ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

GARVEY ELEVATOR SITE

HASTINGS, ADAMS COUNTY, NEBRASKA

EPA FACILITY ID: NEN000704351

JANUARY 12, 2016

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

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Prepared by:

Western Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

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Summary

INTRODUCTION	The Agency for Toxic Substances and Disease Registry's (ATSDR's) top priority for the s Elevator site in Hastings, Nebraska is to ensure that people living near the site, have the best information possible to safeguard their health. One of ATSDR's mandates is to conduct public health activities at sites proposed to the National Priorities List (NPL). The Garvey Elevator site was proposed to the NPL in April 2005. The Environmental Protection Agency (EPA) added the site to the NPL in September 2005. This public health assessment (PHA) reports the results of ATSDR's evaluation of past, present, and future contamination associated with the Garvey Elevator facility in Hastings, Adams County, Nebraska. It also addresses concerns expressed by the potentially affected community. The Garvey elevator site is a grain storage facility that has operated on a 106-acre property southwest of the city limits of Hastings, Nebraska since 1959. Past practices at the site included the use of pesticides and other toxic materials. Carbon tetrachloride (CCl_4) from a leaky pipe beneath the site has contaminated local groundwater. Records do not provide a date as to when the leakage occurred nor the amount of the contaminant released. Use of CCl_4 at the facility ceased in 1985. Trace amounts of CCl_4 began showing up in the municipal water supply in the 1990s. Sampling in 1994 revealed a contaminated onsite supply well that was used as a drinking water source for workers. Subsequent offsite testing found also that area private wells were impacted. The plume has been spreading in an east-southeastern direction. The plume consists mainly of CCl_4 but degradation products, such as chloroform, are sometimes present. ATSDR prepared this public health assessment (PHA) to evaluate any known or potential adverse human health hazards from exposures to contaminants in groundwater, indoor air, and soil gases at or near the Garvey Elevator site. ATSDR staff have met with community members in the past to address any concerns they may have regarding the contaminated water. In addition, a more comprehensive analysis of potential exposures related to soil vapor intrusion into buildings on-site and off-site is

	being conducted by ATSDR. The results of the analysis will be released under separate title.
Conclusions	Based on analysis of site-related data and using certain exposure assumptions, ATSDR concludes that some drinking water wells near the Garvey Elevator site contained contaminants at concentrations high enough to harm people's health in the past. Without proper action, the contaminant concentrations in some wells could become high enough to harm people's health in the present and the future. As of 2011, the CCl_4 plume is estimated to be about 2,100 feet wide. The highest concentrations of CCl_4 appear to be near the center of the plume (near Wabash Street). The concentration of CCl_4 in some of the private wells was and still is high enough to cause increased risk of cancer with 15 years exposure as well as increase risk of non-cancer adverse health effects such as mild damage to the liver. Currently with the exception of one residence, all impacted and potentially impacted residential/business wells near the contaminated plume have been connected to the municipal water system. The residence not connected to the municipal water system was fitted with a whole-house carbon filtration system. According to information provided to ATSDR, that residence is not occupied at this time. It is possible that additional wells near the outskirts of the plume and wells near the plume's leading edge will become contaminated. ATSDR reached separate conclusions–shown below–for the following populations coming into contact with substances from the Garvey Elevator site: • Onsite workers and visitors; • Residents receiving water from a private well water supply; and • Residents receiving water from the municipal well water supply in the past.
CONCLUSION Onsite workers and visitors:	ATSDR cannot currently conclude whether onsite drinking water could have harmed workers' and visitors' health in the past.
BASIS FOR CONCLUSION Onsite workers and visitors:	This conclusion is based on a single tap water sample and it is not known if the contaminant concentrations were significantly higher or lower over the years. The estimated exposure dose due to ingestion for onsite workers, assuming a five day work week and two weeks vacation a year was

	about 0.005 mg/kg/day. The estimated dose exceeds the EPA chronic oral RfD (0.004 mg/kg/day). The estimated dose is just above the RfD and using the uncertainty factor (UF) for human variability, adverse non-cancer health effects are not likely to occur from drinking the water. An estimated increased risk of liver cancer associated with past exposure to drinking CCl_4 contaminated water from the on-site well was derived by multiplying the cancer slope factor by the maximum calculated dose. The cancer risk estimate was 9.8×10^{-5} (about 1 excess cancer case per 10,000 employees exposed). Employees who drank the contaminated water for a prolonged period (about 20 years) were at an increased risk of cancer from CCl_4 exposure.
CONCLUSION Residents with contaminated private wells:	The CCl_4 plume emanating from the Garvey Elevator site is affecting private wells to the east and southeast of the site. In the past, the highest concentrations of CCl_4 detected in private wells were high enough to harm people's health if they were exposed for a period exceeding one year. Prolonged exposure could result in mild damage to the liver as well as increased risk of liver cancer from inhaling, ingesting, and showering in contaminated water when all three routes of exposure are considered together. Residents with contaminated or potentially contaminated private wells near the contamination plume have been connected to the municipal water system. This measure has eliminated current and future exposures.
BASIS FOR CONCLUSION Residents with contaminated private wells:	ATSDR used the maximum water concentration detected (960 ppb) to conduct its initial evaluation for long-term exposures. The estimated exposure doses due to ingestion ranged from about 0.036 for adults to as high as 0.14 mg/kg/day for children. The estimated exposure doses exceed the EPA chronic oral RfD (0.004 mg/kg/day), ATSDR's intermediate oral MRL (0.007 mg/kg/day) and ATSDR's acute oral MRL of 0.02 mg/kg/day. For long-term exposures to carbon tetrachloride, EPA has developed a lower confidence limit benchmark dose (BMDL) of 3.9 mg/kg/day for mild adverse effects to the liver. The estimated exposure doses for noncancer effects are 19 to 68 times lower than observed effect levels in animal studies. However, an uncertainty factor of 1,000 was applied to the BMDL since it was based on animal data. When the uncertainty factor is applied, a health risk to sensitive populations is possible. If people were exposed for a prolonged period to CCl_4 at the maximum concentration of 960 ppb it is

	possible for mild liver damage to occur as indicated by liver enzymes in the blood and by formation of lesions in the liver. ATSDR estimated exposure doses for ingestion exposure using a range of CCl_4 concentrations. For those wells with a CCl_4 concentration above the MCL but less than 40 ppb ATSDR does not expect harmful non-cancer effects from these exposures. For the 15 wells with CCl_4 greater than 40 ppb, residents (especially children less than one year old) who drank water from these wells are at increased risk for damage to the liver as described above. ATSDR estimated the potential exposure to contaminants while showering. For the well with the highest CCl_4 concentration (i.e., 960 ppb), the equivalent 24-hour concentration of CCl_4 in air during a showering event ranged from 98.6 µg/m³ to 143 µg/m³ for persons with typical shower times of about 10 minutes. The EPA reference concentration (RfC) is 100 µg/m³. This additional exposure to CCl_4 from showers increases the risk of harmful effects to the liver for those residents who were also drinking water with CCl_4 above 40 ppb. Exposure to CCl_4 can cause liver cancer at a concentration of 960 ppb. The potential for moderate increased risk of cancer cases in the exposed population exists (about five additional cases per 10,000 exposed individuals over a 15 year period). At the concentration found in a single tap water sample (44 ppb), the potential for low increased risk of cancer cases in the exposed population exists (about two additional cases per 100,000 exposed individuals with 15 years of exposure).
CONCLUSION Residents receiving water from the municipal water system in the past:	The past concentration of CCl_4 in municipal water (prior to 1997) is unlikely to harm people's health.
BASIS FOR CONCLUSION Residents receiving water from the municipal water system in the past:	Municipal water sampling for VOCs began in the late 1980s. Carbon tetrachloride was first noted in 1990 as a contaminant and appeared sporadically in samples until 1995. In 1997, the concentration of CCl_4 reached the MCL. Shortly after, the affected wells were removed from service due to contamination with other contaminants from a nearby NPL site. Well water from the contaminated wells was blended with water from uncontaminated municipal wells prior to distribution to the end-user, which diluted contaminant concentrations even further below a level of concern.

NEXT STEPS	• Continue on-site remedial efforts to reduce exposure to contaminants in on-site groundwater and subsurface soils. This includes operation and maintenance of the soil vapor extraction (SVE) to decrease/prevent build-up of CCl_4 fumes inside of on-site buildings. • EPA or other appropriate authorities should continue to take steps to prevent or mitigate exposures to contaminants in on-site groundwater and subsurface soils. • Continue to monitor the public and private water supply along the path of groundwater plume emanating from the site. • Sample/monitor drinking water from taps of homes and businesses with whole-house water purification systems to ensure that the systems are effective. • Educate residents on the proper care and maintenance of whole-house water purification systems. • Continue to provide the opportunity to be connected to the municipal water source.
FOR MORE INFORMATION	If you have concerns about your health, you should contact your health care provider. For more information about this public health assessment, please call ATSDR at 1-800-CDC-INFO and ask for information about the "Garvey Elevator site in Hastings, Nebraska."

Introduction

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal agency within the U.S. Department of Health and Human Services (DHHS). The agency is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments of hazardous waste sites.

Purpose and Health Issues

The Garvey Elevator site was added to the National Priorities List (NPL) in September 2005. During September 2008, ATSDR issued its conclusions and recommendations about site-related contamination based on a very limited dataset [ATSDR 2008]. In that document, ATSDR found that offsite private wells were being negatively impacted by site-related contamination. ATSDR recommended continued monitoring of private and public water supply wells, continued remedial efforts, exposure point sampling of water sources, and education of potentially affected populations. This document interprets the site's more comprehensive dataset. The major environmental health and community health concerns are:

- Are Garvey Elevator workers exposed to harmful levels of onsite surface soil and groundwater contamination?
- Has the quality of municipal water near the Garvey Elevator facility been affected by site contamination? Is the water safe to drink?
- Has the quality of water in private wells near the Garvey Elevator site been affected by site contamination? Is the water safe to drink?
- Were the concentrations of contaminants in drinking water high enough that those exposed might get cancer in the future?

ATSDR conducted a comprehensive review of environmental sampling data and other site information to address these major health concerns. Specifically, ATSDR examined the nature and extent of contamination and studied how people might have come in contact with site-related contaminants, both on-site and off-site.

The purpose of this report is to present the findings of the evaluation and recommend public health actions.

Data Sources Used

Summaries of data from the following documents were used in preparation of this public health assessment (PHA):

- Combined Preliminary Assessment/Site Inspection (04/03) [TetraTech 2003]
- HRS Documentation Record (02/05) [NDEQ 2005]
- November 2005 Progress Report for the Garvey Elevator Facility (12/05) [ENSR 2005]
- December 2005 Progress Report for the Garvey Elevator Facility (12/05) [ENSR 2005]

- February 2007 Progress Report for the Garvey Elevator Facility (03/07) [ENSR 2007]
- EPA Region 7 Site Update (04/10) [EPA 2010]
- Final Remedial Investigation Report for Garvey Elevator Superfund Site (04/11) [RI 2011]
- Interim Record of Decision for Garvey Elevator Superfund Site OU1 and OU2 (09/13) [ROD 2013]

Site Description and History

Since its founding in 1959, the Garvey Elevator site has operated a grain storage elevator on a 106-acre property southwest of the city limits of Hastings, Adams County, Nebraska. The facility itself occupies approximately 22 acres of the site and the remaining 84 acres are used for agricultural purposes (crop production). [NDEQ 2005, TetraTech 2003, RI 2011 and ROD 2013]

The property is mostly surrounded by agricultural land. A paving company lies along the northern border. The western portion is bordered by Burlington Northern and Santa Fe railroad tracks. The nearest residence is immediately adjacent to the northeast property boundary, approximately 1,200 feet north of the grain storage facility [RI2011]. Additional residences are located northwest of the grain storage facility. Based on 2000 U.S. Census data, 922 residents live within one-mile of the Garvey facility. See Appendix A, Figure 4 for more demographical statistics.

The Garvey Elevator site has been divided into two operable units (OU) by the Environmental Protection Agency (EPA). Operable Unit 1 (OU1) covers soil and groundwater contamination on and immediately off of the Garvey Elevator property. Operable Unit 2 (OU2) covers the contaminated groundwater downgradient of the grain storage facility. OU2 extends about 4.3 miles to the east-southeast of the site (direction of groundwater flow) [ROD 2013].

Garvey Elevators utilized a liquid fumigant that contained 80% carbon tetrachloride (CCl_4) and 20% carbon disulfide from 1959 through 1985. In 1960, a 3,000 gallon above ground storage tank (AGST) was installed onsite to the north of the grain storage silos. The AGST was used to store the fumigant. The fumigant was delivered to the grain storage silos via an underground pipe. According to documents reviewed by state and federal investigators during the remedial investigation (RI), an underground portion of the piping system was found to be leaking and was replaced at some point while the fumigant was in use (prior to 1986). This information could not be confirmed through interviews conducted with former employees during the investigation. The duration of the leak and the amount of CCl_4 and carbon disulfide lost is unknown. The interviewees did state however that some of the fittings for the pipe leaked and that staining could be seen around the tank. [RI 2011]

In April 1994 one on-site water supply well that served the Garvey facility was sampled as part of due diligence procedures prior to the purchase of the property. In addition to providing water for facility activities, this supply well was also used as drinking water for workers. The sample was collected from a tap in the onsite men's restroom after allowing the water to flow

from the faucet for ten minutes. Analysis revealed CCl_4 at a concentration of 199 parts per billion (ppb), exceeding the national drinking water standard's Maximum Contaminant Limit (MCL) of 5 ppb. This led to additional environmental investigations being conducted on and near the site. Between 1994 to 2007, forty-seven groundwater monitoring wells were installed. Soil and soil gas samples were also taken. The Garvey facility was connected to the municipal water supply in March 1996.

In January 1999, Garvey Elevators installed a soil vapor extraction (SVE) system to treat the contaminated soils beneath the site [EPA 2010]. In the early stages of its operation, the vapors extracted for the soils contained large amounts of CCl_4. A catalytic oxidation unit treated the vapors prior to release to the atmosphere. EPA took over operation of the SVE as a source control measure after Garvey Elevator declared bankruptcy.

A groundwater extraction and treatment (GET) system that consists of eight extraction wells and an air stripper was installed to address the problem of CCl_4 in the groundwater beneath the site. After treatment, the extracted groundwater is re-injected back into the aquifer. It appears that between 1999 and 2004, the GET system shut down frequently and the system operated sporadically, allowing CCl_4 to re-enter the groundwater. When EPA took over the operation of the GET in 2008, this problem was identified and corrected.

CCl_4 was first noticed as a contaminant in municipal well water in 1990. CCl_4 appeared sporadically in water samples from that time forward. It was first detected at levels of concern in 1997. The affected municipal wells were removed from service due to trichloroethene and tetrachloroethylene contamination from a nearby National Priorities List site. Monitoring of private wells near the site began in 1994 following the discovery of on-site groundwater contamination. EPA conducted a private well assessment from April 2003 to September 2008. EPA sampled 89 private wells during the initial survey. Forty-one of those wells had been impacted by site-related contaminants. Thirty-four of the forty-one wells contained CCl_4 at concentrations above the MCL. An alternate water source was provided to the residences served by the contaminated wells.

Environmental Contamination

Site investigational history is detailed in the EPA site listing documentation and will only be briefly summarized here. The Introduction section of this PHA lists the documents used in the preparation of this report. The Reference section at the end of this report cites additional documents.

Evaluation Process

After discovery of elevated concentrations of CCl_4 in onsite groundwater in 1994, additional site investigations were conducted by Garvey Elevator and by contractors for the Nebraska Department of Environmental Quality (NDEQ) and EPA. ATSDR evaluated data from their documents to determine which contaminants could be of potential concern.

ATSDR screens sampling data to focus on which contaminants need to be evaluated by comparing the results for each chemical against screening values (SVs)—concentrations of chemicals in the environment (air, water, or soil) below which no adverse human health effects would be expected to occur. Screening values are, by design, conservative (i.e., low) and non-site-specific. If a contaminant is present at a level higher than the corresponding SV, it is retained for evaluation. A contaminant's listing in a summary of contaminants of potential concern table does not mean that a) exposure to that contaminant or adverse health effects have occurred, or that b) ATSDR expects exposures or harmful effects to occur. Inclusion in the table indicates only that the PHA will evaluate and discuss the *potential* for exposures and adverse health effects for that contaminant. See the Health Guidelines section of this document for more information.

Site Investigation Data

ATSDR reviewed groundwater, sediment, soil, soil gas, and surface water data. The concentrations of CCl_4, chloroform, and 1,2-dichloroethane found in on-site and off-site media were above ATSDR screening values and will be evaluated further (see Appendix B).

Surface Soils

Appendix A, Figure 1 shows historical on-site soil sample locations [as identified in RI 2011]. Onsite sampling occurred in June and December 1994 as well as in August 2007. ATSDR's analysis focused primarily on characterizing contamination at locations where individuals are most likely to contact it. Soil samples were collected on-site. Most of the samples were taken in locations extending from the maintenance shop to the grain bin steel tank. This includes the area once occupied by the 3,000 gallon above ground storage tank (AGST). For the purpose of estimating exposures, ATSDR defines surface soil as soil zero to three inches below ground surface (bgs). The closest samples to this depth range were taken for the remedial

investigation. Those samples were collected at zero to six inches bgs. The samples were analyzed for pesticides and not for CCl_4. Heptachlor was found in one sample but it was not detected above ATSDR's screening values. The presence of heptachlor was likely due to agricultural practices on an adjoining field rather than site activities.

Carbon tetrachloride and other chemicals were detected in soil samples taken from depths greater than six inches. Historical sampling results showed that the concentration of CCl_4 in subsurface soils did not exceed ATSDR screening values until a depth of 10 feet or more bgs was reached.

Sediments related to the site are not submerged for long periods of time. ATSDR therefore treated the sediment data as surface soil. Carbon tetrachloride was not detected in sediment samples.

Off-property soil samples were not collected because site contaminants were not expected to migrate to off-property soils due to the surface soil contamination area being confined to the areas formerly occupied by the AST and its underground piping system.

On-Site Groundwater and Drinking Water

Monitoring well sampling results are summarized in Appendix B, Table 1. Most groundwater samples were taken from monitoring wells and soil borings which do not give a clear understanding of end-user exposure concentrations. Samples taken from the potential exposure points, such as an indoor tap, are preferred when evaluating human exposure. In 1994, the concentration of CCl_4 in an on-site potable water supply well was 199 ppb and 29,943 ppb was the maximum concentration in an on-site monitoring well (MW-3B) [see Appendix A Figure 2 (taken from RI2011) for locations]. The on-site water supply well was used for drinking water by on-site workers. The duration of contamination is unknown. The facility was connected to the municipal water supply in March 1996. The on-site water supply well was capped at that time. There are currently no water supply wells on the site. [ROD 2013]

Trichloroethene has also been detected but is believed to be associated with contamination from a nearby site. Issues related to trichloroethene have been addressed in another ATSDR-produced document [ATSDR 2010]. Benzene detections are likely due to chemicals and compounds currently in use at the facility.

On-site groundwater is being remediated through a groundwater recovery system that removes CCl_4 from the groundwater. A review of monitoring well data from progress reports seems to indicate that the concentration of CCl_4 in on-site groundwater is in general decreasing over time. By 2004 the concentration of CCl_4 in MW-3B had decreased to 280 ppb.

Off-site Municipal Drinking Water

Carbon tetrachloride was first noted in 1990 as a contaminant in groundwater when municipal wells in the area were tested [Appendix B, Table 3] (NDEQ 2005); however, the concentration did not exceed drinking water standards at the time. CCl_4 was detected sporadically in municipal well water samples from 1990 to 1995. In November 1997, CCl_4 was first detected at levels of concern in Municipal Well #13, which is located about 1,500 feet east of the Garvey property boundary. The concentration of CCl_4 reached the EPA MCL of 5 ppb. The approximate location of Municipal Well #13 in relation to the site is shown in Appendix A Figure 3. The well was placed on emergency use only and was shut down in November 1997. CCl_4 was detected in Municipal Well #14 at concentrations below the MCL. Both wells are currently shut down due to contamination from another site in the area (West Highway 6 and Highway 281 Site [ATSDR 2010] located northeast of the Garvey Elevator property. No other municipal wells have been impacted by the CCl_4 plume from the Garvey Site.

Off-site Private Drinking Water

Private wells in the vicinity of the site have been monitored since 1994. As part of its Removal Assessment, EPA conducted a private well assessment. More than 89 private wells in the vicinity of the site have been sampled. Forty-one of the private wells were shown to be impacted by site-related contamination. Thirty-four of the wells contained CCl_4 at concentrations above the MCL. With the exception of one currently unoccupied residence, all potentially impacted or impacted residential private wells were connected to the municipal water supply. The EPA continues to maintain a whole-house carbon filtration system at the single residence still using private well water. The residence with the whole-house carbon filtration system currently isn't occupied. [ROD 2013]

The highest concentration of CCl_4 detected in a residential private well was 960 ppb. The residence is located about 1.6 miles east of the Garvey facility boundary and along the edge of the CCl_4 contamination plume. The reported number of individuals using this well is three. The well does not appear to have been part of earlier private well sampling events. The 960 ppb result was from a sample taken in September 2003 from an outside hydrant that served as the well–head for this private well. The maximum concentration detected in an indoor tap water sample was 44 ppb. The residence was connected to the municipal water system in December 2003. The residential well water currently is reportedly used for non-potable purposes only such as irrigation of the yard. It is feasible, based on information from nearby wells, that this private well could have been contaminated for as long as 15 years. Because only one tap water sample was collected, uncertainty exists about the concentration of CCl_4 that residents drank over the years. Therefore, ATSDR used 960 ppb to estimate people's exposure at this one residence.

Because the well listed above is was much higher than the other wells tested, ATSDR ran exposure scenarios using a variety of CCl_4 concentrations to get a better idea of risk for other

community members. Thirty-four of the additional 41 private wells tested had CCl_4 levels above the drinking water standard. The range of these concentrations is shown in Appendix B, Table 2.

Appendix A Figure 3 shows the locations of private wells in relation to the CCl_4 plume. It also shows the highest concentration of CCl_4 found in samples collected between January 2008 and June 2010. Sixty-four residential wells were tested during this time period. CCl_4 was detected in thirty-six of the sampled wells. In thirteen of those wells the detected CCl_4 concentrations were more than ten times the drinking water standard.

Carbon Tetrachloride Contaminated Groundwater Plume (on-site and off-site)

CCl_4 from a leaky underground pipe migrated into groundwater beneath the site and as a result also migrated off-site contaminating nearby public and domestic water wells. Interviews with former employees indicated that staining could be seen on some surfaces due to spillage or leakage of CCl_4 [RI 2011]. It is unknown how much of the fumigant was lost. Use of the fumigant ended in 1985.

The CCl_4 plume was estimated to be 6,500 feet long by 3,200 feet wide in 1996. A soil vapor extraction (SVE) system and groundwater extraction and treatment (GET) system were put into place in 1999. The contamination plume is divided into three groundwater zones (upper, middle, and lower). The GET system's design has extraction wells screened only in the upper and middle zones. This makes the GET system inadequate for treating contamination in the lower zone. The GET system was operated sporadically from 1999 to 2008 due to various system malfunctions (RI 2011). As of May 2008, the plume was estimated to have spread more than 16,000 feet beyond the area of the on-site leaking pipe in a down-gradient direction toward the east-southeast and was up to 5,000 feet wide. As of 2011, the CCl_4 plume is estimated to be about 2,100 feet wide due to EPA's GET system (see Appendix A Figure 3). The highest concentrations of CCl_4 appear to be near the center of the plume (near Wabash Street). There is likelihood that additional wells near the outskirts of the plume as well as the plume's leading edge will become contaminated.

On-site Air

Soil gas and indoor air samples were collected from locations onsite. The samples were taken while the site's SVE system was in use. CCl_4 and chloroform were detected soil gas samples but not in the indoor air samples. The absence of CCl_4 and chloroform in indoor air samples may have been influenced by the use of the SVE while sampling was occurring. ATSDR is addressing potential exposure to contaminants in air in another document, currently under development.

On-site Surface Water

Any surface waters on the site is the result of precipitation events, puddles formed during the washing and rinsing of equipment, and/or watering of crops present on portions of the site. All

of these water bodies are short-lived and any significant contact with these intermittent water bodies is unlikely.

Other Contaminants Detected During Site Investigations (on-site samples)

Carbon tetrachloride is the main contaminant of concern related to the Garvey Elevator facility. However other contaminants were detected in some samples during various site investigations. For the remedial investigation, soil boring samples collected during the installation of onsite monitoring wells were analyzed to determine the vertical extent of onsite contamination. Chloroform, a CCl_4 degradation compound, is a contaminant of potential concern in onsite subsurface soils and groundwater. It was detected in 16 of 25 soil boring samples analyzed at concentrations ranging from 1.2 ppb – 18 ppb (Appendix B, Table 1). Benzene (0.86 – 4 ppb) and trichloroethene (0.37 ppb – 7.3 ppb) were also detected in some of the samples. The benzene detections are most likely related to chemicals and compounds currently used at the grain elevator. The trichloroethene contamination is not considered to be related to the Garvey Elevator site. That contamination appears to be related to a nearby National Priorities List site.

Other Contaminants Detected During Site Investigations (off-site samples)

Municipal water was found to be contaminated with trichloroethene (TCE), up to 1.3 ppb, and tetrachloroethylene (PCE), up to 130 ppb. The TCE and PCE are believed to be contamination related to a nearby site mentioned earlier. Water from municipal wells is blended with water from other municipal wells prior to reaching the consumer. Therefore the concentration at the potential exposure point (e.g., indoor tap) would be diluted in the blended water that is distributed to consumers. Affected wells were removed from service. [RI 2011]

Chloroform, a CCl_4 degradation product, was detected in 42 of 107 residential well samples collected during the remedial investigation. The concentrations ranged from 0.26 ppb – 140 ppb (Appendix A Table 2). Three of the sample concentrations exceeded ATSDR's screening values.

Residential well water was sampled during the remedial investigation sampling events. One hundred five samples were collected and 1,2-dichloroethane was detected in a single sample at a concentration of 3 ppb (Appendix B Table 2). TCE and PCE were not determined to be contaminant of potential concern in the residential wells sample

Discussion of Exposure and Public Health Significance

Introduction

This section summarizes the completed and potential exposure pathways associated with the Garvey Elevator site as well as what such exposures could mean to the individuals exposed. Among ATSDR's first goals during the PHA process is to identify exposure pathways. Exposure pathways are the different ways that contaminants move in the environment and the different ways that people could come into contact with those contaminants. In short, the purpose of the exposure pathways analysis is to determine how, when, where, and whether anyone could come into contact with a contaminant in the past, present, or future.

This information alone does not define exposure, but it helps ATSDR to understand the likelihood of exposures. The exposure pathways information is used together with the environmental data to support the health effects evaluation.

ATSDR obtained information to support the exposures pathways analysis for the Garvey Elevator site from multiple sources:

- Site investigation reports;
- 2010 U.S. Census data; and
- Communications with local and state officials and community members.

The analysis also draws from environmental and exposure data, already presented in this document. The population of concern for the Garvey Elevator site is those persons living in the vicinity of the site who may be impacted by contamination from the CCl_4 contaminated groundwater plume. Past onsite workers potentially were impacted also. Current visitors to the site and potential trespassers are not likely to be adversely impacted due to remedial measures that are in place. ATSDR is accessing the potential impact upon current onsite workers due to soil vapor intrusion in a separate document that is currently under development.

To determine whether residents and on-site workers are exposed to site-related contaminants, ATSDR evaluated exposure pathways related to the Garvey Elevator site.

An "exposure pathway" is the way a contaminant moves from its source (where it began) to where people can come into contact with it. ATSDR regards an exposure pathway as "complete" if all five of the following elements are present:

1. Source of contamination;
2. Environmental media and transport mechanism (e.g., air, water, soil);
3. Point of exposure (a place where human contact is possible);
4. Route of exposure (e.g., breathing, eating, touching); and
5. Receptor population

An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. ATSDR categorizes exposure pathways that are not eliminated as either completed or potential. For completed exposure pathways, all five elements exist and exposure to a contaminant has occurred, is occurring, or will occur. For potential exposure pathways, at least one of the five elements is missing but could exist. For potential exposure pathways, exposure to a contaminant could have occurred, could be occurring, or could occur in the future.

ATSDR's approach to evaluating a potential health concern has two components. The first component involves a screening process which could indicate the need for further analysis. The second component involves a weight-of-evidence approach that integrates estimates of exposure with information about the toxicology and epidemiology of the substances of interest. Screening is a process of comparing appropriate environmental concentrations to health-based screening values. The Health Guidelines section located at the end of this document discusses the implementation, derivation, and use of some of the screening values that ATSDR used to select contaminants for further evaluation.

Health effects resulting from the interaction of an individual with a hazardous substance in the environment depends on several factors. One is the route of exposure, which is, whether the chemical is inhaled, ingested (swallowed), or touched by the skin (i.e., dermal contact). Other factors include how long the exposure occurs, the dose to which a person is exposed, and the amount of substance that is actually absorbed. Mechanisms by which the environment or the body alters chemicals, as well as the combination of chemicals, are also important. Once exposure occurs, characteristics including a person's age, sex, nutritional status, genetics, lifestyle, and health status may influence how the body absorbs, distributes, metabolizes, and excretes contaminants. [ATSDR 2005b]

Together, those factors and characteristics determine the health effects that could occur as a result of exposure to a contaminant. Some variation in those mechanisms exists among individuals. Because of the variation in mechanisms of exposure, ATSDR has made several assumptions to make a conservative estimate of exposure levels for people impacted by contaminants from the Garvey Elevator site.

ATSDR reviewed the site history and environmental data provided by EPA to determine whether people in the vicinity of Garvey Elevator site using domestic and municipal drinking water might experience adverse health effects associated with exposure to site contaminants

through ingestion, through inhalation, and through dermal contact. The following discussion is based upon a summary of the data contained in the previously indicated documents.

On-site Worker and Visitor Exposures

The following table summarizes the status of exposure pathways for on-site workers and visitors:

Exposure Pathways Table 1 – Status of On-site Worker and Visitor Exposure Pathways for the Garvey Elevator site

Source	Medium	Exposure Point	Route of Exposure	Pathway Status	TimeFrame
Contaminated water in private supply well located onsite	Groundwater	Drinking water access points	Ingestion	Complete	Past
Leakage from above ground storage tank (AGST)	Surface soil	Onsite in the vicinity of the AST	Inhalation, dermal contact, incidental ingestion	Complete	Past
Spillage of chemical during operations at the site	Soil gas	Vicinity of maintenance building	Inhalation	Potential	Past; Present; Future
Contaminated onsite subsurface soil and contaminated groundwater	Subsurface soil and groundwater	Work areas	Inhalation; incidental ingestion, direct contact	Potential	Past; Present; Future
Contaminated on-site surface water	Surface water	Puddles	Ingestion; inhalation; direct contact	Eliminated	Past; present; future
Contaminated sediments in drainage ditches	Sediment	Drainage ditches	Incidental ingestion; inhalation; direct contact	Eliminated	Past; present; future

Contaminated surface soils	Surface soil	Onsite soil	Incidental ingestion; inhalation; direct contact	Eliminated	Past; present; future
Contaminated water in plume beneath site	Groundwater	Drinking water access points	Ingestion; inhalation; direct contact	Eliminated	Present; future

In 1994, an on-site water supply well was found to be contaminated with 190 ppb CCl_4. The sample tested was taken from the tap of a restroom basin after allowing the water to flow for ten minutes. Workers at the Garvey facility were exposed to CCl_4 when they drank or otherwise used this water. The date this well became contaminated is not known but it could have been contaminated for more than 20 years. Also, the concentration of CCl_4 could have been higher or lower over the years. Nearby monitoring wells, which were installed in 1994, showed CCl_4 levels as high as 30,000 ppb. Therefore, worker exposure to CCl_4 in groundwater is a completed exposure pathway. As of June 2010, on-property monitoring wells indicate that CCl_4 is present in on-site groundwater at concentrations up to 1,300 ppb. A groundwater extraction and treatment (GET) system consisting of eight recovery wells in the upper and middle aquifer zones, was installed on-site in 1999. The contaminated plume is migrating to the east-southeast and the current GET system is unable to capture all of the contaminants

Through inhalation or dermal contact, people working in the vicinity of the vicinity of the former AGST could have been exposed to spilled CCl_4 when they came in contact with contaminated soil. The concentration of CCl_4 spilled onto surface soils is unknown. Data on concentration of CCl_4 in surface soils was not found. Small amounts of CCl_4 could have been incidentally ingested when digging into the soil (e.g., during repair operations for leaking transport pipe).

Volatile contaminants may volatilize (off-gas) from soil and groundwater, migrate through subsurface air spaces between soil particles, and enter buildings where they may be inhaled by occupants. Many variables influence the levels of chemicals entering a building this way. These variables include the chemical's physical and chemical properties, seasonal variations, and building construction.

The site's vapor extraction (SVE) system was operating when the Remedial investigation sub-slab soil gas (beneath the office/shop and maintenance buildings) and air samples (inside the buildings) were collected. The sampling data show that the primary site contaminants— CCl_4 and chloroform—were detected in the soil gas samples but not in the indoor air samples. The absence of CCl_4 and chloroform may be due to the influence of the SVE system. More specifically, the SVE draws air from the surrounding subsurface soils into extraction wells which may prevent or reduce the movement of CCl_4 and chloroform through the office/shop and maintenance building foundations into the air inside the buildings.

The potential for CCl_4 and chloroform to infiltrate the buildings in the absence of the SVE system cannot be determined because no sub-slab soil gas or indoor air samples were collected when the SVE system was shut down.

ATSDR eliminated the surface water pathway because large water bodies are not present on the site and CCl_4 would evaporate quickly from the shallow drainage ditches. Because sediments are not submerged in water for long periods of time, sediment sampling results were treated as surface soil samples for the purpose of this public health assessment.

Various pesticides were detected during some sampling events. The pesticides were not detected in surface soil samples taken throughout the grain storage facility. Pesticides were detected in sediment samples from on-site drainage ditches at concentrations below ATSDR screening values. The likely source of pesticides is believed to be agricultural practices at adjoining and upgradient fields [RI 2011].

The present and future onsite groundwater exposure pathway has been eliminated from consideration because there is no public access to the property. Workers and visitors are prohibited from drinking water from unapproved sources. The facility was connected to municipal water in March 1996. The onsite water supply well was capped at that time. Past groundwater exposure is a completed pathway, however.

In 1994, an on-site water supply well was found to be contaminated with 190 ppb CCl_4. Due to lack of historical data on the levels of contamination onsite workers and visitors may have been exposed to (from possibly as early as 1959 until the spring of 1994 when the groundwater contamination was discovered), it is not possible to assess that potential exposure or its health effects. However, based on the known sample result, using an extremely conservative exposure scenario, the exposure to contaminated groundwater may have harmed people's health. The maximum concentration of CCl_4 contaminating the well over time is not known. The estimated exposure dose due to ingestion for onsite workers, assuming a five day work week and two weeks vacation a year was about 0.005 mg/kg/day. The estimated dose exceeds the EPA chronic oral RfD (0.004 mg/kg/day). The estimated dose is just above the RfD and using the uncertainty factor (UF) for human variability, adverse non-cancer health effects are not likely to occur from drinking the water. However, this conclusion is based on a single tap water sample and it is not known if the contaminant concentrations were significantly higher or lower over the years.

An estimated increased risk of cancer associated with past ingestion exposure toCCl_4 contaminated water at 190 ppb from the on-site well was derived by multiplying the cancer slope factor by the maximum calculated dose. The cancer risk estimate was 9.8×10^{-5} (about 1 excess cancer case per 10,000 employees exposed). Employees who drank the contaminated water for a prolonged period (about 20 years) were at an increased risk of cancer from CCl_4 exposure.

Private Well Exposures

All residential and commercial properties with private wells shown to contain CCl_4 at or above the MCL have been placed on alternate water source (clean municipal water system or whole-house water purification systems). Those placed on the municipal water system agreed to discontinue use of their private well or to use it for non-drinking water purposes only such as watering lawns, watering gardens, and outside cleaning. The status of filtration system maintenance in homes is unknown.

The following table summarizes the status of exposure pathways for residents exposed to contaminants via their private well water:

Exposure Pathways Table 2 – Status of Residents with Contaminated Private Well Exposure Pathways for the Garvey Elevator site

Source	Medium	Exposure Point	Route of Exposure	Pathway Status	TimeFrame
Contaminated water from plume originating at the site	Groundwater	Potable water access points	Ingestion; inhalation; direct contact	Completed	Past
Contaminated water from plume originating at the site	Groundwater	Potable water access points	Ingestion; inhalation; direct contact	Potential	Present; Future
Spillage of chemical during operations at the site	Soil gas	Residences in the vicinity of CCl_4 groundwater plume	Inhalation	Eliminated	Past; Present; Future

Carbon Tetrachloride
As of August 2009, the CCl_4 groundwater plume extends approximately 4.5 miles east-southeast of the site (Appendix A Figure 3) in the direction of groundwater flow. However, because the depth to groundwater in the area is more than 100 feet, migration of CCl_4 from the groundwater plume into nearby homes, businesses and other buildings is unlikely.

ATSDR used the maximum water concentration detected (960 ppb) to conduct its initial evaluation for long-term exposures. The estimated exposure doses due to ingestion ranged from about 0.036 for adults to as high as 0.14 mg/kg/day for children. Parameters used in estimating the exposure doses are discussed in Appendix D of this document. The estimated exposure doses exceed the EPA chronic oral RfD (0.004 mg/kg/day), ATSDR's intermediate oral MRL (0.007 mg/kg/day) and ATSDR's acute oral MRL of 0.02 mg/kg/day.

For long-term exposures to carbon tetrachloride, EPA has developed a lower confidence limit benchmark dose (BMDL) of 3.9 mg/kg/day for mild adverse effects to the liver. The estimated exposure doses for noncancer effects are 19 to 68 times lower than observed effect levels in animal studies. However, an uncertainty factor of 1,000 was applied to the BMDL since it was based on animal data. When the uncertainty factor is applied, a health risk to sensitive populations is possible. If people were exposed for a prolonged period to CCl_4 at the maximum concentration of 960 ppb it was possible for mild liver damage to occur as indicated by liver enzymes in the blood and by formation of lesions in the liver. See appendices C and D for more information.

To better estimate potential health effects, ATSDR estimated exposure doses for ingestion exposure using a range of CCl_4 concentrations. For those wells with a CCl_4 concentration above the MCL but less than 40 ppb ATSDR does not expect harmful non-cancer effects from these exposures. For the 15 wells with CCl_4 greater than 40 ppb, residents (especially children less than one year old) who drank water from these wells are at increased risk for damage to the liver as described in Appendix C.

ATSDR estimated the potential exposure to contaminants while showering. For the well with the highest CCl_4 concentration (i.e., 960 ppb), the equivalent 24-hour concentration of CCl_4 in air during a showering event ranged from 98.6 µg/m³ to 143 µg/m³ for persons with typical shower times of about 10 minutes. This additional exposure to CCl_4 from showers increases the risk of harmful effects to the liver for those residents who were also drinking water with CCl_4 above 40 ppb.

Exposure to CCl_4 can cause cancer. Carbon tetrachloride was detected at a concentration of 960 ppb in a sample taken from an outside hydrant associated with a private drinking water well. The potential for moderate increased risk of cancer cases in the exposed population exists (about five additional case per 10,000 exposed individuals over a 15 year period). At the concentration found in single tap water sample (44 ppb), the potential for low increased risk of cancer cases in the exposed population exists (about two additional cases per 100,000 exposed individuals with 15 years of exposure).

Chloroform and Methylene Chloride

In addition to CCl_4 its degradation products (chloroform and methylene chloride) were also detected. Methylene chloride was not detected at concentrations above ATSDR screening values. Chloroform was detected at concentrations above screening values.

Chloroform is also a breakdown product of CCl_4. Chloroform in residential wells was measured at a maximum concentration of 140 ppb. The estimated exposure doses due to ingestion ranged from about 0.005 for adults to as high as 0.02 mg/kg/day for children birth to 2 years. The estimated doses for children up to 2 years old exceeded the health guideline for long-term exposure (RfD = 0.01 mg/kg/day). The RfD is based on the benchmark dose lower confidence limit (BMDL) of 1.2 mg/kg/day derived from a dog study. The BMDL represents the 95% confidence lower bound on the dose associated with a 10% extra risk based on the prevalence of dogs with moderate to marked fatty cysts in liver and elevated serum glutamic-pyruvic

transaminase (SGPT), an indication of liver damage[Heywood 1979]. Many other studies in other animals support the conclusion that the liver is the key target organ for chloroform toxicity. Most of these studies have been performed in rats and mice, and most yield lowest-observed-adverse-effect-level (LOAEL) values that are substantially higher than those observed in dogs.

The estimated doses for adults and most children are below the RfD; therefore, harmful effects are not likely. Only the estimated doses for children birth to 2 years exceed the RfD and these estimated doses are far below the harmful effects level established by EPA as the BMDL. In addition, the samples were collected from an outside access point as opposed to tap water. Adverse non-cancer health effects are not expected from exposure to chloroform alone, but given that both chloroform and CCl_4 affect the liver, exposure to chloroform in conjunction with CCl_4 could increase the risk of adverse health effects.

EPA classifies chloroform as likely to be carcinogenic to humans based on 1999 cancer assessment guidelines. There are a few epidemiological studies which relate a weak association between drinking water with chloroform and the development of bladder, rectal, and colon cancer. It is not possible to estimate the cancer risk from chloroform in drinking water because EPA has not established a cancer slope factor.

A single residential well water sample contained DCA at a maximum concentration of 3 ppb. The estimated exposure doses for children (0.0001 to 0.0004 mg/kg/day) and for adults (0.0001 mg/kg/day) are less than ATSDR's intermediate oral MRL (0.2 mg/kg/day) and thus harmful effects are not likely for exposures up to one year. The well water concentration of 3 ppb is also below the MCL of 5 ppb.

Human studies examining whether DCA can cause cancer have been considered inadequate. In animals, increases in the occurrence of stomach, mammary gland, liver, lung, and endometrium cancers have been seen following inhalation, oral, and dermal exposure. DHHS has determined that DCA may reasonably be expected to cause cancer. EPA has determined that DCA is a probable human carcinogen and the IARC considers it to be a possible human carcinogen.

An estimated increased risk of cancer associated with past exposure to DCA was derived by multiplying the appropriate cancer slope factor by the maximum calculated dose. An increased risk of cancer cases in the exposed population is unlikely (about one additional cancer case per 100,000 exposed individuals).

Municipal Water Supply Exposures (prior to 1991)

Through ingestion, inhalation, and dermal contact some residents in Hastings who received their water from the municipal water system were likely exposed to CCl_4 and tetrachloroethylene (PCE) at concentrations below the MCL. Historical (annual) sampling data for the municipal well (beginning in the late 1980s) did not indicate CCl_4 contamination until 1997 at which time the use of the well was restricted. The city has kept concentrations of CCl_4

in the drinking water system below the MCL by changing the status of the affected well to emergency use for firefighting purposes only. The nearest operational municipal well is about 6,000 feet northeast of the Garvey facility [RI 20111] and thus is upgradient of the contaminated groundwater plume and not likely to be contaminated with carbon tetrachloride. Carbon tetrachloride was detected in two municipal water wells located near the Garvey Elevator site at a maximum concentration of 5 parts per billion (ppb). Upon detection the wells were removed from service.

The following table summarizes the status of exposure pathways for individuals exposed to potentially contaminated municipal water:

Exposure Pathways Table3 – Status of Public Water Supply User Exposure Pathways for the Garvey Elevator site

Source	Medium	Exposure Point	Route of Exposure	Pathway Status	TimeFrame
Contaminated water from plume originating at the site and other locations	Groundwater	Potable water access points	Ingestion; inhalation; direct contact	Completed	Past

In the past residents who used municipal water were likely exposed to very small amounts of CCl_4, PCE, and trichloroethene through the drinking of water, skin contact while showering or bathing, and inhalation of vapors released when the water was in use. Exposures above the MCL during showering and other indoor water uses were probably of short duration because water from the affected well was blended with water from other municipal wells before entering the distribution system. Therefore, it is highly unlikely that the concentrations to which people could have been exposed was as high as the concentration detected in the municipal water samples.

Estimated daily doses to the maximum CCl_4 level detected in municipal wells (5 ppb) for children and adults are 0.0025 mg/kg/day and 0.00009 mg/kg/day, respectively. The estimated exposure doses are lower than EPA's RfD for long term exposure and lower than ATSDR's acute and intermediate MRLs for shorter term exposures. ATSDR considers exposures to the levels of CCl_4 detected in the municipal wells unlikely to result in harmful noncancer health effects. In addition, the levels detected in the wells are equal to or less than the MCL and the water is blended with other municipal water prior to entry into the distribution system. The concentration of CCl_4 that could potentially reach the consumer would therefore be below EPA's MCL and not high enough to cause adverse noncancer health effects. [ATSDR 2005a, ATSDR 2005b, EPA 2013, EPA 2011, EPA 2004, and RI 2011]

The lowest cancer effect levels seen for mice were 25 ppm via inhalation and 20 mg/kg/day via ingestion. Significant CCl_4 contamination of the municipal wells never occurred because the

water is blended with water from other wells prior to distribution to the public and thus there is no increased risk of cancer. ATSDR considers exposures to CCl_4 contaminated water from the municipal wells were unlikely to result in cancer health effects.

Child Health Considerations

ATSDR recognizes that infants and children might be more vulnerable than adults to exposures in communities with contaminated air, water, soil, or food. This potential vulnerability results from the following factors: 1) children are more likely to play outdoors and bring food into contaminated areas; 2) children are shorter and therefore more likely to contact dust and soil; 3) children's small size results in higher doses of chemical exposure per kilogram of body weight; and 4) developing body systems can be more sensitive to toxic exposures occur during critical growth stages. Because children depend completely on adults for risk identification and management, ATSDR is committed to evaluating their special interest at the site.

Children are thought to have greater exposure to contaminants in soil than adults. Exposure to contaminants in soil would have only have been a concern on-site in the past. Surface soil contamination at the grain storage facility was reviewed during past environmental investigations. Recent sampling activities did not detect contaminants at levels of public health concern in surface soil samples. ATSDR did not receive any reports of children playing within the boundary of the grain storage facility. Therefore, children are not at risk of harmful effects from historical contamination of soil at the Garvey facility.

ATSDR is unable to determine when each individual private well became contaminated, so the actual length of individual exposure is unknown. When the concentration of CCl_4 reached or exceeded the MCL (5 ppb) the homeowner was offered the opportunity to connect to the municipal water supply or have a whole-house water filtration system installed. Maximum concentration of CCl_4 in the well since the contamination began is unknown. ATSDR used a conservative exposure scenario to estimate the exposure doses for affected residents using contaminated wells. The estimated exposure doses exceed the EPA chronic oral RfD as well as ATSDR's acute and intermediate oral MRLs. The benchmark dose for mild adverse effects to the liver for CCl_4 is 3.9 mg/kg/day. For those wells with a CCl_4 concentration above the MCL but less than 40 ppb, the estimated exposure doses for children were 500 to over 1,000 times lower than the BMDL. ATSDR does not expect children to receive harmful non-cancer health effects from these exposures. For the 15 private wells with a CCl_4 concentration greater than 40 ppb, it is possible that prolonged exposure to the contaminated water may harm a child's health. It was possible for mild liver damage to occur as indicated by liver enzymes in the blood and by formation of lesions in the liver.

Residents with contaminated or potentially contaminated private wells near the contamination plume were connected to the municipal water system.

Community Health-Related Concerns

As part of the public health assessment process, ATSDR staff reviewed site documents and conducted public availability sessions to understand the community member's concerns regarding the contamination, investigation, and remediation of the site. During the sessions, which were held in September 2006, the community expressed concerns about potential exposures and developing cancer from exposure to contaminated drinking water.

- Are nearby residents or Garvey Elevator workers exposed to harmful levels of onsite surface soil and groundwater contamination?

  Based upon information reviewed by ATSDR, the populations at risk to exposure to on-site contamination were past on-site workers and the occasional on-site visitor. On-site workers may have been briefly exposed to contaminants in surface soil following spill events. Since concentration data was not collected during such events, ATSDR did not have data to evaluate. Theoretically, if an on-site worker drank copious amounts of water for an extended period of time (about 20 years), such an employee would be at an increased risk (about 1 excess cancer case per 10,000 employees exposed) of cancer from CCl_4 exposure. The water supplying the site is now from the municipal water system and is safer to drink.

  In 1994, an on-site water supply well was found to be contaminated with 190 ppb CCl_4. The sample tested was taken from the tap of a restroom basin after allowing the water to flow for ten minutes. Workers at the Garvey facility were exposed to CCl_4 when they drank or otherwise used this water. The date this well became contaminated is not known but it could have been contaminated for more than 20 years. Also, the concentration of CCl_4 could have been higher or lower over the years. Nearby monitoring wells, which were installed in 1994, showed CCl_4 levels as high as 30,000 ppb. On-site groundwater is being remediated through a groundwater recovery system that removes CCl_4 from the groundwater.

  In the past fumigant from a former above ground storage tank (AGST) and its underground delivery system spilled on leaked onto surface soils and into subsurface soils. The amount of the fumigant released and the duration of potential exposure is unknown. ATSDR does not know if the concentrations of spilled chemical on the ground or in the air were high enough harm workers or residents health.

  Volatile contaminants may volatilize (off-gas) from soil and groundwater, migrate through subsurface air spaces between soil particles, and enter buildings where they may be inhaled by occupants. The sampling data showed that the primary site contaminants— CCl_4 and chloroform—were detected in the soil gas samples but not in the indoor air samples.

The potential for CCl_4 and chloroform to infiltrate the onsite buildings in the absence of the SVE system cannot be determined because no sub-slab soil gas or indoor air samples were collected when the SVE system was shut down. ATSDR is conducting a more thorough analysis of potential exposures due to soil vapor intrusion. The results of the analysis will be reported in a document which will be released under separate title [under development].

Offsite buildings are at least 100 feet away from site-related contamination and no preferential pathways are suspected. Therefore, no offsite exposures of concern are expected. In addition, residences over the offsite groundwater contamination plume are over 100 feet vertically from the groundwater. No subsurface preferential pathways, such as karst or bedrock fractures, were identified to allow vapors to travel farther than 100 feet.

- Has the quality of municipal water near the Garvey Elevator facility been affected by site contamination? Is the water safe to drink?

  In the past contaminants from the Garvey Elevator site have been detected in municipal water but the levels were not high enough to warrant concern for the consumer. Mixing of water prior to distribution to consumers dilute known contaminants such that ATSDR does not expect the health of individuals to be harmed by drinking the water.

  In the past residents who used municipal water were likely exposed to very small amounts of CCl_4 through the drinking of water, skin contact while showering or bathing, and inhalation of vapors released when the water was in use. Carbon tetrachloride was detected in two municipal water wells located near the Garvey Elevator site at a maximum concentration of 5 parts per billion (ppb). ATSDR considers exposures to the levels of CCl_4 detected in the municipal wells are unlikely to result in harmful noncancer health effects.

  The levels detected in the wells are equal to or less than the MCL and the water is blended with other municipal water prior to entry into the distribution system. The concentration of CCl_4 that could potentially reach the consumer would therefore be below EPA's MCL and not high enough to cause adverse health effects.

  Significant contamination of the municipal wells never occurred because they are continuously monitored and thus there is no increased risk of cancer. ATSDR considers exposures to CCl_4 contaminated water from the municipal wells were unlikely to result in cancer health effects. Upon detection the wells were removed from service.

- Has the quality of water in private wells near the Garvey Elevator site been affected by site contamination? Is the water safe to drink?

Private wells to the east and southeast of the Garvey Elevator site are being impacted by contamination from the CCl_4 plume emanating from the site. The amount of the contaminant in untreated water may be high enough to harm people's health.

The contaminated plume is migrating to the east-southeast (Appendix A Figure 3) and the current groundwater treatment and extraction system that has been installed on-site is unable to capture all of the contaminants. If contaminants reach drinking water wells that are in use, people could get exposed.

Prior to being placed on municipal water or receiving whole-house filtration systems, residents with private wells in the vicinity of the site were likely exposed to CCl_4 in the groundwater through the drinking of the water, skin contact during showering or bathing, and inhaling volatile organic compound (VOC) vapors released during water use. For how long these individuals were exposed is not known.

The highest concentration of CCl_4 found in a private well was 960 ppb. If people were exposed for a prolonged period to CCl_4 at the maximum concentration of 960 ppb it was possible for mild liver damage to occur as indicated by liver enzymes in the blood and by some formation of cavities in liver cells. An indoor tap sample taken at the same residence indicated the presence of CCl_4 at a concentration of 44 ppb. The affected household was hooked up to the municipal water supply.

- Were the concentrations of contaminants in drinking water high enough that those exposed might get cancer in the future?

  ATSDR estimated the risk of cancer if people used water contaminated with various concentrations of CCl_4 for a long period of time. The concentrations of contaminants in the groundwater plume emanating from the Garvey Elevator site may increase risk of cancer if people use untreated contaminated water over for a long time.

  Exposure to CCl_4 can cause cancer. Carbon tetrachloride was detected at a concentration of 960 ppb in a sample taken from an outside hydrant associated with a private drinking water well. The potential for moderate increased risk of cancer cases in the exposed population exists (about 5 additional case per 10,000 individuals exposed over a 15 year period). At the concentration found in single tap water sample (44 ppb), the potential for low increased risk of cancer cases in the exposed population exists (about 2 additional cases per 100,000 exposed individuals exposed over a 15 year time period).

  ATSDR considers exposures to CCl_4 contaminated water from the municipal wells were unlikely to result in cancer health effects. Carbon tetrachloride was first

noted in 1990 as a contaminant in groundwater when municipal wells in the area were tested; however, the concentration did not exceed drinking water standards at the time. CCl_4 was detected sporadically in municipal well water samples from 1990 to 1995. In November 1997, $CCl_4$was first detected at levels of concern in Municipal Well #13, which is located about 1,500 feet east of the Garvey property boundary. The concentration of CCl_4 began to approach the EPA maximum contamination limit (MCL). The concentration measured was 5 ppb. The well was placed on emergency use only and was shut down in November 1997. CCl_4 was also detected in Municipal Well #14 at concentrations below the MCL. Both wells are currently shut down. No other municipal wells have been impacted by the CCl_4 plume from the Garvey Site.

ATSDR believes that employees who drank contaminated on-site water for a prolonged period (about 20 years) were at an increased risk of cancer from CCl_4 exposure. The cancer risk estimate was 9.8×10^{-5} (about 1 excess cancer case per 10,000 employees exposed for 20 years).

Due to past and current remedial and mitigation efforts, the concentrations of contaminants in drinking water sources are being reduced before long-term exposure can occur. Residents with contaminated or potentially contaminated wells in the vicinity of the contamination plume have been connected to municipal water.

A glossary of environmental health terms can be found at the end of this public health assessment.

A public comment version of this PHA was released on October 13, 2015. No comments were received from the community or State and local Agency representatives.

Conclusions

Based on analysis of available data and using certain exposure assumptions, ATSDR concludes that some drinking water wells near the Garvey Elevator site contained contaminants at concentrations high enough to harm people's health in the past. Without proper action, the contaminant concentrations in some wells could become high enough to harm people's health in the present and the future.

The exact duration of exposure to contaminants from the site is unknown. In developing this assessment, ATSDR assumed that a resident drinking and showering with contaminated private well water may have been exposed for as many as 15 years.

As of 2011, the CCl_4 plume is estimated to be about 2,100 feet wide. The highest concentrations of CCl_4 appears to be near the center of the plume (near Wabash Street). The concentration of CCl_4 in some of the private wells is/was high enough to cause low to moderate increased risk of cancer with 15 years exposure as well as increase risk of non-cancer adverse health effects such as mild damage to the liver.

Currently with the exception of one residence, all impacted and potentially impacted residential/business wells near the contaminated plume have been connected to the municipal water system. The residence not connected to the municipal water system was fitted with a whole-house carbon filtration system. According to information provided to ATSDR, that residence is not occupied at this time. It is possible that additional wells near the outskirts of the plume and wells near the plume's leading edge will become contaminated.

ATSDR reached separate conclusions–shown below–for the following populations coming into contact with substances from the Garvey Elevator site:

- Onsite workers and visitors
- Residents receiving water from a private well water supply, and
- Residents receiving water from the municipal well water supply in the past.

On-Site Workers and Visitors Exposure

ATSDR cannot currently conclude whether onsite drinking water could have harmed workers and visitors health in the past. This conclusion is based on a single tap water sample and it is not known if the contaminant concentrations were significantly higher or lower over the years.

The estimated exposure dose due to ingestion for onsite workers, assuming a five day work week and two weeks vacation a year was about 0.005 mg/kg/day. The estimated dose exceeds the EPA chronic oral RfD (0.004 mg/kg/day). The estimated dose is just above the RfD and using the uncertainty factor (UF) for human variability, adverse non-cancer health effects are not likely to occur from drinking the water.

An estimated increased risk of cancer associated with past exposure by drinking CCl_4 contaminated water from the on-site well was derived by multiplying the cancer slope factor by the maximum calculated dose. The cancer risk estimate was 9.8×10^{-5} (about 1 excess cancer case per 10,000 employees exposed). Employees who drank the contaminated water for a prolonged period (about 20 years) were at an increased risk of cancer from CCl_4 exposure.

Private Well Water Exposure

In the past, the concentrations of CCl_4 detected in private wells were high enough to harm the health of people exposed for a period exceeding one year. Prolonged exposure could result in mild damage to the liver as well as low to moderate increased risk of liver cancer from inhaling, ingesting, and showering in contaminated water.

ATSDR used the maximum water concentration detected (960 ppb) to conduct its initial evaluation for long-term exposures. The estimated exposure doses due to ingestion ranged from about 0.036 for adults to as high as 0.14 mg/kg/day for children. The estimated exposure doses exceed the EPA chronic oral RfD (0.004 mg/kg/day), ATSDR's intermediate oral MRL (0.007 mg/kg/day) and ATSDR's acute oral MRL of 0.02 mg/kg/day. For long-term exposures to carbon tetrachloride, EPA has developed a lower confidence limit benchmark dose (BMDL) of 3.9 mg/kg/day for mild adverse effects to the liver. The estimated exposure doses for noncancer effects are 19 to 68 times lower than observed effect levels in animal studies. However, an uncertainty factor of 1,000 was applied to the BMDL since it was based on animal data. When the uncertainty factor is applied, a health risk to sensitive populations is possible. If people were exposed for a prolonged period to CCl_4 at the maximum concentration of 960 ppb it is possible that mild liver damage occurred as indicated by liver enzymes in the blood and by formation of lesions in the liver.

ATSDR estimated exposure doses for ingestion exposure using a range of CCl_4 concentrations. For those wells with a CCl_4 concentration above the MCL but less than 40 ppb ATSDR does not expect harmful non-cancer effects from these exposures. For the 15 wells with CCl_4 greater than 40 ppb, residents (especially children less than one year old) who drank water from these wells are at increased risk for damage to the liver as described above.

ATSDR estimated the potential exposure to contaminants while showering. For the well with the highest CCl_4 concentration (i.e., 960 ppb), the equivalent 24-hour concentration of CCl_4 in air during a showering event ranged from 98.6 µg/m³ to 143 µg/m³ for persons with typical shower times of about 10 minutes. This additional exposure to CCl_4 from showers increases the risk of harmful effects to the liver for those residents who were also drinking water with CCl_4 above 40 ppb.

Exposure to CCl_4 can cause cancer at a concentration of 960 ppb. The potential for moderate increased risk of cancer cases in the exposed population exists (about five additional case per 10,000 exposed individuals over a 15 year period). At the concentration found in single tap water sample (44 ppb), the potential for low increased risk of cancer cases in the exposed

population exists (about two additional cases per 100,000 exposed individuals with 15 years of exposure).

Residents with contaminated or potentially contaminated private wells near the contamination plume have been connected to the municipal water system. This measure has eliminated current and future exposures.

Municipal Water Exposures

The past concentration of CCl_4 (prior to 1997) in municipal water is unlikely to harm people's health.

Municipal water sampling for VOCs began in the late 1980s. Carbon tetrachloride was first noted in 1990 as a contaminant and appeared sporadically in samples until 1995. In 1997, the concentration of CCl_4 reached the MCL. Shortly after the affected wells were removed from service due to contamination with other contaminants from a nearby NPL site.

Well water from the contaminated wells was blended with water from uncontaminated municipal wells prior to distribution to the end-user, which diluted contaminant concentrations even further below a level of concern.

Recommendations

During the PHA process, ATSDR makes recommendations about public health actions that the agency believes should be conducted at a hazardous waste site or in the community. These recommendations may be directed to other agencies or to ATSDR itself. In developing these recommendations, ATSDR consults with other agencies to ensure that someone is available to follow up on these recommendations, where appropriate. Following are ATSDR's recommendations for the Garvey Elevator site:

- Continue on-site remedial efforts to reduce exposure to contaminants in on-site groundwater and subsurface soils. This includes operation and maintenance of the SVE to decrease/prevent build-up of CCl_4 fumes inside of on-site buildings.
- EPA or other appropriate authorities should continue to take steps to prevent or mitigate exposures to contaminants in on-site groundwater and subsurface soils.
- Continue to monitor the public and private water supply along the path of groundwater plume emanating from the site.
- Sample/monitor drinking water from taps of homes and businesses with whole-house water purification systems to ensure that the systems are effective.
- Educate residents on the proper care and maintenance of whole-house water purification system.
- Continue to provide the opportunity to be connected to the municipal water source

Public Health Action Plan

The purpose of the public health action plan is to ensure that this PHA not only identifies ATSDR's past activities at this site but also provides a course of action for mitigating or preventing exposures that may cause adverse human health effects.

Actions Completed

- ATSDR has met with members of the local community to gather information on the community's health-related concerns.
- ATSDR has established a repository at:

  Hastings Public Library
  517 West 4th Street
  Hastings, NE 68601-7560
- ATSDR has evaluated currently available data regarding groundwater contamination at the site.
- ATSDR has previously conducted a thorough evaluation of volatile organic compounds found in municipal well water. For more information please see; Health Consultation: Groundwater data review for West Highway 6 and Highway 281 site, Hastings, Adams County, Nebraska. Atlanta: U.S. Department of Health and Human Services; January 2010. The document is located at the following URL: http://www.atsdr.cdc.gov/HAC/pha/WestHwy6andHwy281Site/WestHwy6andHwy281SiteHC01-07-2010.pdf

Future Actions

- If requested, ATSDR will evaluate new, relevant data and will revise this public health assessment for the Garvey Elevator site if new data change the findings of this document.
- Copies of this PHA developed for the Garvey Elevator site will be placed in the site repository.
- ATSDR will assist appropriate stakeholders in the development of educational materials related to the Garvey Elevator site contaminants, if requested.

Preparer of Report

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Agency for Toxic Substances and Disease Registry

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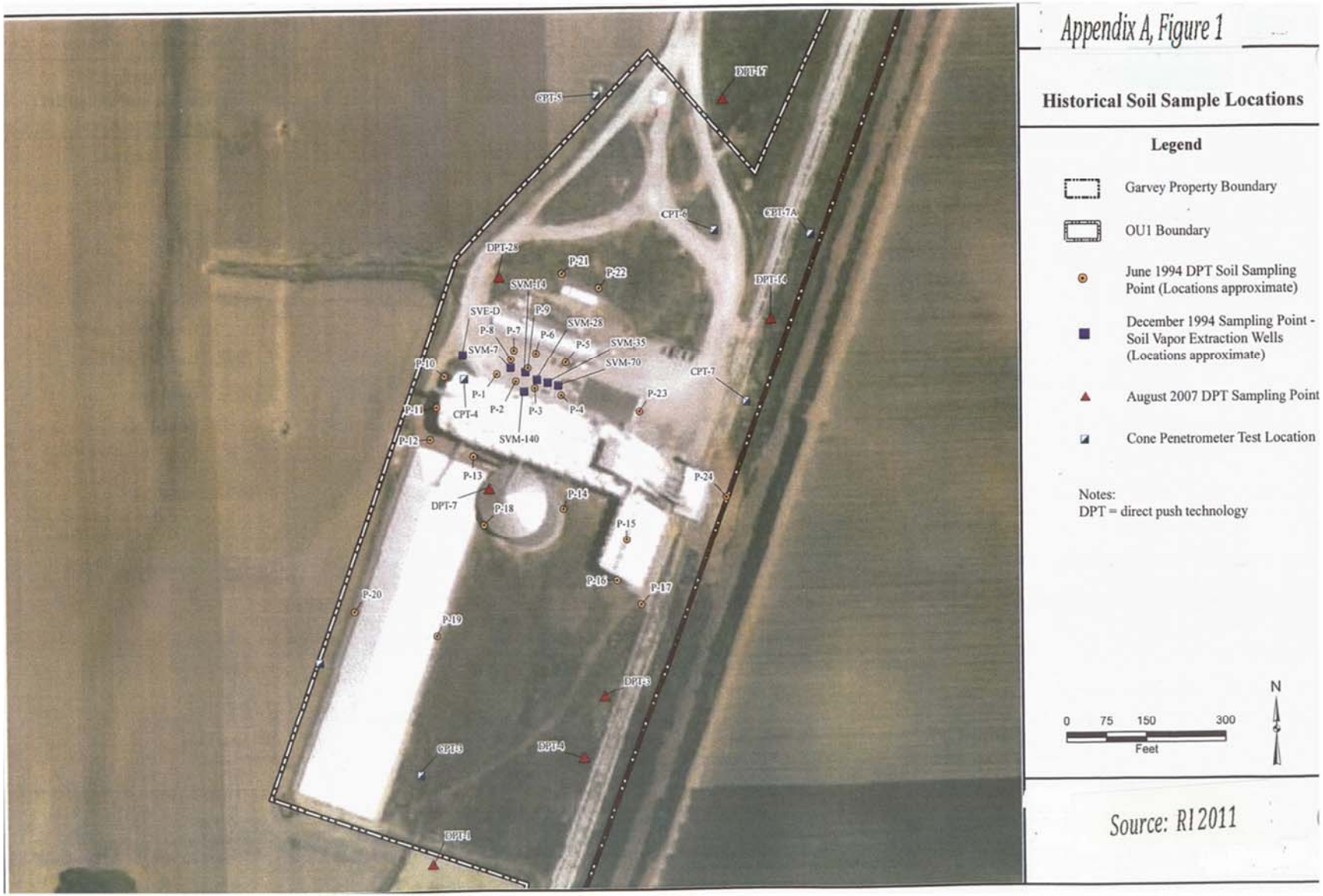
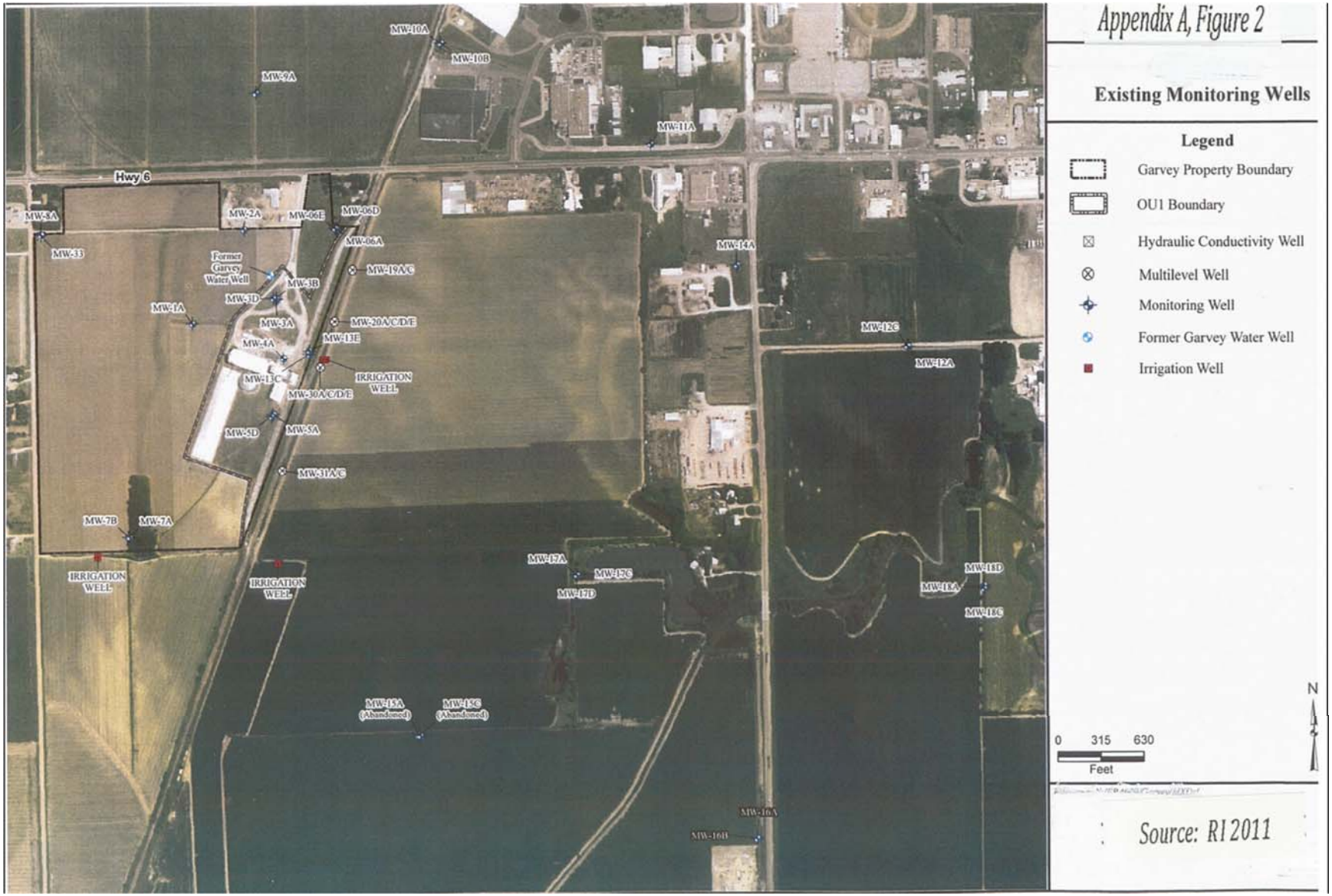
Appendices

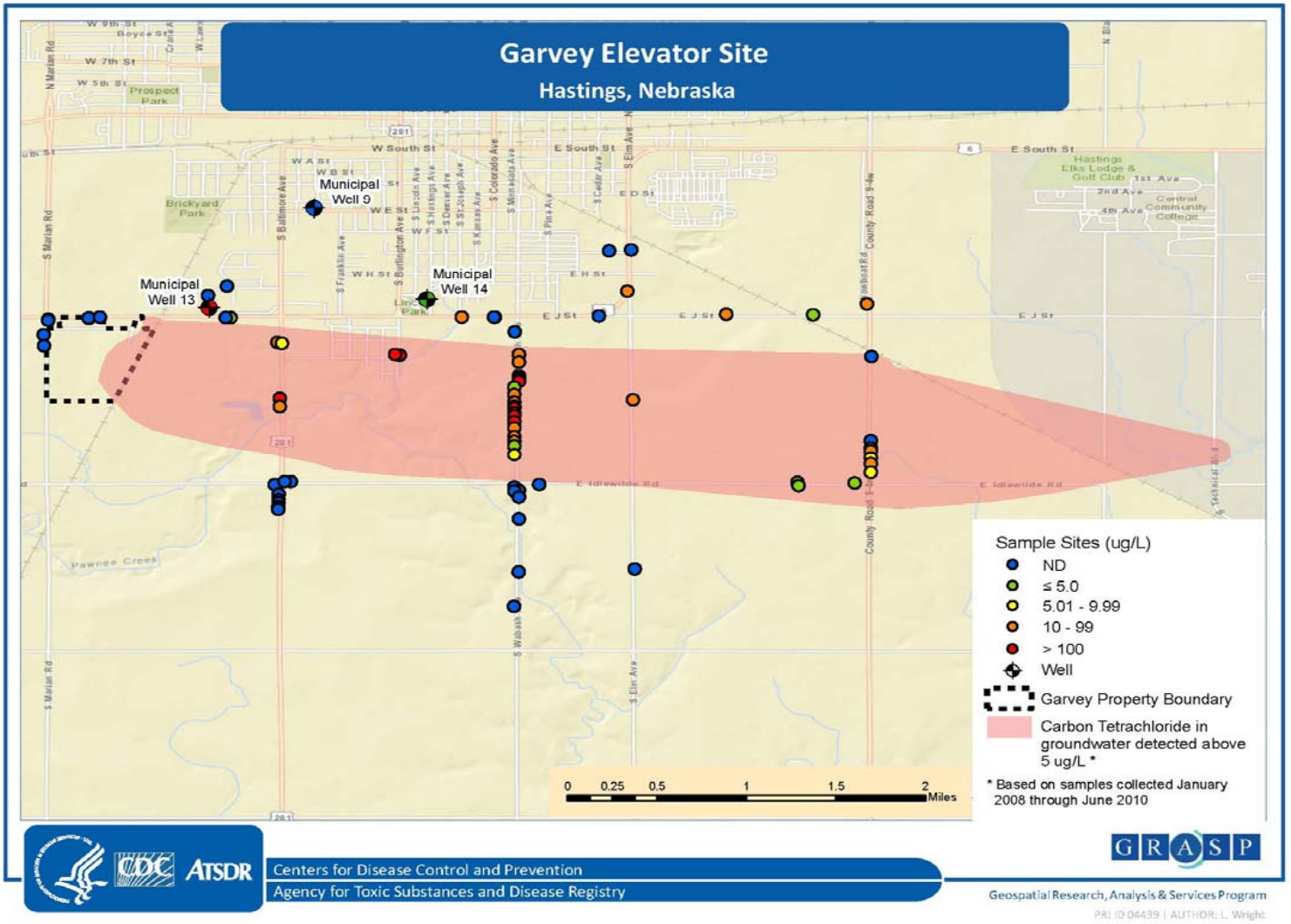
Appendix A - Figures



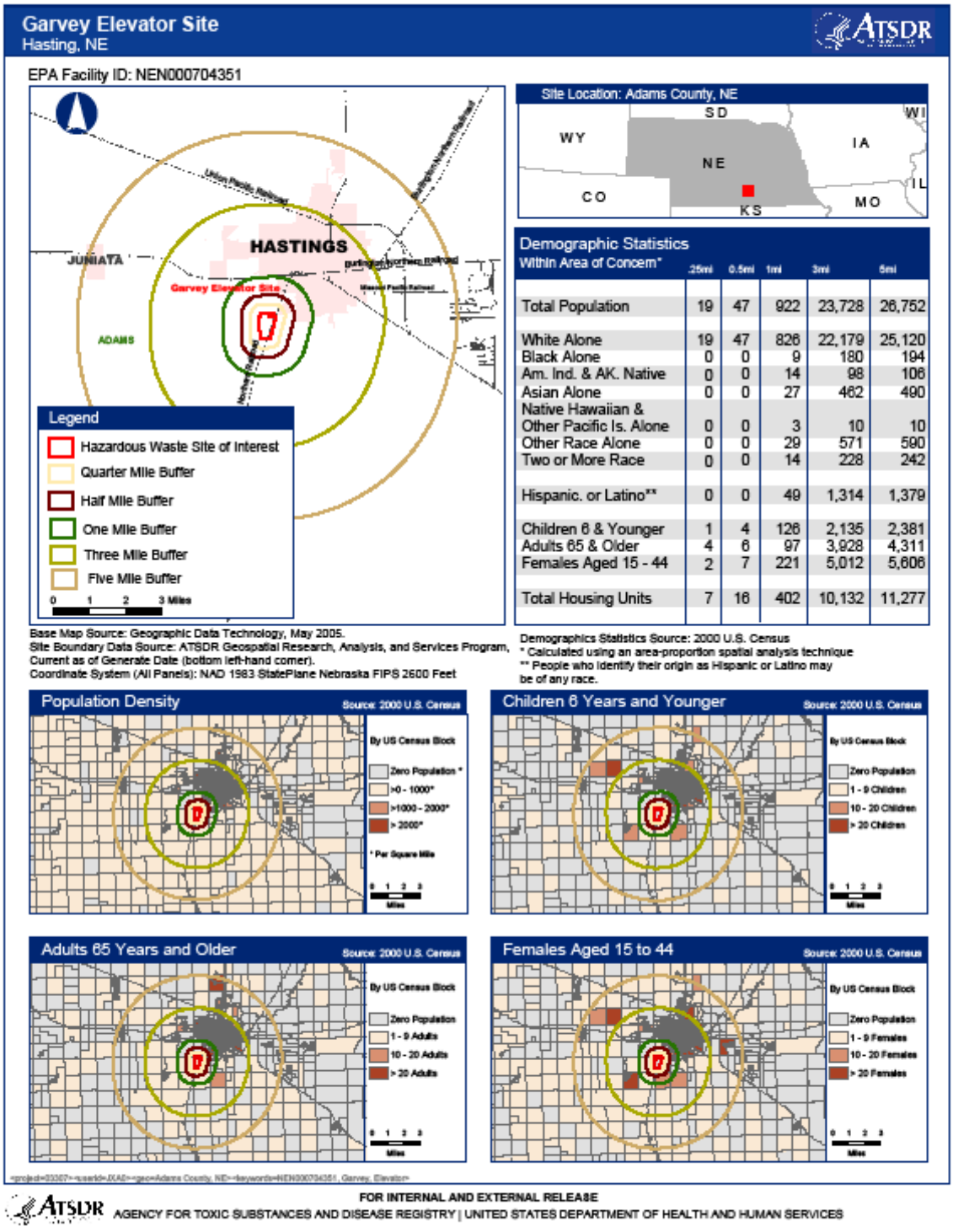
Appendix A Figure 1 Historical Soil Sampling Locations



Appendix A Figure 2 Location of Former Garvey Water Supply and Existing Monitoring Wells



Appendix A Figure 3 Private Well Locations in relation to site and CCl_4 plume



Appendix A Figure 4 - Site Location Map and Demographic Data

Appendix B - Tables

Appendix B Table 1 - Summary of Potential Contaminants of Concern in On-site Groundwater at the Garvey Elevator site. Samples from Monitoring Wells and Soil Borings**.**

Contaminant	Number of Samples	Number of Detections	Range of Concentrations (ppb)	Screening Values				Number of Detections Greater than Screening Value
				Non-Cancer Value (ppb)	Source	Cancer Value (ppb)	Source	
Benzene	25	4	0.86-4	5	$_{c}EMEG_{c}$	0.64	CREG	4
Carbon Tetrachloride	25	25	1.8-1,300	30	LTHA	0.5	CREG	25
Chloroform	25	16	1.2-18	100	$_{c}EMEG_{c}$	None	NA	0
Trichloroethene	25	3	0.37-7.3	18	$_{c}EMEG_{a}$	0.76	CREG	1

ppb = parts of contaminant per one billion parts of the medium
CREG = Cancer Risk Evaluation Guide
$_{c}EMEG_{c}$ = chronic exposure Environmental Media Evaluation Guide for a child
LTHA = Lifetime Health Advisory

Appendix B Table 2 - Summary of Potential Contaminants of Concern in Off-site Groundwater (including Residential Wells) near the Garvey Elevator site. Samples taken at outside access point. Not from indoor tap.

Contaminant	Number of Samples	Number of Detections	Range of Concentrations (ppb)	Screening Values				Number of Detections Greater than Screening Value
				Non-Cancer Value (ppb)	Source	Cancer Value (ppb)	Source	
Carbon Tetrachloride	114	114	0.61-960	30	LTHA	0.5	CREG	114
Chloroform	107	42	0.26-140	100	$_{c}EMEG_{c}$	None	NA	3
1,2-Dichloroethane	102	1	3	2000	$_{i}EMEG_{c}$	0.38	CREG	1

ppb = parts of contaminant per one billion parts of medium
CREG = Cancer Risk Evaluation Guide
NA = Not Available
$_{i}EMEG_{c}$ = intermediate exposure Environmental Media Evaluation Guide for a child
LTHA = Lifetime Health Advisory
$_{c}EMEG_{c}$ = chronic exposure Environmental Media Evaluation Guide for a child

Appendix B Table 3 – Summary of Potential Contaminants of Concern in Municipal Well Water (1986-2006) near Garvey Elevator site. Water is blended prior to reaching consumer, therefore the final concentrations will be reduced.

Contaminant	Number of Samples	Number of Detections	Range of Concentrations (ppb)	Screening Values			
				Non-Cancer Value (ppb)	Source	Cancer Value (ppb)	Source
Carbon Tetrachloride	35	31	ND – 5	30	LTHA	0.58	CREG
Tetrachloroethylene*	24	20	ND – 130	10	LTHA	17	CREG
Trichloroethene*	46	43	ND – 1.3	5	$_{c}EMEG_{c}$	0.76	CREG

Ppb = parts of contaminant per one billion parts of medium
LTHA = Lifetime Health Advisory
CREG = Cancer Risk Evaluation Guide
cEMEGc – chronic exposure Environmental Media Evaluation Guide for a child
ND = Not detected
* = tetrachloroethylene and trichloroethene were evaluated by ATSDR in the Groundwater data review for West Highway 6 and Highway 281 site [ATSDR 2010]

Appendix C – Contaminants of Concern General Discussion

Carbon Tetrachloride

Carbon tetrachloride is a man-made chemical that evaporates very quickly and is typically found as a gas. People can begin to smell the sweet odor of carbon tetrachloride at 10 ppm in air. Carbon tetrachloride has been used in the past as refrigeration fluid and aerosol propellant, but the use and manufacture of carbon tetrachloride has declined due to the adverse impact of carbon tetrachloride on the ozone layer. In the 1960s, the use of carbon tetrachloride as a dry cleaning solvent, in degreasers, in fire extinguishers and as a grain fumigant was discontinued. The use of carbon tetrachloride in pesticides was discontinued in 1986.

When carbon tetrachloride gets into the environment, it usually forms a gas. Carbon tetrachloride can remain in the air for several years before it is broken down to other chemicals. It will quickly evaporate from surface water, but it can remain in groundwater for months. It is not expected to build up in fish, but the accumulation in plants is unknown. People can be exposed to low background levels in soil, air, and/or water due to the historical uses.

Studies have not been performed to determine whether ingesting or breathing CCl_4 causes cancer in humans but there is convincing evidence that exposure to CCl_4 leads to liver cancer in rodents exposed by inhalation or dosed orally. DHHS has determined that CCl_4 may reasonably be anticipated to be a carcinogen. The International Agency for Research on Cancer (IARC) has classified CCl_4 as possibly carcinogenic to humans. EPA has determined that CCl_4 is a probable human carcinogen.

Studies indicate that when you inhale carbon tetrachloride, 30-40% enters your body, where it can accumulate in body fat temporarily. Some can enter other organs and skeletal muscle. When you breathe or drink carbon tetrachloride, most of the chemical leaves the body very quickly, typically through the exhaled breath (34-75%) within a few hours. Some (20-62%) carbon tetrachloride leaves the body in feces, while very little is excreted in urine.

Medical tests are available to determine if a person has been exposed to carbon tetrachloride. However, the tests require special equipment, and because carbon tetrachloride leaves the body quickly, the test would have to be conducted within days of exposure. If conducted quickly, the test will only be able to determine if a person was exposed, but it will not be able to tell if health effects will occur.

EPA has determined that carbon tetrachloride is a “probable human carcinogen,” based on sufficient animal studies but inadequate human studies. The DHHS considers carbon tetrachloride to be “reasonably anticipated” to cause cancer, and the IARC has determined that it is “possibly carcinogenic”, based on limited human evidence and less than sufficient evidence in animals.

EPA has established an MCL of 5 ppb for carbon tetrachloride. This concentration was exceeded in 41 residential private wells tested (114 detections above MCL in 114 samples). The RMEG for children (40 ppb) and the CREG (0.5 ppb) were also exceeded in many cases. CREGs are

established at concentrations which are unlikely to cause "increased" risk of cancer (less than 1,000,000).

For this assessment ATSDR used the maximum water concentration detected (960 ppb) to conduct its evaluation. The estimated doses for adults was 0.036 mg/kg/day and the estimated doses for children ranged from 0.135 mg/kg/day for 1-year old children to 0.033 mg/kg/day for teenagers. These doses are above the established MRL (0.02 mg/kg/day) for acute (less than 14 days) exposure and above EPA's chronic oral RfD of 0.004 mg/kg/day. EPA's RfD is based upon a BMDL of 3.9 mg/kg/day. The BMDL for carbon tetrachloride is the lower confidence limit on the dose that would result in an adverse effect to the liver. Moderate liver effects were seen in animals exposed to 10 mg/kg-day, as shown by a significant (two- to threefold) elevation of the liver enzyme sorbitol dehydrogenase (SDH) and the presence of mild centrilobular vacuolization in the liver. The intermittent dose of 10 mg/kg/day was adjusted to a continuous exposure of 7.1 mg/kg/day and was further adjusted using benchmark methods to a BMDL of 3.9 mg/kg/day. The BMD approach uses animal or human data to generate a dose-response curve and statistical methods are applied to identify the lower confidence limit of the adverse effect that's modeled. An uncertainty factor of 1,000 was applied to the BMDL to derive the RfD because the animal study was a 12-week study.

ATSDR has calculated an acute oral MRL of 0.02 mg/kg/day for exposures up to 14 days. This acute oral MRL is based on a LOAEL of 5 mg/kg/day over 10 days for minimal liver effects (vacuolar degeneration) in the rat (ATSDR 2005). ATSDR has also calculated an intermediate oral MRL of 0.007 mg/kg/day for exposures of 15 to 364 days. The intermediate oral MRL is based on a NOAEL of 1 mg/kg/day and a LOAEL of 10 mg/kg/day for liver effects in rats dosed 5 days/week over 12 weeks (Bruckner et al. 1986). The NOAEL and LOAEL can be adjusted from intermittent to continuous exposure resulting in a NOAEL of 0.71 mg/kg/day and a LOAEL of 7.1 mg/kg/day. The Bruckner *et al.* study is the same study that EPA used to develop their RfD for long-term exposure.

The liver appears the most sensitive target organ for carbon tetrachloride-induced effects. Based upon rat studies, harmful effects to the liver can result from long-term exposure to 3.9 mg/kg/day. Slightly higher exposure to 5 to 7 mg/kg/day for shorter periods (e.g., a few weeks to several months) can also cause mild liver damage.

For residents with the private well containing 960 ppb, the estimated exposure doses for children and adults are 29 to 108 times lower than the BMDL effect level of 3.9 mg/kg/day observed in animal studies. If people drank water containing carbon tetrachloride at 960 ppb damage to the liver is possible. Some uncertainty exists in this conclusion because the 960 ppb was found at the well-head and much lower concentrations were found inside the house at the tap. Therefore, it's uncertain whether residents drank well water containing 960 ppb CCl_4. Uncertainty also exists because the variation in CCl_4 levels over time is not known.

Exposure to CCl_4 can cause cancer. Carbon tetrachloride was detected at a concentration of 960 ppb in a sample taken from an outside hydrant associated with a private drinking water well. The potential for moderate increased risk of cancer cases in the exposed population exists

(about five additional cases per 10,000 individuals exposed over a 15 year period). At the concentration found in single tap water sample (44 ppb), the potential for low increased risk of cancer cases in the exposed population exists (about two additional cases per 100,000 individuals exposed over a 15 year period).

To better estimate potential health effects, ATSDR estimated exposure doses for ingestion exposure using a range of CCl_4 concentrations. For those wells with a CCl_4 concentration above the MCL but less than 15 ppb, the estimated exposure doses were 200 to over 1,000 times lower than the NOAEL. ATSDR does not expected harmful non-cancer effects from these exposures. For the 23 wells with CCl_4 greater than 16 ppb, residents who drank water from these wells are at increased risk for damage to the liver as previously described.

The cancer risk was estimated using the geometric mean concentration of CCl_4 based on residential private well sampling data collected from January 2008 until June 2010. Using the geometric mean concentration (23.75 ppb) and a default residency time of 15 years, the estimated cancer risk ranged from 1.7×10^{-5} to 2.3E-5 (about 2 excess cancer cases per 100,000 people exposed for 15 years). Therefore, if people were to ingest drinking water contaminated at the average concentration detected for a long period of time, there would likely be a "low increased risk of cancer" from CCl_4 exposure.

Based upon exposure dose calculations and remedial actions that have occurred or are occurring at the site, ATSDR concludes that exposure to contaminants in private well drinking water in the past represented a public health hazard. These exposures were reduced/eliminated by the residence being connected to municipal water or by installation of a whole house filtration system. Any private drinking water well in the area of the plume that has not been tested has the potential to be contaminated with site-related contaminants at concentrations above the MCL. It would be prudent for any homeowner whose property is located in the area to have their well water tested so that appropriate actions can be taken to reduce/eliminate any potential exposures.

Chloroform

Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste. It will burn only when it reaches very high temperatures. In the past, chloroform was used as an inhaled anesthetic during surgery, but it isn't used that way today. Today, chloroform is used to make other chemicals and can also be formed when small amounts of chlorine are added to water. Other names for chloroform are trichloromethane and methyl trichloride. [ATSDR 1997a]

Chloroform evaporates easily into the air. Most of the chloroform in air breaks down eventually, but it is a slow process. Some of the breakdown products are toxic (phosgene and hydrogen chloride). Chloroform doesn't stick to soil so it can travel through soil and enter the groundwater. Once it is in the groundwater it dissolves easily and it can last a long time.

1,2-Dichloroethane

1,2-Dichloroethane (DCA) is also known as ethylene dichloride. It is a manufactured chemical and is not found naturally in the environment. It is a clear liquid and has a pleasant smell and a sweet taste.

The most common use of DCA is in the production of vinyl chloride which is used to make a variety of plastic and vinyl products including polyvinyl chloride (PVC) pipes, furniture and automobile upholstery, wall coverings, housewares, and automobile parts. It is also used as a solvent and is added to leaded gasoline to remove lead. [ATSDR 2001]

DCA breaks down very slowly in water and most of it will evaporate into the air. DCA released in soil will evaporate into the air or travel down through the soil and enter underground water.

Appendix D - Health Guidelines and Formulas Used to Estimate Exposure Dose

Health guidelines provide a basis for comparing estimated exposures with concentrations of contaminants in different environmental media (soil, air, water, and food) to which people might be exposed.

Background Information

Screening values (SVs) are chemical and media-specific concentrations in air, soil, and drinking water that are used by ATSDR health assessors and others to identify environmental contaminants at hazardous waste sites that require further evaluation. SVs incorporate assumptions of daily exposure to the chemical and, in the case of soil and water, a standard amount that someone may likely take into their body each day. SVs are conservative and non-site specific. SVs are based on health guidelines with uncertainty or safety factors applied to ensure that they are adequately protective of public health.

The comparison of environmental data with ATSDR SVs is one of the first steps in the public health assessment process. The results of this screening step give health assessors an understanding of the contaminants of concern at a site. When a contaminant is detected at a concentration less than its respective SVs, exposure is not expected to result in health effects and it is not considered further as part of the public health assessment process unless a mixtures effect is possible. **It should be noted that contaminants detected at concentrations that exceed their respective SVs do not necessarily represent a health threat.** Instead, the results of the SV screening identify those contaminants that warrant a more detailed, site-specific evaluation to determine whether health effects may occur. SVs are not intended to be used as environmental clean-up levels.

SVs can be based on either carcinogenic or non-carcinogenic effects. Cancer-based SVs are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation unit risk (IUR). SVs based on cancerous effects account for a lifetime exposure (70 years) with a calculated excess lifetime cancer risk of 1 extra case per million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer SV exists for the same chemical, the lower of these values is used in the data screening for public health protectiveness.

Minimal Risk Levels

Minimal Risk Levels (MRLs) are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure. MRLs are based only on non-carcinogenic effects. MRLs are derived for acute (1-14 days), intermediate (15-364 days), and chronic (365 days and longer) durations for the oral and inhalation routes of exposure. Currently, MRLs for dermal exposure are not derived.

$$MRL = \frac{\text{NOAEL (or LOAEL or BMDL)}}{\text{UF}}$$

MRL = Minimal Risk Level (mg/kg/day or ppm)
NOAEL = No Observed Adverse Effect Level (mg/kg/day or ppm)
LOAEL = Lowest Observed Adverse Effect Level (mg/kg/day or ppm)
BMDL = benchmark dose lower confidence limit (mg/kg/day or ppm)
UF = Uncertainty Factor (unitless)

Cancer Risk Evaluation Guides

Cancer Risk Evaluation Guides (CREGs) are media-specific screening values that are used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's CSF or IUR, a target risk level (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents a calculated risk of one excess cancer cases in an exposed population of one million.

Estimation of Exposure Dose

Once concentrations in contaminants are screened the next step in the assessment process is to take those contaminants present at levels above the screening values and further evaluate whether those chemicals may be a health hazard given the specific situations at the site. For exposures by inhalation, the air concentration of the contaminant may be compared directly with health guideline air concentrations. For other pathways, an exposure dose has to be estimated. The exposure dose is the amount of the contaminant that gets into a person's body. The exposure dose is typically expressed as milligrams of contaminant per kilogram of body weight of the person exposed, per day (mg/kg/day). This allows comparison with toxicological studies which express dose in the same units. Exposure that occurs through skin contact may be converted to either an exposure dose or equivalent air concentration, depending on the exposure routes being considered.

To do these estimates, ATSDR made assumptions about weight and other body characteristics of children and adults exposed, how they may be exposed, and how often they may be exposed to allow estimation of site- and pathway-specific exposure dose. The following sections detail the exposure assumptions and calculation of exposure dose for the pathways evaluated in this PHA.

$$Exposure\ Dose = \frac{C\ x\ IR\ x\ AF\ x\ EF}{BW}$$

Where:

C = Substance concentration (milligrams/liter or parts per million
IR = Intake rate (liters/day)
AF = Bioavailability factor (unitless)
EF = Exposure factor (unitless)
BW = Body weight (kilograms)

The exposure factor is an expression of how often and how long a person may be contacting a substance in the environment. The exposure factor is calculated using the following general equation:

$$Exposure\ Factor = \frac{F\ x\ ED}{AT}$$

Where:

F = Frequency of exposure (days/year)
ED = Exposure duration (years)
AT = Averaging time (ED x 365 days/year)

For the example above, a 1-year old consuming groundwater from an in-home drinking water source contaminated with CCl_4 at a concentration of 960 ppb:

$$Exposure\ Factor = \frac{365\frac{days}{year}\ x\ 1\ year}{1\ year\ x\ 365\frac{days}{year}} = 1$$

$$Exposure\ Dose = \frac{960\frac{micrograms}{liter}\ x\ 1.1\frac{liters}{day}}{7.8\ kilograms\ x\ 1000\ micrograms/milligram}$$

= 0.135 milligrams/kilogram/day of CCl_4

Appendix D Table 1 - Exposure Assumptions for Estimating Exposure Doses Due to Ingestion of Contaminated Media at the Garvey Elevator Site, Hastings, Nebraska

Group	Body Weight kg	Ingestion Rate, liters/day
Children from Birth Up to 1 Year Old	7.8	1.1
Children from 1 Year Old Up To Age 2	11.4	0.9
Children from 2 Years Old Up To Age 3	13.8	0.9
Children from 3 Years Old Up To Age 6	18.6	1
Children from 6 Years Old Up To Age 11	31.8	1.4
Children from 11 Years Old Up To Age 16	56.8	2
Children from 16 Years Old Up To Age 21	71.6	2.5
Adults Greater Than 21 Years Old	80	3

Inhalation and Skin Absorption of CCl_4 During Showering

Private wells in the vicinity of the Garvey Elevator site and the CCl_4 contaminated groundwater plume were used for all household uses including drinking. Because inhalation and skin

absorption of CCl_4 during showering can be significant, ATSDR evaluated those exposures directly. ATSDR compared the estimated 24-hour CCl_4 concentration with health guideline values. There are several steps in estimating the equivalent 24-hour air concentration, which will be discussed below.

ATSDR used a model developed by Andelman [Andelman 1990] to estimate the peak CCl_4 concentration occurring in the bathroom as a result of showering. The equation is given below.

$$Peak\ Conc.\left(\frac{\mu g}{m^3}\right) = \frac{C_W(\frac{\mu g}{L}) \times k \times F_W(\frac{L}{min}) \times T_s(min)}{V_a\ (m^3)}$$

where

C_w = Concentration of the volatile compound in water, in ppb
k = volatilization coefficient, unitless (default is 0.6)
F_w = Flow rate of water through showerhead, in L/min (default is 8 L/min)
T_s = Time of shower, in min (varies with age, found in [EPA 2011])
V_a = Volume of air in shower in m^3 (default is 10 m^3)

For example, a 10-year-old takes a 15-minute shower in water containing 960 ppb carbon tetrachloride. The peak concentration of CCl_4 in the bathroom is:

$$Peak\ Conc.\left(\frac{\mu g}{m^3}\right) = \frac{960\frac{\mu g}{L} \times 0.6 \times 8\frac{L}{min} \times 15\ min}{10\ m^3}$$

$$= 6912\ \mu g/m^3$$

The peak air concentration will be breathed in during the shower and during any time stayed in the bathroom after the shower. ATSDR used shower stay times listed in [EPA2011]. The intake of contaminant due to inhalation is given by the following:

$$Intake_{Inhalation} = Peak\ Conc.\left(\frac{\mu g}{m^3}\right) \times IR_{st}(\frac{m^3}{min}) \times (T_s + T_b)(min),$$

where

IR_{st} = short term inhalation rate in m^3/min (varies with age, found in [EPA2011], assumed to reflect “light intensity” activity)
T_s = Time of shower and/or bath, in min (varies with age, found in [EPA2011])
T_b = Time in bathroom after shower/bath, in min (varies with age, found in [EPA2011])

For example, the inhalation intake for the 10-year-old in the previous example, who has an average short term inhalation rate of 0.011 m^3/min and remains in the bathroom for 5 minutes after a 15-minute shower is:

$$Intake_{Inhalation}(\mu g) = 6912\frac{\mu g}{m^3} \times 0.011\frac{m^3}{min} \times (5+15)min$$

= 1520.64 µg CCl_4

Skin Uptake While Showering

Intake also occurs during showering through skin absorption. ATSDR estimated skin intake using the general methods of EPA's Risk Assessment Guidance for Superfund, Part E [EPA 2004]. The formula for skin intake of VOCs during a shower is:

$$Intake_{Skin}(\mu g) =$$
$$2 \times FA \times K_P \left(\frac{cm}{hr}\right) \times Cw \left(\frac{\mu g}{L}\right) \times \left(\frac{1\ L}{1000\ cm^3}\right) \times SA(cm^2) \times \sqrt{\frac{6 \times \tau\ (hr) \times T_s(min)}{60\frac{min}{hr} \times \pi}}$$

where

C_w	= Concentration of the volatile compound in water, in ppb
FA	= Fraction Absorbed, assumed to be 1.
K_P	= Permeability constant for compound of interest (for CCl_4, 0.022 cm/hr)
SA	= total skin surface area in cm^2 (varies with age, found in [EPA 2011])
τ	= lag time, in hr (estimated at 0.76 for CCl_4)
T_s	= Time of shower plus time of bath, in min (varies with age, found in [EPA2011])
π	= pi, 3.14

For the example above, a 10-year old taking a 15 minute shower in water containing 960 ppb CCl_4 will have the following skin intake of CCl_4:

$$Intake_{Skin} =$$
$$2 \times 1 \times 0.022\frac{cm}{hr} \times 960\ \frac{\mu g}{L} \times \frac{1\ L}{1000 cm^3} \times 10{,}800 cm^2 \times \sqrt{\frac{6 \times 0.76\ hr \times 15\ min}{60\frac{min}{hr} \times \pi}}$$

= 274.85 µg CCl_4

The total intake is the sum of inhalation and skin intake. To convert to an equivalent 24-hour air concentration, the total intake is divided by the daily average breathing rate.

$$24-Hr\ Equivalent\ Conc.\left(\frac{\mu g}{m^3}\right)=\frac{Intake\ (\mu g)}{IR_{day}(\frac{m^3}{day})}$$

For the example above, a 10-year-old has an average inhalation rate of 12 m^3/day. The 24-hour equivalent TCE concentration is:

$$24-Hr\ Equivalent\ Conc.=\frac{(1520.64+274.87)\mu g}{12\ \frac{m^3}{day}}$$

$$=149.63\ \mu g/m^3$$

The table below summarizes the assumptions used in calculating the 24-hour equivalent air concentrations from inhalation and dermal exposure during showering. We recognize that very young children likely take more baths than showers. Bathing would not likely result in exposures as great as showering because showering has a high flow rate and more volatilization of VOCs. Therefore, estimating exposures assuming showers is protective of bathing scenarios as well.

Appendix D Table 2 - Exposure Assumptions for Estimating CCl_4 Inhalation and Dermal Exposures From Showering – Private Well Pathway, Garvey Elevator Site, Hastings, Nebraska

Group	Total Skin Surface Area (cm^2)	Short Term Inhalation Rate, m^3/min	Long Term Inhalation Rate, m^3/day	Time in Shower, min	Time in Bathroom after shower, min
Pregnant Women (16 Up To 45 Years Old)	18,400	0.0123	22	15	5
Children from Birth Up to 1 Year Old	3,992	0.0076	3.5	10*	5
Children from 1 Year Old Up To Age 2	5,300	0.012	8	10	5
Children from 2 Years Old Up To Age 3	6,100	0.012	8.9	10	5
Children from 3 Years Old Up To Age 6	7,600	0.011	10.1	12	5
Children from 6 Years Old Up To Age 11	10,800	0.011	12	15	5
Children from 11 Years Old Up To Age 16	15,900	0.011	15.2	15	5
Children from 16 Years Old Up To Age 21	18,400	0.012	16.3	15	5
Adults Greater Than 21 Years Old	19,683	0.012	15.1	15	5

*Infants do not shower but estimating exposure for showers will be protective of bathing because more volatilization occurs during showers.

Sources:

- Skin surface area obtained from Table 7.1 of [EPA 2011], recommended values for total body surface area, for children (sexes combined) and adults by sex. (Weighted averages used to obtain body surface area for specific age ranges/groups listed in this table.)
- Short term inhalation rate obtained from Table 6-2 of [EPA 2011], mean recommended short-term exposure values for inhalation (males and females combined), light intensity activity level.
- Long term inhalation rate obtained from Table 6-1 of [EPA 2011], recommended long-term exposure values for inhalation (males and females combined). Rate for pregnant women estimated using Table 6-54 of [EPA 2011] and professional judgment.
- Time in shower and bathroom obtained from Table 16-32 of [EPA 2011], time spent (minutes) showering and in shower room immediately after showering (minutes/shower).

cm^2 = square centimeters m^3/min = cubic meter per minute m^3/day = cubic meter per day

The following table lists the 24-hour equivalent CCl_4 concentrations calculated using the above equations.

Appendix D Table 3 - Estimated Equivalent 24-Hour CCl_4 Air Concentrations Resulting from Inhalation and Dermal Exposure to Water Containing 960 ppb CCl_4, One Private Well Near the Garvey Elevator Site, Hastings, Nebraska

Age Group	Inhalation Intake (µg)	Skin Intake (µg)	Equivalent 24-Hour CCl_4 Air Concentration from Inhalation and Dermal Exposure to Water Containing 960 ppb CCl_4 (µg/m^3)
Pregnant Women From 16 Years Old Up To Age 45	1700.35	468.31	98.57
Children from Birth Up To 1 Year Old	525.21	82.96	173.79
Children from 1 Year Old Up to Age 2	829.44	110.14	117.45
Children from 2 Years Old Up To Age 3	829.44	126.76	107.44
Children from 3 Years Old Up To Age 6	829.44	173.01	99.25
Children from 6 Years Old Up To Age 11	1520.64	274.87	149.63
Children from 11 Years Old Up To Age 16	1520.64	404.68	126.67
Children from 16 Years Old Up To Age 21	1658.88	468.31	130.50
Adults Greater Than 21 Years Old	1658.88	500.96	143.04

All estimated using mean shower and bathroom stay times tabulated by EPA [EPA 2011]. Shower estimates will overestimate exposures that might occur through bathing because of lower volatilization during baths.
µg = microgram µg/m^3 = microgram per cubic meter

ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to 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 environmental 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. If you have questions or comments, call ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

General Terms

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

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.

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]

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.

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].

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

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

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

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

EPA
United States Environmental Protection Agency.

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 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.

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.

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

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

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

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

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.

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].

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].

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]

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they

move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

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

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

ppb
Parts per billion.

ppm
Parts per million.

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

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.

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.

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

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].

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 Center for Environmental Health (CDC)
(http://www.cdc.gov/nceh/dls/report/glossary.htm)

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

Greetings,

You are receiving a document from the Agency for Toxic Substances and Disease Registry (ATSDR). We are very interested in your opinions about the document you received. We ask that you please take a moment now to complete the following ten question survey. You can access the survey by clicking on the link below.

Completing the survey should take less than 5 minutes of your time. If possible, please provide your responses within the next two weeks. All information that you provide will remain confidential.

The responses to the survey will help ATSDR determine if we are providing useful and meaningful information to you. ATSDR greatly appreciates your assistance as it is vital to our ability to provide optimal public health information.

https://www.surveymonkey.com/r/ATSDRDocumentSatisfaction

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