Health Consultation

JET GAS SPILL SITE

LOWELL, HENRY COUNTY, IOWA

OCTOBER 21, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

JET GAS SPILL SITE

LOWELL, HENRY COUNTY, IOWA

Prepared by:

Iowa State Department of Public Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose

An attorney representing seven property owners in Lowell, Iowa, requested the Iowa Department of Public Health (IDPH) Hazardous Waste Site Health Assessment Program to perform a health consultation for the Jet Gas Spill Site. The attorney asked the IDPH to provide comments concerning the potential and likely health effects to her clients due to exposure from the spill. The specific issues to be addressed are listed in this health consultation. The information in this health consultation was current at the time of writing. Data that emerges later could alter this document's conclusions and recommendations.

Background

Lowell is a small, unincorporated town in Henry County, Iowa, approximately 14 miles southeast of Mount Pleasant, Iowa. On January 8, 2001, a tanker truck owned by the Jet Gas Corporation overturned and spilled gasoline into a ditch alongside County Road X23 on the north side of Lowell. It was estimated that about 2,200 gallons of gasoline were spilled. Some of the spilled gasoline entered a culvert and flowed 300 feet to the outlet of the culvert.

An initial emergency response was conducted that included removing contaminated soil at the spill location and at the outlet of the culvert [1]. The initial site remediation activities included the recovery of any remaining gasoline from within the culvert, and the removal of a total of about 180 tons of contaminated soil from the spill location and at the outlet of the culvert on January 11 and 12, 2001 [2].

On January 9, 2001, the day after the spill, water was collected from four wells utilized by nearby homes. The water was analyzed for gasoline; benzene, toluene, ethylbenzene, xylenes (collectively known as BTEX); and methyl tertiary-butyl ether (MTBE). The water from these wells was sampled again on May 15, 2001, and analyzed for the same chemicals. None of the chemicals analyzed for was found at detectible levels in water from either the January 2001 sampling or the sampling in May 2001. The Iowa Department of Natural Resources (IDNR) sent all residents a letter informing them of the analytical results [2].

After the initial emergency response activities were completed, a site investigation was begun to make a determination concerning the future remediation of the site. To identify the extent of contamination in the original spill area and throughout Lowell, more than 40 additional monitoring wells were installed between April 2001 and December 2003 [1]. Water in the monitoring wells was sampled at various times from May 2001 until January 2004. In addition, various residential wells were sampled between August 2002 and January 2004; however, not every well was sampled on each date that the sampling was conducted. Eight of the ten residential wells in Lowell have been sampled. Water from both the monitoring wells and the residential wells was analyzed for BTEX and MTBE. The Iowa Department of Public Health is conducting an ongoing investigation of the soil and groundwater impacted by the spill.

Table 1 provides a summary of the highest concentrations of BTEX and MTBE detected in water from the groundwater monitoring wells during the sampling events. The values shown in the table include the analytical results that exceeded either the maximum contaminant level (MCL) that the U.S. Environmental Protection Agency (EPA) established for BTEX or EPA's drinking water advisory level for MTBE.

Table 1. Highest concentrations of benzene, toluene, and MTBE in groundwater, all in parts per billion

Monitoring Point	Sample Date	Benzene Concentration	Toluene Concentration	MTBE Concentration
MW-1	05/01/02	12.6	*	*
MW-3	05/14/03	6,640.0	*	206.0
MW-6	01/29/04	1,505.0	*	*
MW-12	08/22/02	6,890.0	*	83.3
MW-17	02/18/03	400.0	*	40.9
MW-18	10/16/03	7.37	*	*
MW-20	02/18/03	5.4	*	*
MW-21	02/18/03	6,560.0	4,610	67.0
MW-23	02/18/03	419.0	*	23.4
MW-26	05/16/03	1,150.0	*	36.0
MW-27	01/29/04	5,230.0	*	49.0
MW-29	01/20/04	501.0	*	206.0
MW-30	01/20/04	379.0	*	*
MW-31	01/21/04	219.0	*	*
MW-32	01/30/04	254.0	*	*
MW-33	01/21/04	778.0	*	39.9
MW-34	01/21/04	49.6	*	*
MW-35	01/21/04	160.0	*	37.9
MW-37	01/22/04	5.6	*	25.8
MW-39	01/30/04	183.0	*	24.5
MW-40	01/30/04	182.0	*	23.2

The MCLs for benzene, toluene, ethylbenzene, and xylenes are 5 ppb, 1,000 ppb, 700 ppb, and 10,000 ppb, respectively. The EPA drinking water advisory level for MTBE is 20 ppb (www.epa.gov).
* Detected level below MCL or drinking water advisory.

Table 2 presents a summary of the highest concentration of BTEX and MTBE detected in samples from the private wells. Wells at eight of the residential locations were sampled. As in the previous table, the only concentration levels shown are those that exceeded EPA's MCLs for BTEX or EPA's drinking water advisory level for MTBE.

Table 2. Levels of benzene and MTBE detected in private well water (in parts per billion)

Monitoring Point	**Sample Date**	Benzene Concentration	MTBE Concentration
Residence 1 tap (without filter)	08/13/02	11.0	*
Residence 1 basement (without filter)	08/19/02	12.4	*
Residence 2 well	03/17/03	306.0	53.7
Residence 2 well	05/16/03	245.0	31.6
Residence 2 well	10/26/03	5.82	*

The MCLs for benzene, toluene, ethylbenzene, and xylenes are 5 ppb, 1,000 ppb, 700 ppb, and 10,000 ppb, respectively. The EPA drinking water advisory level for MTBE is 20 ppb (www.epa.gov).
* Detected level below MCL or drinking water advisory.

The map in this document shows the location of groundwater monitoring wells and private wells that have been sampled in Lowell.

Elevated concentrations of benzene, toluene, and ethylbenzene were found in the groundwater in Lowell. On September 2, 2002, IDNR issued a requirement that Jet Gas Corporation connect residences to the rural water system if the residences are within three blocks of the original spill site and have private wells [3]. According to the Rathbun Rural Water Association, three of the residences in Lowell, including Residence 1, were connected to rural water in September 2002; an additional three residences in Lowell were connected to rural water in January 2003; and Residence 2 was connected to rural water prior to the spill event in 1992 (B. Benjamin, personal communication, March 24, 2004).

Contaminants of Concern

The contaminants of concerns at the site that are addressed in this health consultation are benzene and MTBE, components of gasoline. Other contaminants that were analyzed for in the water from private wells (toluene, ethylbenzene, and xylenes) are not being considered for further discussion because the detected levels of these contaminants were far below their MCL or EPA advisory levels.

Benzene was detected in private wells at levels above EPA's MCL of 5 parts per billion (ppb). MTBE was detected in private wells above EPA's drinking water advisory of 20 ppb. Elevated levels of benzene (above the MCL) have been detected in two of the seven private wells tested. Elevated levels of MTBE (above the drinking water advisory) have been detected in one of the seven private wells tested. Benzene and MTBE have also been detected in groundwater monitoring wells installed to determine the extent of groundwater contamination, but are not being considered in the exposure evaluation included with this health consultation because the data available from the private wells can be used to measure actual or potential human exposure to benzene and MTBE.

Discussion

Exposure to Benzene and MTBE

Exposure to benzene and MTBE is determined by examining human exposure pathways. An exposure pathway has five parts:

1. a source of contamination
2. an environmental medium such as air, water, or soil that can hold or move the contaminants
3. a point at which people come into contact with a contaminated medium, such as surface soil or drinking water
4. an exposure route such as drinking water from a contaminated well or eating contaminated soil on homegrown vegetables, and
5. a population that could come into contact with the contaminants.

An exposure pathway is eliminated if at least one of the five parts is missing and will not occur in the future. For a pathway to be considered completed, all five parts must exist, and exposure to a contaminant must have occurred either in the past or is occurring currently. A potential exposure pathway is a pathway in which exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future.

Exposure Through Ingestion of Contaminated Drinking Water

In Lowell, an exposure pathway to benzene and MTBE has been completed via residents ingesting contaminated drinking water. Water in eight of the ten residential wells in Lowell was tested for BTEX and MTBE. In two of these wells, benzene and MTBE were detected at levels above their respective MCL and drinking water advisory level. The length of time that Lowell residents may have ingested drinking water with elevated levels of benzene and MTBE is uncertain. Analysis of the initial private well water samples collected in January and May 2001 from four residences did not show elevated levels of these chemicals. Private well water was not sampled between May 2001 and August 2002. Additional sampling was conducted in Analysis of samples of private well water collected in August 2002 indicated levels of benzene above the MCL for Residence 1. Benzene was found in well water above the MCL for Residence 2 in

March, May, and October of 2003. MTBE was found in well water above the drinking water advisory for Residence 2 in March and May of 2003.

Within a month after the well at Residence 1 was found to be contaminated in August 2002, the residence was connected to the rural water system and the exposure pathway was eliminated. Residence 2 had been connected to the rural water system in 1992, but the residents kept the option to use their private well water. The residents' practice was to use water from the rural water system until they used the amount allowed for their monthly minimum charge and then switch to their private well for the remainder of the month. The residents reported that they noticed a change in the odor and taste of the well water in February 2003 and since that time have purchased bottled water for drinking (Personal communication, April 16, 2004).

Using the information currently available, we can estimate that the longest length of time anyone in Lowell may have been exposed to benzene and MTBE in their drinking water would have been from May 2001 to February 2003. However, shortly after contamination in the private wells was noticed and documented, the residences were connected to the rural water system. Most likely, the maximum period of exposure was somewhere between 1 month and 1 year. The maximum concentrations documented in private wells in Lowell were for Residence 2, where benzene was found at 306 ppb and MTBE at 53.7 ppb. It is difficult to determine accurately the exposure time for the family living in this residence because they did not use their private well water consistently throughout every month.

Exposure Through Vapor Inhalation and Dermal Exposure

Because benzene and MTBE are volatile organic chemicals, there is a potential exposure pathway for these chemicals from inhalation of vapors during bathing and showering with contaminated water. In addition to inhalation of vapors, a person bathing and showering in contaminated water will be exposed to benzene and MTBE through adsorption of these chemicals through the skin.

Estimations of the amount of benzene and MTBE a person could potentially be exposed to during showering and bathing can be determined by utilizing several mathematical equations that calculate an estimated exposure to benzene and MTBE through inhalation. Details of these calculations for benzene are provided in an appendix to this report. The highest concentrations of benzene and MTBE detected in the contaminated drinking water wells was used in calculating potential exposure. Table 3 provides a summary of these calculations.

Table 3. Estimated Inhalation Exposure From Benzene and MTBE

Chemical	Estimated Acute Vapor Exposure Level ppb	Estimated Intermediate and Chronic Vapor Exposure Level ppb
Benzene	465	14
MTBE	73	2

ppb: parts per billion
Source: Calculations are shown in the appendix.

Using the highest concentration of benzene found (306 ppb), the estimated acute exposure was calculated as 465 ppb and the intermediate and chronic exposure at 14 ppb. Using the highest concentration of MTBE found (53.7 ppb), the estimated acute exposure was calculated as 73 ppb and the intermediate and chronic exposure as 2 ppb. Keep in mind that these numbers are not measured levels, only estimated levels. Benzene and MTBE in indoor air in Lowell residences has not been measured. To more accurately determine inhalation exposure to benzene and MTBE, indoor air monitoring would need to be completed.

Table 3 shows the estimated acute exposure level and the estimated intermediate and chronic exposure level to the two chemicals. For these inhalation exposure pathways in Lowell, the acute level is an estimate of the potential exposure level to vapors while taking a shower or bath. The estimated intermediate and chronic exposure level is an estimate of the potential exposure throughout the day for an extended period of time.

Toxicologic Evaluation

The following information has been prepared as a toxicologic evaluation for exposure to benzene and MTBE from water in private wells in Lowell. This evaluation examines ingestion of drinking water containing benzene and MTBE and the inhalation of benzene and MTBE in vapors during showing and bathing using the highest documented levels of these chemicals found in private wells in Lowell. This toxicologic evaluation will compare the estimated exposure levels to the following comparison values: minimal risk levels, the cancer risk evaluation guide, and the chronic oral reference dose.

Minimal Risk Levels

This toxicologic evaluation will compare the estimated levels of exposure in Lowell to minimal risk levels (MRL) established by the Agency for Toxic Substances and Disease Registry. An MRL is defined as "an estimate of daily exposure to a human being to a chemical that is likely to be without an appreciable risk of deleterious effects (noncarcinogenic) over a specified period of time." MRLs are based upon human and animal studies, include several safety factors, and are reported for acute exposure (less than or equal to 14 days), intermediate exposure (15–364 days), and chronic exposure (greater than or equal to 365 days).

Cancer Risk Evaluation Guide

This toxicologic evaluation will also compare the estimated levels of exposure in Lowell to the cancer risk evaluation guide (CREG) for 1×10^{-6} excess cancer risk. The CREG is an estimated level of exposure to a chemical at which there is a risk of an additional one-in-one million cancer incidence. That is, if a group of one million people was exposed to the chemical above the CREG, it is estimated that one additional person in the group of one million people would get cancer.

Chronic Oral Reference Dose

This toxicologic evaluation will compare the estimated levels of oral exposure in Lowell to the chronic oral reference dose (RfD) that EPA has established for benzene because oral MRLs have not been established for benzene. The chronic RfD is defined as “an estimate of a daily exposure to the general public (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects (noncarcinogenic) during a lifetime exposure.” The chronic RfD for benzene is 4.0×10^{-3} milligrams per kilogram per day (mg/kg/day).

To compare the concentrations of benzene in drinking water to the chronic RfD, one must estimate the daily consumption of water by adults and children. Using standard assumptions of water consumption of 2 liters per day (L/day) and weight of 70 kg for adults and the standard assumptions of water consumption of 1 L/day and weight of 10 kg for children, corresponding concentrations of benzene in water can be calculated. The benzene comparison concentrations calculated from the RfD are 0.14 mg/L (which is equivalent to140 ppb) for adults and 0.04 mg/L (or 40 ppb) for children.

Evaluation for Benzene

Table 4 and Table 5 show the highest level of benzene documented in private well water in Lowell, the estimated inhalation exposures resulting from showering or bathing in this water, and comparison values for MRLs, RfD, and the CREG. As shown in Table 4, the maximum concentration of benzene found in private well water in Lowell was 306 ppb; the Rfd for chronic exposure of children is 40 pbb and the Rfd for chronic exposure of adults is 140 ppb.

Table 4. Maximum Benzene Concentration and Reference Dose for Chronic Oral Exposure

Maximum Level of Benzene In Private Wells (in parts per billion)	RfD Concentration (in parts per billion) Child	RfD Concentration (in parts per billion) Adult
306	40	140

Table 5. Inhalation Exposure (all concentrations in parts per billion)

Estimated Inhalation of Benzene for Acute Exposure	Acute Exposure MRL	Estimated Inhalation of Benzene for Intermediate and Chronic Exposure	Intermediate Exposure MRL	CREG
465	50	14	4	0.031

The highest levels of benzene documented in private wells in Lowell and the corresponding estimated levels of inhalation exposure are above the comparison values for chronic oral exposure and for both acute and intermediate inhalation exposures. In addition, the estimated level of chronic inhalation exposure to benzene is above the CREG.

Our conclusion from this evaluation is that a potential for some adverse health effects exists for residents of Lowell who were exposed to the elevated levels of benzene documented in private wells. As stated earlier, the length of time that residents may have been exposed to contaminated private well water is not known. The maximum length of time residents may have been exposed to benzene contamination in private well water is 2 years; however the maximum time of exposure to benzene-contaminated private well water was most likely less than a year. Residents may have experienced acute and intermediate exposures to benzene; however, residents were not likely to have experienced chronic exposures to benzene.

Because the RfD is based upon chronic exposures to benzene and it is expected that exposures to elevated levels of benzene did not occur for much more than one year, it is our opinion that minimal health impacts to the residents of Lowell were experienced from drinking contaminated well water. In addition, because the CREG is based upon chronic exposures to benzene for many years, it is expected that the residents of Lowell would have minimum carcinogenic impacts from being exposed to benzene from private well water because those exposures to benzene most likely occurred for less than one year.

It is our opinion that the health of the residents of Lowell may have been impacted from acute or intermediate inhalation exposure (or both) from showering and bathing in water contaminated with benzene. As previously mentioned, residents of Lowell may have been exposed to levels of benzene above MRLs for a period of several months to one year. The lowest-observed-adverse-effect levels (LOAELs) for acute and intermediate inhalation exposure to benzene included within the studies referenced in toxicological profile for benzene are 10,000 ppb and 780 ppb benzene, respectively. The estimated maximum inhalation exposure level in Lowell is calculated at 465 ppb benzene, a little greater than one-half the LOAEL of 780 ppb. The health effects seen at levels of 10,000 ppb and 780 ppb were leukopenia (which may result in immune system depression) and decreased reflexes. These effects were seen in studies conducted on mice. The toxicological profile for benzene indicates that long-term or chronic exposure to benzene (365 days or longer) may produce health effects in humans that include anemia, immune system depression, and neurological effects such as dizziness and headache [5].

Evaluation for Methyl Tertiary-Butyl Ether

Tables 6 and 7 show the highest level of MTBE documented in private well water in Lowell, the estimated inhalation exposures resulting from showering or bathing in this water, and comparison values for MRLs.

Table 6. Oral Exposure to MTBE

Maximum Level MTBE in Private Wells (ppb)	Acute Oral MRL (ppb)		Intermediate Oral MRL (ppb)	
	Child	Adult	Child	Adult
57.3	4,000	14,000	3,000	10,500

ppb: parts per billion

Table 7. Inhalation Exposure (in parts per billion)

Estimated Acute Inhalation Exposure	Acute MRL	Estimated Intermediate and Chronic Exposure	Intermediate MRL	Chronic MRL
73	700	2	700	700

The highest levels of MTBE documented in private wells in Lowell and the corresponding estimated exposure through inhalation are below all comparison values for oral and inhalation exposure. Table 7 shows the estimated exposure to MTBE for acute and intermediate and chronic exposure. Therefore, it is our conclusion that it is unlikely for adverse health effects to be experienced by residents of Lowell who may have been exposed to MTBE in private wells.

Children's Health Concerns

Children have unique vulnerabilities to some environmental chemicals, and IDPH's Hazardous Waste Site Health Assessment Program evaluated the potential impact of the presence of benzene and MTBE in private wells on children's health. Children and fetuses may be at increased risk to exposure to benzene because their hematopoietic cell populations are expanding and dividing cells are at a greater risk than quiescent cells [5]. According to ATSDR, children are not expected to be at increased risk to exposure to MTBE [6].

Exposure to well water above the chronic oral RfD for benzene (40 ppb) may adversely impact children's health (noncarcinogenic) if the water was ingested for many years. The highest documented level of benzene in private well water in Lowell was 306 mg/L. It is expected that very limited impact to children's health has occurred in Lowell from consumption of private well water because the consumption of contaminated water did not occur over a long time period (probably no more than 1 year).

As previously discussed, children in Lowell may have been impacted from acute and/or intermediate inhalation exposure from showering or bathing in water contaminated with benzene. It is not expected that children who may have played in outside pools filled with contaminated water would be impacted by benzene vapors because any volatizing vapors would be diluted by the outside air.

Community Health Concerns

According to the attorney representing several property owners in Lowell, some of the residents in Lowell are very concerned that their health has been or will be affected by exposure to BTEX. One of the families indicated they have been sick for much of the past 3 years. This same family indicated that their youngest child has had many unexplained health problems. Several of the families have indicated that their well water smelled like gasoline. One of the residents in Lowell in the area of the spill was diagnosed with lung cancer this year and has recently died [4].

The attorney representing several property owners in Lowell has requested that the following issues be addressed by this health consultation:

- Whether benzene is a known human carcinogen;
- What the MCL for benzene is in drinking water and why it is set at this level;
- Whether persons who consume drinking water containing benzene at levels that exceed the MCL possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed drinking water with benzene levels above the MCL;
- Whether MTBE is a human carcinogen;
- What the MCL for MTBE is in drinking water and why it is set at this level;
- Whether persons who consume drinking water that exceeds the MCL for MTBE possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed drinking water that exceeds the MCL for MTBE;
- Whether persons who use water that is contaminated with benzene or MTBE for bathing, washing dishes, cooking, and personal use (other than drinking) possess any increased statistical likelihood of physical injury or future illness than those persons who have never used water which is contaminated with benzene or MTBE; and

- Whether persons who eat vegetables and fruit from a garden contaminated by BTEX chemicals possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed vegetables and fruit from a garden contaminated by BTEX.

In addition to these questions, conversations with one of the residents revealed the following additional health concerns:

- What are the health risks to children playing in a small pool filled with water contaminated by BTEX and MTBE?
- What are the health risks to children playing in the soil in areas where groundwater is contaminated with BTEX and MTBE?
- What are the health risks to pets ingesting water contaminated with BTEX and MTBE?
- What are the health risks from using water contaminated with BTEX and MTBE for washing clothes and cooking?

Answers to Community Health Concern Questions

The community members' health concern questions are answered in the following paragraphs.

Is benzene a known human carcinogen?

ATSDR and EPA have determined that benzene is a known human carcinogen. Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs. No human studies have reported a link between cancer and ingestion or oral exposure to benzene [5].

What is the MCL for benzene in drinking water and why it is set at this level?

EPA has established a maximum contaminant level (MCL) for benzene of 5 ppb in drinking water. The MCL is based upon the maximum contaminant level goal (MCLG). The MCLG is the maximum level of a contaminant in drinking water at which no known or anticipated adverse human health effect would occur and which includes an adequate margin of safety [7]. Because EPA classifies benzene as a known human carcinogen (due to inhalation exposure), the MCLG for benzene is set at zero. The MCL has been set at 5 ppb because EPA believes that, given the present technology and resources, this is the lowest level to which public water systems can reasonably be required to remove benzene from drinking water [8].

Do persons who consume drinking water that exceeds the MCL for benzene possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed drinking water that exceeds the MCL for benzene?

The risk posed by drinking water with benzene concentrations in excess of the MCL depends upon the concentration of benzene in the water and the length of exposure. These parameters have not been well defined for exposure to contaminants at the site. Drinking water standards (MCLs) incorporate safety factors to protect against adverse health effects. Therefore, consuming water that contains benzene concentrations above the MCL would not necessarily result in adverse health effects.

Is MTBE a human carcinogen?

MTBE is not classified as a human carcinogen by ATSDR or by EPA. There is no evidence that MTBE causes cancer in humans. One study with rats found that breathing high levels of MTBE for long periods of time might cause kidney cancer in rats. Another study with mice found that breathing high levels of MTBE for long periods might cause liver cancer in mice [6].

What is the MCL for MTBE in drinking water and why it is set at this level?

No MCL has been established for MTBE. EPA has issued a drinking water advisory for MTBE that recommends keeping concentrations in the range of 20 to 40 micrograms per liter (µg/L) of water or below to prevent unpleasant taste and odor in the water. EPA also states that concentrations in this range are at least 20,000 to 100,000 lower than the range of exposure levels at which either cancer or noncancer health effects were observed in animal studies. EPA states that protecting the water from unpleasant taste and odor will also protect against potential health effects. EPA's drinking water advisory for MTBE is based on aesthetic qualities of odor and taste and not upon potential human health effects [9].

Do persons who consume drinking water which exceeds the MCL for MTBE possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed drinking water which exceeds the MCL for MTBE?

There is no MCL for MTBE. The drinking water advisory level for MTBE is a range of 20 µg/L to 40 µg/L. Because the drinking water advisory is not necessarily based upon health concerns, but on aesthetic qualities, consuming drinking water that exceeds the drinking water advisory does not necessarily increase the likelihood of physical injury or future illness. Very limited toxicologic information is available on the human health impacts from ingestion of water containing MTBE above the drinking water advisory level.

Do persons who use water which is contaminated with benzene or MTBE for bathing, washing dishes, cooking, and personal use (other than drinking) possess any increased statistical likelihood of physical injury or future illness than those persons who have never used water which is contaminated with benzene or MTBE?

As with any contaminant, it is the amount or dose that creates health problems. Cooking or bathing with water containing very high levels of benzene and MTBE would likely cause health problems. Cooking or washing dishes with water contaminated with benzene and MTBE at the levels found in Lowell would not be expected to cause physical injury or future illness. The exposures to benzene vapors, which may be experienced when showering or bathing, may be a health concern.

Do persons who eat vegetables and fruit from a garden contaminated by BTEX chemicals possess any increased statistical likelihood of physical injury or future illness than those persons who have never consumed vegetables and fruit from a garden contaminated by BTEX?

As with any contaminant, it is the amount or dose that causes health problems. Consuming vegetables and fruit that are saturated with BTEX chemicals would likely cause health problems. Consuming fruits and vegetables that were watered or washed with private well water in Lowell would be even less hazardous than consuming that water for drinking purposes. There is a possibility that vegetables may bioaccumulate chemicals from contaminated irrigation water or from soil vapor, but any exposure from this source would be insignificant.

What are the health risks to children playing in a small pool filled with water contaminated by BTEX and MTBE?

As previously stated, it is not expected that children who may have played in an outside pool filled with private well water in Lowell would be impacted by any benzene vapors at the levels of BTEX and MTBE found in private well water in Lowell because any volatizing vapors would be diluted by the outside air.

What are the health risks to children playing in the soil in areas where groundwater is contaminated with BTEX and MTBE?

The depth to groundwater in Lowell may range from 15 feet to 20 feet below ground surface. While benzene and MTBE in the groundwater may volatize and eventually migrate to the surface, very small amounts would reach the ground surface. The amount that will reach the ground surface will mix with the outside air and is unlikely to pose any health hazard to children playing in the surface soil.

What are the health risks to pets ingesting water contaminated with BTEX and MTBE?

It is assumed that the health risk to pets would be similar to that of humans.

What are the health risks from using water contaminated with BTEX and MTBE for washing clothes and cooking?

Similar to consuming homegrown vegetables or fruit in Lowell, minimal health risks would be expected from washing clothes and cooking with private well water in Lowell.

Conclusions

The Jet Gas Spill Site poses an indeterminate pubic health hazard. The contamination of groundwater in Lowell that occurred as a result of the Jet Gas spill in January 2001 may have posed a short-term public health hazard to Lowell residents who utilized contaminated private well water for their personal use. This possible public health hazard was due to the potential for inhalation of benzene vapors during activities such as showering and bathing. Definitive conclusions are limited because of the uncertainty regarding the possible length of exposure for residents of Lowell and the lack of available toxicologic information on human oral exposure to benzene and MTBE.

Recommendations

- All residents whose private wells have been impacted from the spill are encouraged to use water from the rural water system for all personal uses such as drinking and showering or bathing.

- A survey of residences in the pathway of the benzene plume should be completed to ensure that they are connected to the rural water system.

- IDNR should continue to monitor the levels of benzene in private wells in Lowell along with the monitoring wells during the ongoing investigation.

- IDNR should consider having soil-gas samples taken from soil surrounding homes in Lowell or consider having indoor air samples from basements and first floors of Lowell residences collected and analyzed for benzene to determine whether benzene levels are elevated and whether there is a potential or ongoing exposure to elevated benzene vapors.

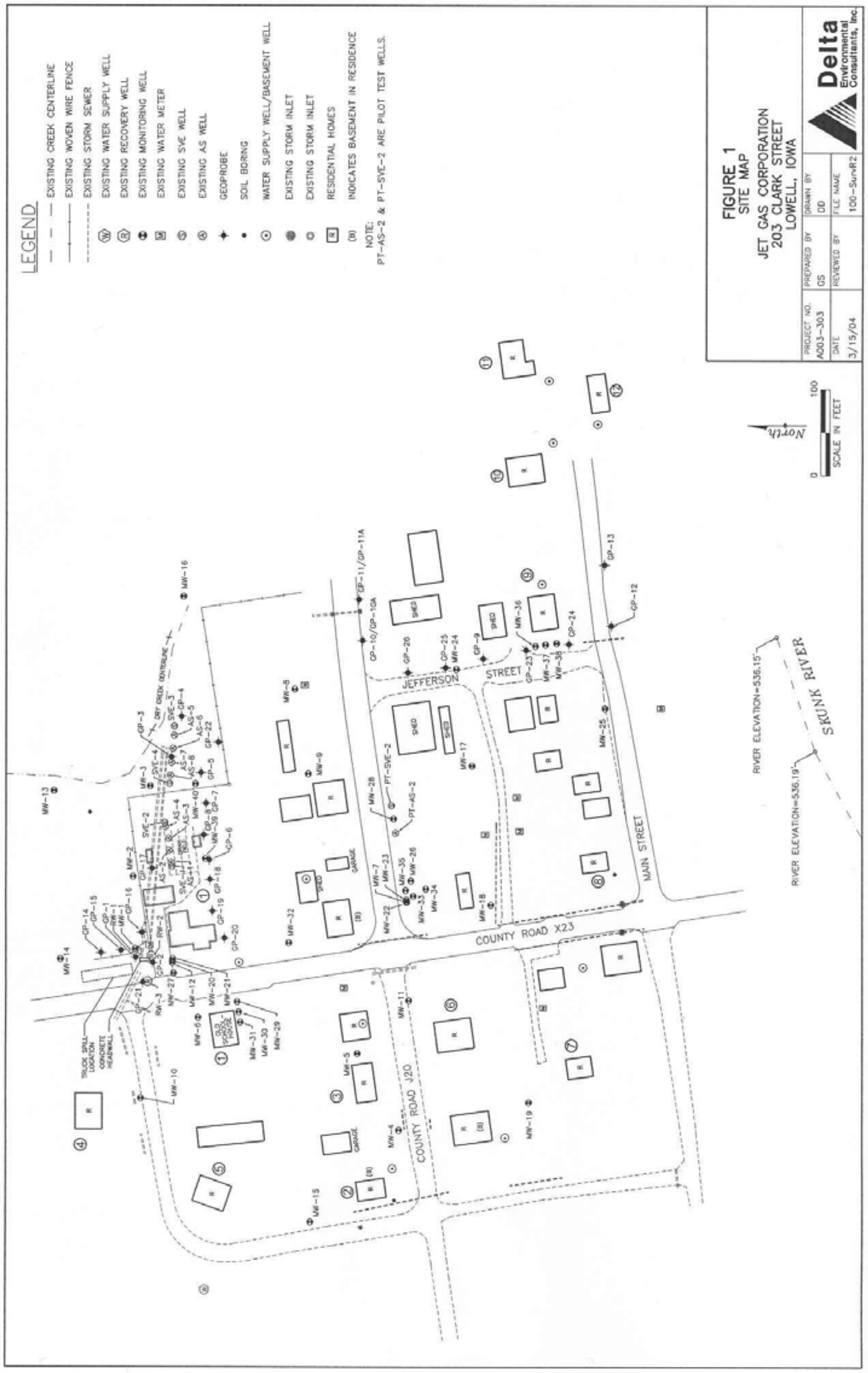
Public Health Action Plan

- IDPH will provide assistance with community health education as needed and requested.

- IDPH will continue to review any new private well monitoring data provided by IDNR and update health recommendations as necessary.

- IDPH will work with IDNR to follow up with Lowell residents to address any health concerns.

Location of Monitoring Wells and Private Wells



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CERTIFICATION

The Iowa Department of Public Health, Hazardous Waste Site Health Assessment Program, has prepared this health consultation for the Jet Gas Spill Site under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The document is in accordance with approved methodology and procedures existing when the health consultation was being prepared.

Technical Project Officer, CAT, SPAB, DHAC, ATSDR

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

Team Lead, CAT, SPAB, DHAC, ATSDR

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Appendix
Calculations for Inhalation and Dermal Exposure to Benzene

Description of Calculations for Estimating Exposure to VOCs through Inhalation and Dermal Exposure

Acute Exposures

When adults and children bathe or shower in water contaminated with volatile organic chemicals VOCs, such as benzene and methyl tertiary-butyl ether (MTBE), these chemicals will get into the body in two ways. First, these chemicals will evaporate from the water into indoor air where adults and children will be exposed when they breathe the air, and these chemicals can penetrate the skin during the time that a resident is bathing or showering.

Volatilization from showers

Scientists have studied how chemicals volatilize from shower water and have developed equations for estimating indoor air levels in the shower and bathroom (Andelman 1985, Andelman 1990, Jo et al. 1990, Wester and Maibach 1986). Therefore, the maximum concentration of a VOC in the bathroom can be estimated for a 10 minute shower and for the 20 minute period in the bathroom following a shower using the following equation:

C air max = (k) (Fw) (Ts) (Cw) / Va

where,

C air max = maximum concentration in air during the shower and after period in bathroom,
k = fraction of chemical that evaporates from water while showering (assumed to be 0.6),
Fw = flow rate of water through shower head in L/minute (assumed to be 8 liters/minute),
Ts = duration of shower in minutes (assumed to be 10 minutes),
Va = volume of shower and bathroom in liters, (assumed to be 10,000 liters, the approximate size of a small bathroom), and
Cw = concentration of VOC in water in mg/L (Andelman 1990).

The following example shows how units cancel to arrive at mg VOC per cubic meter of air.

C air max = (k) (Fw) (Ts) (Cw) / Va

C air max = (%) (L/min) (min) (mg VOC/L) / L

C air max = mg VOC / L air

C air max = mg/L air x 1000 L air/m^3

C air max = mg/m^3.

Using benzene at 0.306 mg/L (or 306 ppb) as an example, the following bathroom air concentration is estimated:

C air max = (0.6) (8 L water/min)(10 min) (0.306 mg/L water) / 10,000 L air

C air max = 0.0014688 mg/L air

C air max = 0.0014688 mg/L air x 1000 L air/m^3 = 1.4688 mg/m3

C air max = 1.4688 mg/m3 = 0.4533 ppm or 453.3 ppb
(using conversion of 3.24 ppm per mg/m^3)

To determine the amount of VOC exposure from inhalation, adults are assumed to 1 cubic meter of air each hour (EPA 1989).

Dermal intake converted to an air concentration

In addition to the exposure from breathing VOCs, people also absorb VOCs through their skin while showering and bathing. Using a skin permeability constant for VOCs, scientists have developed an equation for estimating the amount of VOC that is absorbed through the skin during a shower (Brown et al. 1984). The VOC exposure via skin can be estimated using the following formula:

Skin dose =

(dermal permeability constant) (duration of exposure)(total body surface area)(percent of body surface area exposed)(VOC concentration in water)(fraction remaining after volatilization)

The units are (L/cm^2 x hr) (hr) (cm^2) (%) (mg/L)(%), which cancel out to mg. The permeability constant for benzene can be found from US EPA Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim and is determined to be 1.5 x 10^{-5} L/cm-hr. Forty percent of the VOCs are assumed to remain in the shower water after volatilization (Andelman 1985, McKone 1991).

Because exposure to VOCs via the skin does not pass first through the liver, skin exposure is likely to be more toxicologically similar to inhalation exposure rather than ingestion exposure. Like inhalation exposure, a VOC absorbed through the skin will be distributed throughout the body before reaching the liver for detoxification. Therefore, to evaluate both inhalation exposure and skin exposure, it is necessary to convert the dose from skin absorption to an air concentration. Adding the air concentration that exists in the bathroom from taking a shower and the air concentration that is equivalent to the skin dose gives a total concentration in air that can be used to evaluate toxicity of a VOC from both routes of exposure.

The following example using benzene shows the estimated dose from skin absorption and how to convert that estimated dose to an air concentration. First, it is necessary to estimate the skin dose, which has been shown in previous equation.

Skin dose = $(1.5 \times 10^{-5}\ L/cm^2 \times hr)(10/60 hr)(20{,}000\ cm^2)(1)(0.306\ mg/L)(0.4)$.

Skin dose = 6.12×10^{-3} mg benzene

Next, it is necessary to convert the skin dose of 6.12×10^{-3} mg to an air concentration.

Air concentration from skin exposure =

Skin dose / inhalation rate x shower duration =

$6.12 \times 10^{-3} / 1\ m^3/hr \times 1\ hr/60\ minutes \times 10\ minutes = 1.02 \times 10^{-3}\ mg/m^3$
Converting to ppb = 11.3 ppb

Therefore, a concentration of $1.02 \times 10^{-3}\ mg/m^3$ (or 11.3 ppb) benzene in air will give an equivalent skin dose of 6.12×10^{-3} mg for a 10 minutes shower. The total exposure from volatilization and from skin absorption is 453.3 ppb plus 11.3 ppb, which is 465 ppb benzene in air.

Chronic exposure

To evaluate chronic exposure, it is necessary to also include the additional VOC exposure that occurs the remainder of the day indoors.

To estimate the total exposure of a specific VOC from bathing in contaminated water, the following exposures need to be consider:

$$\text{Total exposure}_{\text{specific VOC}} = \text{exposure}_{\text{shower inhalation}} + \text{exposure}_{\text{bathroom inhalation}} + \text{exposure}_{\text{shower}}$$

Thus, the equation to estimate each exposure pathway is as follows:

(Conc. air max in mg/m^3) ($1\ m^3/hr$) (10/60 hr) +

(Conc. air max in mg/m^3)(1m3/hr)(20/60 hr) +

(L/cm^2 x hr)(hr)(cm^2)(% surface area)(mg/L)(% remaining)

As an example, the total exposure for bathing in benzene-contaminated water containing 0.306 mg/L benzene is:

Total exposure $_{benzene}$ =

(1.4688 mg/m^3) (1 m^3/hr) (10/60 hr) +

(1.4688 mg/m^3) (1 m^3/hr) (20/60 hr) +

(1.5 x 10^{-5} L/cm^2 x hr)(10/60hr)(20,000 cm^2)(1)(0.306 mg/L)(0.4).

Total exposure $_{benzene}$ = 0.245 + 0.490 + 0.005 mg = 0.740 mg for a 10 minute shower and a 20 minute bathroom stay.

Using the maximum VOC detected, the exposure from summing all VOCs from bathing is estimated to be about 0.740 mg. This, however, is not the total exposure of VOCs for the day since adults and children are exposed to VOCs from breathing indoor air during the remainder of the day. This estimate can be made by using results from actual indoor air measurements or estimates from published information. In the toxicological profile for benzene, a study was referrenced that found average ambient benzene concentrations in homes at 7 μg/m^3. The exposure for a VOC can be estimated assuming a reasonable situation where someone stays at home most of the day. Typically men breathe about 23 cubic meters of air each day and women breathe about 21 cubic meters of air each day. Assuming that some time is spent away from the home each day, 20 m^3/day might be a reasonable, average upper-end exposure situation, thus the VOC exposure can be estimated using the following formula:

VOC exposure $_{indoor\ air}$ = (concentration of VOC indoors in ug/m^3) (20 m^3/day)(1mg/1000ug)

Substituting into the above equation for benzene we can estimate the daily exposure to benzene from indoor air.

Indoor air exposure $_{benzene}$ = (7 ug/m^3) (20 m^3/day)(1mg/1000ug)
= 0.140 mg/day

The next step is to convert the total daily exposure (in mg/day) for the VOC (based on shower exposure, bathroom air exposure, dermal exposure, and indoor air exposure) into a daily dose and a daily dose based on air concentration.

Total daily dose = 0.740 + 0.140 = 0.880 mg/day

Daily air concentration = 0.880 mg/day ÷ 20 mg/m^3 = 0.044 mg/m^3

Converting to ppm = 0.0136 ppm or 14 ppb

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