and incidence rates are based on incidence rates for Minnesota.

A standardized incidence rate (SIR) is the ratio of the observed cancer incidence in a population over the expected incidence in the same population, and is based on incidence rates for the Minnesota statewide population. Although rates of some individual cancers appear to be slightly elevated, none of the elevations were statistically significant, and the overall cancer rates were as expected. The three cancers that may be most associated with exposure to high concentrations of solvents such as TCE (as demonstrated by animal studies and human epidemiologic studies) are cancer of the liver, kidney, and non-Hodgkin's lymphoma (EPA 2001). Evidence of a relation between TCE exposure and other types of cancer is much less certain. The exposure concentrations reported in the studies cited by EPA are invariably tens to hundreds of times higher than the highest concentrations ever detected at the site. With the exception of liver cancer in women, rates of these three cancers were at or below expected incidence rates. The number of liver cancer cases was too small to allow any real conclusions. Overall, the results do not suggest any relation between TCE exposure from the municipal water supply and cancer incidence in Faribault.

MCSS only reports a patient's address at the time the cancer is diagnosed. Thus, the data only capture cancers diagnosed in residents of the city during 1997–2001. People who may have lived in Faribault in the past (when concentrations of TCE were at their highest in the city water supply) but moved from the area and whose cancer was diagnosed elsewhere would not be included. Conversely, some cancers undoubtedly were diagnosed in people who recently had moved into the city. Thus, they potentially were exposed to much lower TCE concentrations for a relatively short time. Because the latency period for cancer development can be long, the MCSS is an imperfect tool for assessing the effects of environmental exposure to carcinogens.

Some studies also suggest exposure to high TCE concentrations (again, many times higher than those commonly detected in the city water supply) in pregnant women may be associated with adverse effects (such as cardiac and eye defects, and decreased fetal weight) on the developing fetus (EPA 2001). Unfortunately, Minnesota lacks a birth defects registry, and no quantitative data are available. A search of reportable vital statistics showed that the percentage of infants of low birth weight in Rice County (of which Faribault is the largest city) for 1992 to 1997 was 6%, about the same as the statewide average of 5.8%. Low birth weight could be a possible indicator of maternal exposure to TCE during the pregnancy, although many other environmental and lifestyle factors contribute to low birth weight as well.

Child Health Considerations

MDH recognizes that the unique vulnerabilities of infants and children are of special concern to communities faced with contamination of their water, soil, air, or food. Children are at a greater risk than adults are from certain kinds of exposures to hazardous substances at waste disposal sites. They are more likely to be exposed because they often play outdoors and bring food into contaminated areas. Children are smaller than adults, which means children breathe dust, soil dust, and heavy vapors that are close to the ground; and children receive higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk-identification and risk-management decisions, housing decisions, and for access to medical care.

Child exposures to TCE at levels above the regulatory and health-based criteria are being prevented through careful management of the water supply system. However, children within the city are still being exposed to TCE in drinking water at levels below the applicable criteria, but MDH considers the health-based criteria to be sufficiently conservative to protect human health, including the health of children.

Conclusions

TCE contamination in Faribault's municipal water supply was first discovered in 1982, and investigation and response actions have been ongoing since that time. Earlier disposal or spillage of a large quantity of TCE (and/or other VOCs) at unknown locations in the city has contaminated a large area of groundwater that has, in turn, affected several major groundwater aquifers. Two private water-supply wells, and four of five active municipal-supply wells in the city have been affected; however, concentrations of TCE in the water supply itself have not exceeded the MCL since 1992.

Because careful management of the water supply system is preventing exposure to TCE at levels above regulatory and health-based criteria, the site represents no *apparent public health hazard* at this time. Based on a review of available health outcome data, no evidence exists of an unusual incidence of adverse health effects from past exposure to TCE through the water supply system. In the past, estimated exposure doses exceeded the MDH definition of a *negligible excess lifetime cancer risk* (i.e., one additional cancer case in 100,000 exposed people). For this reason, intervention to reduce the TCE concentrations was necessary.

Recommendations

The city of Faribault should continue its actions to prevent exposure to TCE at levels exceeding 1) the MCL and 2) the TCE interim recommended exposure limit, including the following:

1. Continue the process of replacing the most contaminated well (#4) as proposed, including sealing it and installing a new well that is completed in the Jordan Aquifer north of the Cannon River.

2. Complete and implement its wellhead protection plan according to MDH requirements.

Public Health Action Plan

The MDH Public Health Action Plan for the site includes the following: 1) distribution of this public health assessment (and/or an information sheet summarizing the information contained in this public health assessment) to area residents; 2) continued consultation with MPCA and the city of Faribault on implementing response-action activities and the recommendations provided in the *Recommendations* section of this document; 3) continued outreach to private-well owners in the city; and 4) participation in public outreach events.

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Certification

This Faribault Municipal Well Field Public Health Assessment was prepared by the Minnesota Department of Health, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was written in accordance with ATSDR policies and guidelines available at the time of publication.

Technical Project Officer

ATSDR has reviewed this public health consultation and concurs with its contents.

Team Leader CAT, SPAB,DHAC, ATSDR

Glossary

General Terms

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.

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. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

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.

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], of intermediate duration, or long-term [chronic].

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 endpoint (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 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 ($t_{½}$)
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 Risk Limit (HRL)
An MDH standard, a HRL is the concentration of a contaminant in water that is considered safe for people if they drink two liters (about two quarts) of water daily for a lifetime.

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.

MAC
The Metropolitan Airports Commission.

MDH
The Minnesota Department of Health.

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/cm2
Milligram per square centimeter (of a surface).

mg/m3
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.

MPCA
The Minnesota Pollution Control Agency.

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].

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].

TCE
Trichloroethene, also known as trichloroethylene.

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 TCE.

Other glossaries and dictionaries:

U.S. Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)

National Center for Environmental Health/Agency for Toxic Substances and Disease Registry (CDC) (http://www.cdc.gov/nceh/dls/report/glossary.htm)
http://www.cdc.gov/exposurereport/

National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)
http://www.nlm.nih.gov/medlineplus/mplusdictionary.html

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