Health Consultation

DINITROTOLUENE IN PRIVATE WELLS

BADGER ARMY AMMUNITION PLANT

BARABOO, SAUK COUNTY, WISCONSIN

EPA FACILITY ID: WI9210020054

SEPTEMBER 30, 2006

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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Prepared By:

Wisconsin Department of Health and Family Services
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Summary

Since December 2003, dinitrotoluene (DNT) has been found in a number of private wells near the Badger Army Ammunition Plant (BAAP), located in Baraboo, Wisconsin. DNT was found above the Wisconsin Enforcement Standard (ES) in three private wells. Three other private wells had nitrates above the Wisconsin ES. While these levels of DNT and nitrates are slightly above their respective Wisconsin ES, the highest concentrations found in private wells are not likely to cause adverse health effects among people may who drink the water for many years and, as a result, poses *no apparent public health hazard*. As of June 2005, of the three wells with DNT above the ES, two were replaced and now provide clean drinking water, and in the third well, DNT has not been found in the past 4 rounds of sampling.

The current Wisconsin ES for 2,4-DNT and 2,6-DNT takes into account the current base of knowledge and is protective of public health. For the other 4 DNT isomers, this Wisconsin ES for DNT is expected to also be protective of public health. However, the Wisconsin Department of Health and Family Services (DHFS) recommends that, as technically possible, the laboratory methods used for analysis of groundwater samples related to BAAP look for all isomers of DNT. DHFS encourages the Army pursue an evaluation of lowering the method detection limit for DNT that will provide data with a larger margin below the Wisconsin ES for DNT. DHFS supports the ongoing groundwater investigations near BAAP, and recommends the continued testing of nearby private wells to ensure people are not drinking unsafe levels of DNT.

The purpose of this health consultation is to specifically address only the human health implications of groundwater and private well contamination by DNT around BAAP, a completed exposure pathway. DHFS is not planning to conduct a health study of BAAP-area residents in related to DNT in drinking water because exposures were too low to cause adverse health effects that could be studied. This health consultation underwent a 30-day public comment period and comments received were taken into account in preparing the final release of the health consultation.

Background

The Badger Army Ammunition Plant (BAAP) is a large former industrial installation located in south-central Wisconsin, approximately 9 miles south of Baraboo and 30 miles northwest of Madison. The plant covers approximately 7,354 acres within Sumpter and Merrimac townships in Sauk County, Wisconsin. In 1942, the U.S. Department of Defense built BAAP for the production of nitrocellulose-based propellants used in rocket propelled artillery, cannon, and small arms shells. Ammunition production at BAAP was greatest during World War II, the Korean War, and the Vietnam War. BAAP was deactivated by the Department of Defense after its last period of production, and placed on standby status in 1975. The Department of the Army is in the process of permanently closing the idle BAAP.

The land surrounding BAAP is primarily agricultural. In some locations groundwater has low levels of fertilizer compounds and nitrates, which is not unusual for this region of Wisconsin. Most homes and farms near BAAP draw water from wells for potable and agricultural uses. Since the early 1990s concerns have been raised by the public about groundwater contamination coming from BAAP.

Groundwater contamination due to past manufacturing activities at BAAP has been an issue for many years, with the U.S. Army and public environmental agencies working to address this matter. Nearby residents have also been very aware and concerned about contaminants in groundwater, particularly since all drinking water comes from private and municipal supply wells. Site-related contamination was found in the past in several private wells, located south of the facility. Prior to 1999, in an area south of the facility carbon tetrachloride was found up to 130 μg/L in one irrigation well, and up to 80 μg/L in three private wells above its NR140 Wisconsin Groundwater Quality Enforcement Standard (ES) of 5.0 μg/L (State of Wisconsin Admin Code, 2004). Chloroform was found in one private well above its ES of 6.0 μg/L. All concentrations posed *no apparent public health hazard*. The human health implications of private wells impacted by chlorinated solvents, carbon tetrachloride, and chloroform, were addressed in a public health assessment that was prepared by the DHFS and issued by the federal Agency for Toxic Substances and Disease Registry (ATSDR 1999).

Groundwater and Private Well Contamination by Dinitrotoluene (DNT)

The BAAP facility has a number of on-site waste areas, but at this time only several have been identified as apparent sources of DNT in groundwater (there may be other sources of DNT in groundwater, such as in the Water's Edge neighborhood)[1]. One identified on-site area is the Propellant Burning Ground (PBG), in the southwestern portion of the facility, and the other identified source is the Deterrent Burning Ground (DBG), in the northeastern portion of the

[1] The Water's Edge neighborhood is within an area that was formerly part of the Badger Army Ammunition Property.

facility. At the PBG, DNT has been consistently found in groundwater, with concentrations ranging between 0.04 and 43,000 μg/L (micrograms per liter). At the DBG, DNT has been sporadically detected in groundwater over the past 5 years, and for two monitoring wells, DNT detections have been consistent for the past 3 years. Remediation actions were taken at both the DBG and PBG and included the excavation of contaminated soils. The DBG was covered with a waterproof cap and an infiltration system was installed to promote biodegradation. At the PBG, a soil vapor extraction system operated from 1999 to 2001, after which a bioremediation system was installed. While these actions were taken to capture DNT-contaminated groundwater before it migrates away from the BAAP facility, some contamination appears to have already gone beyond facility boundaries. Located in the southeast corner of BAAP and Gruber's Grove Bay, the Settling Ponds and Spoils Area also has DNT contamination in soils and sediments.

In 2003, very low levels of DNT appeared in off-site groundwater monitoring wells along the southern edge of the facility. In 2004, DNT was detected in groundwater monitoring wells along the NE corner of BAAP. While the actual sources of this DNT are not clear, concerns have been raised about the reliability of this laboratory data. Since 1998, traces of DNT have been detected in several on-site and off-site groundwater monitoring wells along the south boundary of BAAP. In December 2003, DNT was detected in two groundwater monitoring wells located along the southeastern edge of BAAP and near the on-site settling ponds.

As part of a groundwater monitoring plan, fourteen private wells south of BAAP and a Prairie du Sac municipal well have been sampled quarterly since 1998 for inorganic/metals, volatile organic compounds, semi-volatile organic compounds, and DNT. Prior to 2003, DNT had not been detected in any sampled private or public drinking water supply well near BAAP.

In December 2003, very low levels of 2,4-DNT were first detected in water samples from two private wells, with one at 0.03 μg/L and the other at 0.05 μg/L (micrograms per liter). These two homes are located directly south of, and approximately one-quarter mile from, the BAAP boundary. When the laboratory reported these results in late January, the residents of each home were notified and provided bottled water. In follow-up, three more rounds of water samples were collected from each well in March 2003. These water samples confirmed the presence of 2,4-DNT at "no detect", 0.021 and 0.01 μg/L in one well, and 0.03, 0.37, and 0.04 μg/L in the other. DNT was found once in one private well at the Wisconsin ES for DNT, which is 0.05 μg/L. In response, the Army provided bottled drinking water as a clean, alternative drinking water source.

The growing presence of DNT in groundwater monitoring wells and private wells near the BAAP boundary suggested that DNT may be migrating to the south and further away from BAAP in the groundwater. These groundwater monitoring wells are located up gradient from private wells along Hwy 78. The impacted monitoring wells are in an area where the DNT could be coming from an up-gradient source.

Due to uncertainty about the actual sources of DNT in private wells south of BAAP and the unknown degree and full extent of DNT in off-site groundwater, in March 2004, the Wisconsin Department of Natural Resources (DNR) requested the Army to expand sampling to all the private wells located between Gruber's Grove Bay and the northern edge of the Village of Prairie du Sac, including all the homes along Hwy 78, around Gruber's Grove Bay, and between Hwy 78 and Lake Wisconsin (Figure 1). DNR requested that each private well be sampled for volatile organic compounds, DNT and nitrates. Selected homes were also sampled for ammonia.

In follow-up to the discovery of DNT in private wells, another round of well water samples were collected from 90 homes later in March 2004. The laboratory results reported the detection of very low levels of 11 contaminants in private well water, with DNT detected in 9 private wells and nitrates in 34 private wells. Not all of these contaminants appeared to be site-related. Nitrates were found above the Wisconsin ES in two private wells. All detections of DNT in private well water were less than the Wisconsin ES, including the two private wells where DNT was above the Wisconsin ES in the first round of March 2004 sampling. In response, the Army provided bottled drinking water to over 60 homes in the Windings subdivision (south of Gruber's Grove Bay), where DNT detections occurred.

In April 2004, another round of private well sampling was conducted from 23 selected homes, including those with prior DNT detections. DNT was found above the Wisconsin ES in two private wells of the Water's Edge Subdivision (on Lake Wisconsin, the north side of Gruber's Grove Bay). For one of the wells in Water's Edge Subdivision, 2,4-DNT was at 0.01 μg/L and 2,6-DNT was at 0.1 μg/L, for a combined DNT level of 0.11 μg/L, the highest DNT level found in a private well near BAAP. DNT was also detected at less than the Wisconsin ES in the single private well where it was previously detected in December 2003 above the Wisconsin ES. Additionally, nitrates in one private well exceeded the Wisconsin ES.

In mid-May 2004, these 83 private wells were sampled again. DNT was detected above the Wisconsin ES in two private wells that were in the Water's Edge Subdivision. DNT was not detected in any other private wells, including those where it was previously detected.

Later in May 2004, 10 private wells were resampled, with DNT detected in 6 private wells, of which 2 wells had DNT above the Wisconsin ES, including 1 private well in the Water's Edge Subdivision.

In summary, between December 2003 and June 2005, over 103 private wells near BAAP were tested for DNT. For this time frame, 2,4-DNT was detected at least once in 19 wells, 2,6-DNT at least once in 12 wells, and 3,4-DNT was found one time in a single well (Table 1). The isomer 2,3-DNT was not detected in any other private well water samples.

Repeated sampling consistently found DNT in only four private wells near BAAP: two private wells directly south of and one-quarter mile from the BAAP boundary (where DNT was first detected in December 2003) and two other private wells in the Water's Edge Subdivision. For the two private wells near the BAAP southern boundary, only the isomer 2,4-DNT was detected. For these two private wells, the highest concentration of 0.05 μg/L 2,4-DNT was found in December 2003. Afterwards, in March and April 2004 DNT was found less than the Wisconsin ES, 4 times in one well and 3 times in the other. As of June 2005, after 5 additional rounds of sampling, DNT has not been detected in these 2 private wells. The highest level of DNT in a private well was found in the Water's Edge Subdivision, at 0.1 μg/L for 2,6-DNT and 0.011μg/L for 2,4-DNT. This also is the highest combined level of DNT observed in a private well near BAAP property.

Table 1: Detections of Dinitrotoluene (DNT) in Private Well Water

103 Private Wells Located Near
Badger Army Ammunition Plant
Sauk County, Wisconsin
December 2003 to June 2005

All concentrations in Micrograms per Liter (μg/L)

DNT Isomers	Highest Level Detected	Frequency of Detection	Number of DNT Detections **Less Than** WI Enforcement Std. of 0.05 μg/L			Number of DNT Detections **At or Above** WI Enforcement Std. of 0.05 μg/L		
			once	**twice**	**3 or more times**	**once**	**twice**	**3 or more times**
2,3-DNT	**0**	**0/99**	0	0	0	0	0	0
2,4-DNT	**0.05**	**19/103**	**14**	**1**	**3**	0	0	**1**
2,6-DNT	**0.10**	**12/103**	**8**	0	0	**2**	0	**2**
3,4-DNT	**0.01**	**1/99**	**1**	0	0	0	0	0

In January and March 2005, the Army's contractor installed two new drinking water wells in the Water's Edge Subdivision to replace those wells that consistently had DNT above the Wisconsin ES. Testing did not find DNT in water samples from these two new wells and in July 2005 the wells began to provide safe drinking water for residents. In December 2004, the Army stopped providing bottled water to all homes where several rounds of sampling did not find DNT in private well water.

After May 2004, several rounds of sampling did not detect DNT in private well water in "The Windings" or of homes located close by. Since then, private well sampling in The Windings was cut back to the quarterly testing of 3 homes, as well as another nearby home on Highway 78. DNT continues to not be detected in drinking water from these private wells. To better study groundwater in this area, in late 2005, the Army installed 3 groups or clusters of groundwater monitoring wells in The Windings. The Army sampled these monitoring wells in March 2006, but the finalized results were not available when this health consultation was completed.

In June and September 2005, groundwater investigations detected DNT in monitoring wells farther south from BAAP than previously found. These two rounds of groundwater sampling found DNT in four monitoring wells along Highway County Z and another monitoring well approximately 0.6 miles further south and close to the Village of Prairie du Sac. The DNT concentrations ranged from 0.017 to 0.034 μg/L.

It is possible that the degradation of DNT in groundwater around BAAP may contribute to the levels of nitrates in groundwater, particularly near DNT sources, where soil and groundwater concentrations are substantially elevated. As of the writing of this health consultation, nitrates in off-site groundwater have not been clearly linked to contaminants originating from past operations at BAAP. However, nitrates can be a by-product from the environmental degradation of DNT, with the resulting nitrate concentration likely be in a similar range as the DNT concentration. When both DNT and nitrates were found in the same private well near BAAP, nitrate concentrations ranged between 1,000 and 10,000 μg/L and DNT concentrations were less than 0.1 μg/L. At another site in Wisconsin with DNT-contaminated groundwater, the former DuPont Barksdale Works in Bayfield County (URS 2001), there was an association between the presence of DNT and nitrates in private well water. A similar association has not been observed in private wells near BAAP. For private wells near BAAP and the DuPont site, no correlation has been observed between the levels of DNT and levels of nitrates in private well water. Furthermore, elevated levels of nitrates in groundwater coming from the DuPont site were associated with the location of specific production process and not with the presence or degradation of DNT.

Nitrates have also been detected in many private wells around BAAP where site-related contamination has not been detected nor likely to be present. Therefore, it is likely that a large portion of the nitrates found in private well water near BAAP are primarily from agricultural sources, the most common source in Wisconsin of nitrate-contaminated groundwater.

Community Health Concerns

This section lists some of the health-related questions and concerns that people have raised about DNT in groundwater near BAAP. The questions received by DHFS include:

- Is the current Wisconsin Enforcement Standard for DNT in private well water protective of public health for all DNT isomers?
- Is the current Wisconsin Enforcement Standard for DNT in private well water protective of the health of the unborn and young children?
- Even though DNT is no longer found in the drinking water of my home, will any DNT residues remain behind in the pipes and contaminate clean water?
- Can people be exposed to DNTs through inhalation and skin absorption while using DNT-contaminated water when showering, bathing, or swimming?
- Is it safe to wash clothes in water that has DNT at the Wisconsin Enforcement Standard?

- Because of DNT in private well water, should there be a health study of BAAP area residents?
- Regarding the potential degradation products of DNT in groundwater:
    - Is the Army testing groundwater and drinking water for all of these?
    - What are the drinking water standards for each of these?

Discussion

DNT was found above the Wisconsin Enforcement Standard (ES) in three private wells. Three other private wells had nitrates above the Wisconsin ES. While these levels of DNT and nitrates are slightly above their respective Wisconsin ES, the highest concentrations found in private wells are not likely to cause adverse health effects among people who may drink the water for many years and, as a result, poses a *no apparent public health hazard*. The current Wisconsin ES for 2,4-DNT and 2,6-DNT takes into account the current base of knowledge and is protective of public health. For the other 4 DNT isomers, this Wisconsin ES for DNT is expected to also be protective of public health. While there have been substantial investigations of groundwater on and around BAAP, it appears the degree and extent of DNT contamination in groundwater has not been fully characterized. DHFS supports the ongoing groundwater investigations being conducted by the Army, and recommends the continued testing of nearby private wells in order to ensure that the public is not being exposed to unsafe levels of DNT in drinking water. At this time, DHFS is not planning a health study of BAAP-area residents related to DNT in drinking water because exposures were too low to cause adverse health effects that could be studied.

<u>Toxicological Implications of Dinitrotoluene</u>

Dinitrotoluene (DNT), in its various forms or isomers, is a synthetic or man-made chemical that has a number of industrial and commercial uses, including the production of foams, dyes, ammunition, gunpowder, and explosives, but the main use today of DNT is in making polyurethane or foam (NIOSH 1985). DNT does not tend to accumulate in the environment, nor does it accumulate in plant or animal tissues. The highest exposures people have with DNT are when they work with pure forms of the chemical. Most people who are unknowingly exposed to DNT do so by drinking contaminated water. Such people may absorb small amounts when they shower with contaminated water or wear clothes washed in this water, but ingesting contaminated water makes up the bulk of their exposure to DNT. When DNT enters people and animals, most of the chemical is rapidly excreted through urine or feces. DNT is rapidly degraded by sunlight and bacteria, but when DNT reaches groundwater, it tends to undergo very little degradation (EPA 1992).

DNT has a number of known toxic effects on the health of both people and animals, but these harmful effects occur at levels that are many times higher than the levels found in private well water near BAAP.

Residents with DNT- contaminated well water not only had DNT exposures by ingestion, but they also had a very small dose of DNT due to inhalation and dermal absorption. Most human studies on the health effects of DNT were of workers in occupational settings related to the manufacturing or commercial use of DNT (ATSDR 1998). For workers who handled pure DNT, dermal contact may have added to their overall exposure dose, but it is viewed that inhalation resulted in the primary exposure dose for these workers. Their DNT exposures were notable when workers inhaled smoke or particulates contaminated by DNT. DNT has a low vapor pressure and its not likely that DNT vapors were inhaled by these workers.

When water is contaminated with the DNT levels found in private wells near BAAP, it is possible that very small amounts of DNT are in fine water particles released to indoor air as a result of bathing, showering, or washing. A person could the inhale these water vapors or come in direct contact with contaminated water, and then be potentially exposed to DNT. However, such a DNT inhalation exposure dose likely would be many times smaller than the ingestion exposure dose of drinking this water. Therefore, the DNT doses received via inhalation and dermal contact with DNT-contaminated water probably occur, but are likely to be minimal and dwarfed when compared to a DNT exposure dose from drinking the same water.

Noncancer Health Effects of DNT

Studies of laboratory animals exposed to high concentrations of DNT have shown increased adverse health effects on the blood, nervous system, liver, kidney, and the male reproductive systems. Acute or short-term health effects appear shortly after an exposure to a high concentration of DNT. Long-term or chronic health effects sometimes take many months or years to appear, and are caused by repeated, daily exposures to low concentrations of DNT. Laboratory studies that examine chronic health effects of a chemical are useful because they help us understand when a long-term exposure becomes unacceptable.

Laboratory studies of animals chronically exposed (over 12 months) to DNT show that adverse health effects start appearing when a dose is above 1.0 milligrams of DNT per kilogram body weight per day (mg/kg/day). In one study, groups of beagle dogs were fed various doses of DNT. A group of 12 beagles dosed at 1.5 mg/kg/day of 2,4-DNT for 24 months developed neurotoxic effects, as well as changes to the liver and kidneys. Such effects were not noticed in another group of 12 beagles dose 2,4-DNT at 0.2 mg/kg/day (Ellis 1985). Taking into account many other laboratory studies of 2,4-DNT, both the U.S. Environmental Protection Agency (EPA) and ATSDR concluded that 1.5 mg/kg/day was the lowest known chronic exposure to result in an adverse health effect, and 0.2 mg/kg/day was the threshold for a "no observed adverse effect level" (NOAEL). This NOAEL is the basis for determining both the ATSDR "Minimal Risk Level"[2] (MRL) and EPA's "Reference Dose" (RfD) for 2,4-DNT (EPA 2002). Using a 100-fold safety factor, 0.002 mg/kg/day was established for chronic oral exposure to 2,4-DNT. This converts to a

[2] ATSDR Minimal Risk Level: The dose of a chemical that is likely to be without a measurable risk of adverse, noncancerous effects.

2,4-DNT concentration in water of 70 μg/L for an adult and 20 μg/L for a child. EPA has not established a RfD for either 2,6-DNT or mixtures of DNT isomers. For 2,6-DNT, ATSDR has only established an "intermediate" health effect MRL, which is 0.004 mg/kg/day, or equivalent to 100 μg/L for an adult and 40 μg/L for a child (ATSDR 1998).

The highest combined level of DNT observed in private wells near BAAP property was 0.11 μg/L. Based on the ATSDR MRLs and EPA RfD for DNT, drinking water over a long term with the highest level of DNT found in private well water near BAAP is not expected to result in a non-cancer health effect.

Cancer and DNT

A mixture of 2,4- and 2,6-DNT causes certain cancers in laboratory animals, but has not been clearly linked to causing cancer in humans. Human cancer studies of DNT examined workers who were exposed for a long time to high DNT concentrations. A study of more than 450 workers who used DNT in making polyurethane foam did not show an increased death rate from any cancers, though the death rate from heart disease was significantly higher when compared against workers who were not exposed to DNT (Levine 1986). Another study of 4,989 munition plant workers exposed to high levels of DNT found a higher than expected number of deaths attributed to liver cancer (n=6), but the number of cancer deaths, including liver cancer, was not statistically significant. With the exception of a slightly elevated number of lymph system cancers, the number of deaths among munition plant workers from all other cancers was less than expected (Stayner 1993). A 1998 study of 500 German miners (who worked frequently with DNT, including bare-handling of explosive charges) found an elevated number of urinary tract cancers (n=6) and renal cell cancers (n=14). The urinary tract cancers occurred among miners who had the highest exposures to DNT. Other types of cancers in these miners were not above expected rates, including liver cancer (Bruning 1999). When compared against the rates of these cancers among the German public (tumor registry data), these miners had an incidence rate of urinary tract cancer and renal cell cancer that was 4.5 and 14.3 times higher, respectively, than expected (Bruning 2002). It should be noted that the subjects in these occupational studies were mostly male.

Laboratory bioassay and animal studies often found that 2,4-DNT caused kidney cancer and that mixtures of 2,4-DNT and 2,6-DNT caused liver cancers. For example, in one study, rats fed only 2,4-DNT for 2 years later developed liver cancer, but two other studies did not find liver cancer when different laboratory rats were similarly fed DNT over 2 years. Significant increases in liver cancer were found in several studies of rats fed 2,4-DNT or 2,6-DNT for at least 1 year. Another laboratory study of rats dosed with 2,4-DNT did not show an increase of any cancers, but there was an increase in the numbers of benign tumors of the skin and mammary glands, though the increase was not significant (ATSDR 1998).

Studies suggests that when these two DNT isomers are present, their combined ability to increase cancer risk is more than just additive, and may be synergistic or multiplicative (ATSDR 1998). Laboratory animal studies indicate that 2,6-DNT acts as both a tumor promoter and initiator, while

2,4-DNT functions as a tumor promoter. Laboratory rats were dosed over 1 year with mixtures of 2,4-DNT and 2,6-DNT (in proportions similar to technical-grade DNT) and in each study, a significant increase in liver cancer was observed (ATSDR 1998). As a result, the EPA cancer slope factor for mixtures of 2,4- and 2,6-DNT takes into account this effect and, when applied to the derivation of a cancer-based risk factor exposure guideline, results in an even more protective concentration than either isomer individually or added together. Currently, the EPA only classifies mixtures of the 2,4-DNT and 2,6-DNT isomers as a “B2” or “probable human carcinogen.” No individual DNT isomer is classified by the EPA as a carcinogen. The “B2” classification is based on “insufficient human carcinogenicity data” and “sufficient animal carcinogenicity data” (EPA 2002), and is the most frequent cancer classification for chemicals issued by EPA.

The current Wisconsin Groundwater Quality Public Health Enforcement Standard (ES) for DNT is 0.05 μg/L (Wisc Adm. Code 2004), and is based on the EPA cancer slope factor for DNT mixtures (EPA 2002). Wisconsin’s Enforcement Standards are designed to provide safeguards and to be protective of public health and welfare when using groundwater as a drinking water source. The highest combined level of DNT observed in private wells near BAAP property was 0.11 μg/L. Based on the current EPA cancer slope factor for mixtures of DNT, a person who drinks water over a long term with the highest level of DNT mixtures that were found in a private well near BAAP is very unlikely to develop cancer as a result of this exposure[3]. However, DHFS uniformly recommends that people do not drink water whenever a contaminant is above its Wisconsin ES value.

Other Health Investigations of Human Exposures to DNT in Drinking Water

DHFS searched available resources for information about other communities that have been exposed to low levels of DNT in drinking water. This search found only one case of DNT detected in a number of drinking water wells, which at the Cornhusker Army Ammunition Plant (CAAP), in Grand Island, Nebraska. In 1992, ATSDR completed a public health assessment on the site, which reported that site-related contaminants were found in over 460 private wells (ATSDR 1992). However, this situation is somewhat different from the BAAP because many other contaminants were found in private well water, as well as a much higher level of DNT. The highest levels of explosive contaminants found in private well water near CAAP was 445 μg/L for trinitrotoluene (TNT), 371 μg/L for RDX (an explosive), 114 μg/L for trinitrobenzene, and 11 μg/L for both DNT isomers. Contamination was discovered in private wells in 1983. The ATSDR report did not

[3] When Wisconsin establishes a Groundwater Enforcement Standard for a carcinogen, the concentration listed in NR140 is generally equivalent to a 1 in 1,000,000 excess lifetime increased cancer risk. This theoretical cancer risk means that if 1,000,000 people were to drink water contaminated by 0.05 μg/L of DNT, at a rate of 2 liters (or 2.12 quarts) per day of every day for 70 years, this would result in 1 additional case of liver cancer. Considering the highest combined levels of 2,4- and 2,6-DNT found in single private well near the Badger Army Ammunition Plant was 0.011 μg/L and using the EPA cancer slope factor for mixtures of DNT, then if over 70 years 1,000,000 people drank 2 liters per day of this DNT-contaminated water, theoretically an additional 2 cases of liver cancer would be seen over 70 years for these 1,000,000 people. Taking into account the occurrence of cancer (DHFS 2005), for 1,000,000 Wisconsin residents each year there is expected to be approximately 40 new cases of liver cancer.

estimate when contaminants first reached most private wells, but some people may have drank contaminated well water for as long as 25 years. Based on the levels of RDX & TNT found in drinking water wells, ATSDR concluded that this situation posed a public health hazard for people who drank contaminated groundwater. ATSDR did not find that DNT in drinking water was a public health hazard.

To address the health concerns expressed by Grand Island residents, ATSDR conducted a symptom and disease with biomarkers health study of selected Grand Island residents (ATSDR 1996). In this study, ATSDR compared the self-reported symptoms and diseases of 300 residents who likely drank contaminated well water (target area) with 300 residents from a nearby neighborhood who did not have contaminated drinking water (comparison area). Overall, 77 percent of residents of the target and comparison area neighborhoods of similar size and demographics participated in the study. Study participants in the target area reported 8 cases of cancer compared to 16 cases reported for the comparison area. For breast cancer, there was one case in the target area, compared to three cases in the comparison area. When statistical analysis was conducted, no significant difference was found between the number of specific cancer cases for the target and comparison areas. There was also no significant difference in reproductive histories of women from the target and comparison areas. ATSDR found target area residents were twice as likely than comparison area residents to self-report the occurrence of seven health outcomes: neurological problems; weakness or paralysis of limbs not due to stroke; urinary tract disease; numbness or tingling sensation in toes or fingers; trouble sleeping; trouble remembering; and irritated eyes. A longer residence in the target area was not associated with an increase of self-reported health outcomes.

In order to clinically evaluate whether the health of target area residents was adversely affected, ATSDR also collected urine and blood specimens from both target area and comparison area residents. Specimens underwent a battery of laboratory tests for organ damage or dysfunction of the immune, renal (kidney), hepatic (liver), and hematopoietic (blood) systems. No difference was found when the test results of target area residents were compared against established reference levels. When results for the target area were compared against results for the comparison area, only two differences were found: comparison residents had higher levels of a urinary protein and a blood protein than target area residents. A battery of neurobehavioral tests was administered on 76 target area residents and 77 comparison area residents and did not find a difference between the two areas.

Toxicity of DNT Isomers

Questions have been raised about the different isomers of DNT that may be present, as well as the toxicological and human health implications of exposure to the various isomers. The question has also been raised about whether the current Wisconsin ES for 2,4-DNT and 2,6-DNT are also protective for the other 4 DNT isomers in drinking water. Taking into account the current base of knowledge of DNT, the current Wisconsin ES for 2,4- and 2,6-DNT is expected to also be protective of public health for the other 4 DNT isomers.

DNT can present itself as six different chemical isomers: 2,4-DNT, 2,3-DNT, 2,5-DNT, 2,6-DNT, 3,4-DNT, and 3,5-DNT. The current body of toxicological knowledge about DNT is primarily based on the isomers 2,4-DNT and 2,6 DNT. These two DNT isomers make up 95 percent of various production grades of DNT (including technical grade DNT) and the other four DNT isomers comprise the remaining 5 percent. Since these other isomers are less common both in industrial products and in the environment, toxicological and epidemiological studies have focused almost exclusively on the isomers 2,4-DNT and 2,6-DNT. Very little information is available about the toxicological properties of the other four DNT isomers.

However, some laboratory studies indicate that the other isomers of DNT may have a slightly greater toxic effect on certain systems than 2,4-DNT and 2,6-DNT. Since DNT is known to adversely affect the male reproductive system, Reader (1990) studied cultures of certain rat testes cells and found they were 2 to 10 times more sensitive to adverse changes when dosed with 3,4-DNT than when dosed with 2,3-DNT, 2,4-DNT, or 2,6-DNT. In another laboratory study of rat testes cells, Sorenson (2003) described that these same cells were slightly more sensitive to extended exposures of 3,4-DNT than 2,4-DNT. In a study of cultured liver cells from rats, Spanggord (1990) observed that 2,3-DNT, 3,4-DNT, and 2,5-DNT inhibited protein synthesis up to 4 times higher and decreased enzyme activity by 10 times when compared to the isomers 2,4-DNT, 2,6-DNT and 3,5-DNT. There is some indication that for certain effects other isomers of DNT may have a greater mutagenic potency than 2,4-DNT and 2,6-DNT (Tchounwou 2003, U.S. EPA 1992). Several assay studies of single cell organisms suggested 3,5-DNT may be a more potent mutagen than other DNT isomers, as much as 10 times more potent. These studies indicate a similar level of mutagenicity for technical grade DNT as well as each individual isomer of DNT. Despite the very limited body of knowledge about the other DNT isomers, human studies have not identified an increase adverse health effects associated with exposures to various isomers of DNT or technical grade DNT. These human studies were work-related exposures to production grades of DNT, which includes all isomers.

Even though some DNT isomers appear to have a slightly more potent non-cancer adverse effect on certain systems than other isomers, the Wisconsin ES for DNT is based on the carcinogenicity of 2,4-DNT and 2,6-DNT mixtures and is protective of public health for all DNT isomers. As previously described, the lowest a long-term drinking water guideline value for a non-cancer endpoint (adverse effects on the blood) is 70 μg/L for 2,4-DNT (for both the ATSDR MRL and the EPA RfD). The Wisconsin ES for DNT is 0.05 μg/L, which is based on the classification by the EPA that mixtures of 2,4-DNT and 2,6-DNT are a probable human carcinogen. For DNT, there is a 1,400-fold difference between the 70 μg/L non-cancer drinking water guideline and the 0.05 μg/L Wisconsin ES. However, even though the Wisconsin ES for DNT protects public health for all DNT isomers, DHFS recommends that, as technically possible, the laboratory methods used for analysis of groundwater samples related to BAAP look for all isomers of DNT.

Community members near BAAP noted that the United Kingdom Department of the Environment (UKDE) has classified several other DNT isomers (3,4-DNT, 3,5-DNT, and 2,5-DNT) into the category of "may cause cancer". Currently, these isomers of DNT are not classified as known or suspected carcinogens by the U.S. Environmental Protection Agency, the U.S. National Toxicology Program, or the U.N.'s International Agency for Cancer Research. Furthermore, when DHFS examined this cancer classification by the UKDE, they were unable to identify a specific policy or determine the scientific basis by which this classification was developed and issued. DHFS staff were also unable to locate any value, such as a cancer slope factor, issued by UKDE that could be used to determining an acceptable threshold for quantitative health risk-based assessment. DHFS will continue to rely on cancer classifications and cancer slope factors for DNT isomers as determined and issued by the U.S. Environmental Protection Agency.

<u>Toxicological Implications of Nitrates</u>

The Wisconsin Enforcement Standard for nitrates of 10 mg/L was established because when infants are exposed to elevated levels of nitrates, they are susceptible to developing methemoglobinemia. An infant's digestive tract is less acidic than an adult's and, under this condition, nitrates are converted to nitrites. When entering the blood, nitrites react with hemoglobin to produce methemoglobin. Fetal hemoglobin is even more susceptible than adult hemoglobin to reacting with nitrite and producing methemoglobin.

Methemoglobin will not transport oxygen between the lungs and tissues, and elevated methemoglobin levels can result in asphyxia. Based on various studies of infant methemoglobinemia, the U.S. EPA determined that 10 mg/L nitrates is the NOAEL (no observable adverse effect level) for infants. Both the U.S. EPA Maximum Contaminant Level and the Wisconsin Enforcement Standard were established based on this NOAEL. Methemoglobinemia has been observed starting to appear in infants when nitrates are above 22 mg/L.

The highest level of nitrates recently observed in private well water near BAAP is12.9 mg/L. Based on the derivation of the current Wisconsin ES for nitrates of 10 mg/L, a young child who drinks water that has nitrates at 12.9 mg/L is not expected to develop an adverse health effect. However, DHFS uniformly recommends that people do not drink water with a contaminant above its Wisconsin ES value.

<u>Laboratory Analytical Issues</u>

In March and April 2004, there was the spotty appearance of DNT in drinking water samples collected from private wells in the vicinity of BAAP. A review of laboratory methods, as well as quality assurance and quality compliance, indicated that many detections of DNT in private well water samples may have been the result of laboratory errors or problems with the analytical method used by the contracting laboratory. It is difficult to know with certainty whether DNT was actually present in water samples from these private wells, but the situation indicates that for a number private wells, the detection of DNT was not accurate. One of the unfortunate consequences was uncertainty among people who were informed that a contaminant was in their groundwater when prior and subsequent rounds of sampling did not find DNT.

In late 2004, the current laboratory under contract with the Army switched to an analytical method called "liquid chromatography/mass spec/mass spec". Since then DNT was not detected in these wells with a single prior detection. However, there are a few shortcomings with this newer analytical method.

The first shortcoming is this newer method only analyzes for the two isomers, 2,4-DNT and 2,6-DNT. The other methods previously used at BAAP also analyzed for 2,3-DNT and 3,4-DNT. The Department of Natural Resources (DNR) recommended to the Army that when conducting analysis with the new method, if any isomer of DNT is detected, the sample also be analyzed using mass spectroscopy procedure used in the September 2004 sampling round, which is also capable of looking for the 2,3-DNT and 3,4-DNT isomers. This previously used method is not used as the first analytical step because it has a higher chance of generating false positives. The DNR also recommended that the Army's contractor develop the ability of this newer method to analyze for these other isomers of DNT. DHFS also supports the expansion of the method to analyze for the additional two DNT isomers 2,5-DNT and 3,5-DNT.

The second shortcoming of this newer method is a less stringent detection limit for DNT, which is raised from 0.010 μg/L to 0.038 μg/L. Since the Wisconsin ES for DNT is 0.05 μg/L, this places the detection limit closer to the groundwater standard, and well above the Wisconsin NR140 Preventive Action Limit (PAL) for DNT, which is 0.005 μg/L. DHFS recognizes that the Wisconsin ES is the lowest drinking water standard or guideline for DNT in the nation and pushes the limits of available technology. However, DHFS encourages the Army pursue a technical evaluation of lowering the method detection limit for DNT that will provide reliable data that has a larger margin below the Wisconsin ES for DNT, ideally closely approaching or reaching the PAL of 0.005 μg/L. In the June 2005 round of private well sampling, the detection limit was 0.013 μg/L.

<u>Other Issues Related to DNT</u>

Once low levels of DNT are removed from drinking water going into a home, no DNT residues are likely to remain inside the pipes or be detected in tap water. Between 1997 and 2005, DNT was consistently found above the Wisconsin ES in a number of private wells near the former DuPont Barksdale Works site, located in Bayfield County, Wisconsin (ATSDR 2002). Each affected home had DNT cleansed from well water by an activated carbon treatment system. In order to demonstrate the effectiveness of the treatment systems, well water was regularly tested for DNT both prior to entering and after passing though the systems. Throughout the 7 years that treatment systems were on these private wells, DNT was never detected in water samples collected from treated water inside of a home.

Table 2: Health-Based Comparison Values for Dinitrotoluene Isomers and Potential Degradation Compounds

All Concentrations in Micrograms per Liter (μg/L)

Compound	Wisconsin Groundwater Enforcement Standard (NR140)	Other Drinking Water Quality Guidelines
2,4-dinitrotoluene	0.05	70.0[a]
2,6-dinitrotoluene	0.05	37.0[c]
3,4-dinitrotoluene	n/a	n/a
2,3-dinitrotoluene	n/a	n/a
2,5-dinitrotoluene	n/a	n/a
3,5-dinitrotoluene	n/a	n/a
2-nitroaniline	n/a	110.0[d]
3-nitroaniline	n/a	330.0 [d]
4-nitroaniline	n/a	330.0 [d]
1,3-dinitrobenzene	n/a	1.0[b]
p-nitrotoluene	n/a	0.62 [d]
m-nitrotoluene	n/a	120.0 [d]
o-nitrotoluene	n/a	0.046 [d]
Nitrobenzene	n/a	3.5e

Notes: n/a - no available health-based guidance value
Source: a - ATSDR Chronic Environmental Media Evaluation Guideline
b - EPA Drinking Water Lifetime Health Advisory
c - Withdrawn EPA Reference Dose Concentration or Cancer Risk Evaluation Guideline
d - EPA Region III Provisional Health Value
e - EPA Reference Dose Value for Drinking Water

A question was raised about other chemicals that can be formed in groundwater when DNT breaks down or degrades, with a follow-up question about the health-based comparison values for each of the resulting degradation chemicals. These comparison values appear in Table 2.

When BAAP-area groundwater and private well water samples are tested for semi-volatile compounds, the standard laboratory screen looks for 60 different compounds, including certain isomers of dinitrotoluene and several potential DNT degradation products, which are: nitrobenzene; 2-nitroaniline; 3-nitroaniline; and 4-nitroaniline. None of these DNT- related degradation compounds have been found in private well water near BAAP. Research suggests that nitrobenzene and certain nitrotoluenes and dinitrobenzenes can form when DNT decomposes in the presence of sunlight or aerobic conditions (ATSDR 1998), but is unclear if these compounds occur when DNT undergoes either aerobic or anaerobic degradation in groundwater. For the compounds listed in Table 2, all are specifically targeted for in-laboratory analysis of water samples from BAAP, except for 1,3-dinitrobenzene and the three isomers of nitrotoluene. The Army's contractor informed DHFS that the presence of the other four compounds in a groundwater sample would be described in the laboratory analytical report as 'tentatively identified compound', or TIC. A review of laboratory data for private wells regularly tested in the Badger area did not find detections of these degradation compounds. DHFS is continuing discussions with the Army and other agencies about DNT degradation compounds and groundwater at BAAP.

Child Health Considerations

DHFS recognizes that children can be especially sensitive to contaminants. Children are often at greater risk than adults to certain kinds of exposure from hazardous chemicals in the environment. Children engage in activities, such as playing outdoors and hand-to-mouth behaviors, that increase their exposure to hazardous substances. Being much smaller than adults and playing on their hands and knees, children breathe air close to the ground that can have more dust, soil particles, and vapors. Children have a lower body weight, but a higher intake rate which results in a greater dose to hazardous substances per unit body weight. Also, children's bodies are developing and have permanent damage if toxic exposures are high enough during critical growth stages. For that reason, DHFS considers children as one of the most sensitive population evaluated in this health consultation, and always takes into account children when evaluating exposures to contaminants. With regard to BAAP, children have not been exposed to site-related contaminants at levels in drinking water that would be expected to cause adverse health effects.

This health consultation takes into account that children and the unborn can be more sensitive than adults to the health effects of DNT. There are no reported studies of how DNT specifically affects the health of children and the unborn because all documented human exposures were of adults who worked with high concentrations or pure forms of the chemical. Therefore, we must rely on laboratory animal studies to give us insight on how children may be more sensitive to DNT than adults. In one of the few developmental studies of animals, male and female rats were fed DNT and their offspring survived less frequently at higher doses, but a decrease in survival was not observed at a dose of 5.1 mg/kg/day. In another animal study, high DNT doses were fed to pregnant rats and adversely affected the blood and organ weights of the fetus, with a lowest observed adverse effect level (LOAEL) of 14 mg/kg/day (ATSDR 1998). This LOAEL is 1,000,000 times greater than 0.00001 mg/kg/day, which is the dose that a child would have from drinking water with DNT at 0.1 μg/L, the highest concentration detected in a private well near BAAP.

Both newborns and the unborn are more sensitive than adults to chemicals, such as DNT, that causes methemoglobinemia, such as DNT. It is well documented that DNT is reduced in the digestive tract and then oxidizes the iron in hemoglobin to form methemoglobin, which prevents the transport of oxygen by the blood. DNT-related methemoglobinemia has been observed among workers who handle pure forms of DNT and consequently receive very high DNT exposures (Jones 2005, Tchounwou 2003). When dosed with high DNT concentrations, methemoglobinemia has also been observed in many studies of laboratory animals. ATSDR's MRL for 2,4-DNT was derived from a "No Observed Adverse Effect Level" (NOAEL) of methemoglobinemia observed in a beagle study (ATSDR 1998). The ATSDR chronic MRL for 2,4-DNT is 0.002 mg/kg/day, which is equivalent to a drinking water concentration of 70 μg/L for an adult. Infants appear to be 10 times more sensitive than adults to nitrate-related methemoglobinemia and it is expected that DNT would have a similar ratio. The Wisconsin Enforcement Standard (NR140) for DNT is 0.05 μg/L, over a 1,000 times lower than the ATSDR MRL for 2,4-DNT. This strongly indicates that the Wisconsin Enforcement Standard for 2,4-DNT and 2,6-DNT is very protective of infants and the potential for DNT-induced methemoglobinemia.

Conclusions

1. Contaminants were found in a number of private wells near the Badger Army Ammunition Plant, but only six wells had contaminants at levels above a Wisconsin ES. DNT was found above the Wisconsin ES in three private wells, but currently no nearby residents are drinking water with DNT above the Wisconsin ES. Three other private wells had nitrates above the Wisconsin ES. While these levels of DNT and nitrates were slightly above their respective Wisconsin ES, the highest concentrations found in private wells are not likely to cause adverse health effects among people who may drink the water for many years, and, as a result, poses no apparent public health hazard.

2. Taking into account the current base of knowledge about all isomers of DNT, the current Wisconsin Enforcement Standard for DNT of 0.05 μg/L is protective of public health.

Recommendations

1. DHFS recommends that, as technically feasible, the laboratory methods used for analysis of groundwater and private well water samples will look for all isomers of DNT. DHFS also encourages the Army to pursue, as technically feasible, decreasing the method detection limit for DNT to levels well below the Wisconsin ES, and, ideally, closely approaching or reaching the Wisconsin PAL. This will provide a larger margin between when DNT is first found in drinking water and the Wisconsin ES.

2. DHFS supports the ongoing groundwater investigations around BAAP being conducted by the Army, and recommends the continued and regular testing of nearby private wells to ensure that the public is not being exposed to unsafe levels of DNT in drinking water.

Public Health Action Plan

1. As the Army continues to regularly monitor groundwater and private wells around BAAP, DHFS will continue to review and evaluate new drinking water test results as they become available.

2. DHFS will continue discussions with the Army and other agencies about DNT-degradation compounds and groundwater at BAAP.

3. DHFS will continue to seek out and address the health concerns of BAAP residents, in coordination with the Wisconsin DNR, the EPA, the Army, and the Sauk County Health Department.

4. DHFS will continue to consult and collaborate with the Sauk County Health Department, the Wisconsin DNR, the EPA, the Army, and interested community members on environmental health issues that might arise as any action or new information becomes available about BAAP, particularly related to ongoing results from private wells and future investigations.

5. In 2006/2007, DHFS will prepare a health consultation report on the human health implications of sediment contamination in Gruber's Grove Bay, which is located adjacent to BAAP.

Public Comments

This health consultation was released for a 30-day public comment period, from June 9 to July 9, 2006. DHFS received one set of comments at the end of this public comment period. These comments were reviewed and taken into account in preparing the final release of this health consultation. Those comments requiring a specific response appear in Appendix B.

References

Agency for Toxic Substances and Disease Registry (ATSDR). September 1992. Public Health Assessment for Cornhusker Army Ammunition Plant, Grand Island, Hall County, Nebraska. EPA Facility ID NE2213820234. Atlanta, GA: U.S. Department of Health & Human Services.

ATSDR. September 1996. Division of Health Studies. Symptom and Disease Prevalence with Biomarkers Health Study, Cornhusker Army Ammunition Plant, Hall County, Nebraska. Final Report. PB96-187760. Atlanta, GA: U.S. Department of Health and Human Services.

ATSDR. December 1998. Toxicological Profile for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene – Update. Atlanta, GA: U.S. Department of Health and Human Services.

ATSDR. May 28, 1999. Public Health Assessment for U.S. Army Badger Army Ammunition Plant, Baraboo, Sauk County, Wisconsin. Cerlis No. WI9210020054. Atlanta, GA: U.S. Department of Health and Human Services.

ATSDR. November 14, 2002. Public Health Assessment for the Former DuPont Barksdale Works, Town of Barksdale, Bayfield County, Wisconsin. Public Comment Release. Atlanta, GA: U.S. Department of Health and Human Services.

Bruning T, Chronz C, Thier R, Havelka J, Ko Y, and Bolt HM. 1999. Occurrence of Urinary Tract Tumors in Miners Highly Exposed to Dinitrotoluene. J Occup Env Med, 41(3): 145-149.

Bruning T, Thier R, and Bolt HM. 2002. Nephrotoxicity and Nephrocarcinogenicity of Dinitrotoluene: New Aspects to Be Considered. Rev Env Hlth, 17(3): 163-172.

Ellis, H.V., C.B. Hong, C.C. Lee, J.C. Dacre and J.P. Glennon. 1985. Subchronic and chronic toxicity studies of 2,4-dinitrotoluene. Part I. Beagle dogs. J Am Coll Toxicol, 4(4): 233-242.

Jones CR, Liu Y, Sepai O, Yan H, and Sabbioni G. 2005. Hemoglobin Adducts in Workers Exposed to Nitrotoluenes. Carcinogenesis, 26(1):133-143.

Levine RJ, Dragana AA, Kersteter MG, Arp EW, Sandor AB, Blunden PB, and Stanley JM. 1986. Heart Disease in Workers Exposed to Dinitrotoluene. J Occup Med, 28(9): 811-816.

National Institute for Occupational Safety and Health. July 5, 1985. Current Intelligence Bulletin 44, Dinitrotoluene. Cincinnati, OH: NIOSH. Available from URL: http://www.cdc.gov/niosh/85109_44.html.

Reader SC & Foster PM. Nov 1990. The in Vitro Effects of Four Isomers of Dinitrotoluene on Rat Sertoli and Sertoli-germ Cell Cocultures: Germ Cell Detachment and Lactate and Pyruvate Production. Toxicol Appl Pharmacol, 106(2):287-294.

Sorenson DR & Brabec M. 2003. The Response of Adult Rat Sertoli Cells, Immortalized by a Temperature-sensitive Mutant of SV40, to 1,2-Dinitrobenzene, 1,3-Dinitrobenzene, 2,4-Dinitrotoluene, 3,4-Dinitrotoluene, and Cadmium. Cell Biol Toxicol, 19(2): 107-119.

Spanggord RJ, Meyers CJ, LeValley SE, Green CE, & Tyson, CA. Nov-Dec 1990. Structure-Activity Relationship for the Intrinsic Hepatotoxicity of Dinitrotoluenes. Chem Res Toxicol, 3(6):551-558.

State of Wisconsin. February 2004. Groundwater Quality. Chapter NR 140.10, Wisconsin Administrative Code.

State of Wisconsin. 2004. Groundwater Protection Standards. Chapter 160, Wisconsin State Statutes.

Stayner LT, Tannenberg AL, Bloom T, and Thun M. 1993. Excess Hepatobiliary Cancer Mortality Among Munitions Workers Exposed to Dinitrotoluene. J Occup Med, 35(3): 291-296.

Tchounwou PB, Newsome C, Glass K, Centeno JA, Leszczynski J, Bryant J, Okoh J, Ishaque, & Brower M. 2003. Environmental Toxicology and Health Effects Associated with Dinitrotoluene Exposure. Rev on Env Hlth, 18(3):203-229.

URS Diamond Laboratory Services. November 2001. Barksdale Works, Residential Well Sampling, October 16-21, 2001. Wilmington, DE: URS Diamond.
U.S. Environmental Protection Agency (EPA). April 1992. Health Advisory for 2,4- and 2,6-Dinitrotoluene. Office of Water, Office of Science and Technology. Washington DC: EPA, 540/R-95-036. NTIS Publication No. PB95-189315.

EPA. August 22, 2002. Integrated Risk Information System (IRIS). 2,4-Dinitrotoluene (CASRN 121-14-12). Available from URL: http://www.epa.gov/iris/subst/0542.htm.

Wisconsin Department of Health and Family Services (WDHFS), Division of Public Health, Bureau of Health Information. June 2005. Wisconsin Cancer Incidence and Mortality, 1998-2002. (PPH 5328-02). Madison, WI: DHFS. Available from URL: http://dhfs.wisconsin.gov/wcrs/pdf/cainwi98-02.pdf.

WDHFS, Division of Health. Bureau of Public Health. March 1998. A Review of Cancer Mortality and Incidence for Communities Near the Badger Army Ammunition Plant. Madison, WI: DHFS.

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Certification

This Health Consultation on Dinitrotoluene in Private Wells near Badger Army Ammunition Plant was prepared by the Wisconsin Department of Health and Family Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures existing at the time the Health Consultation was begun. Editorial review was provided by the cooperative agreement partner.

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

Alan Yarborough
Team Leader
CAPEB, DHAC, ATSDR

Appendix A: Maps

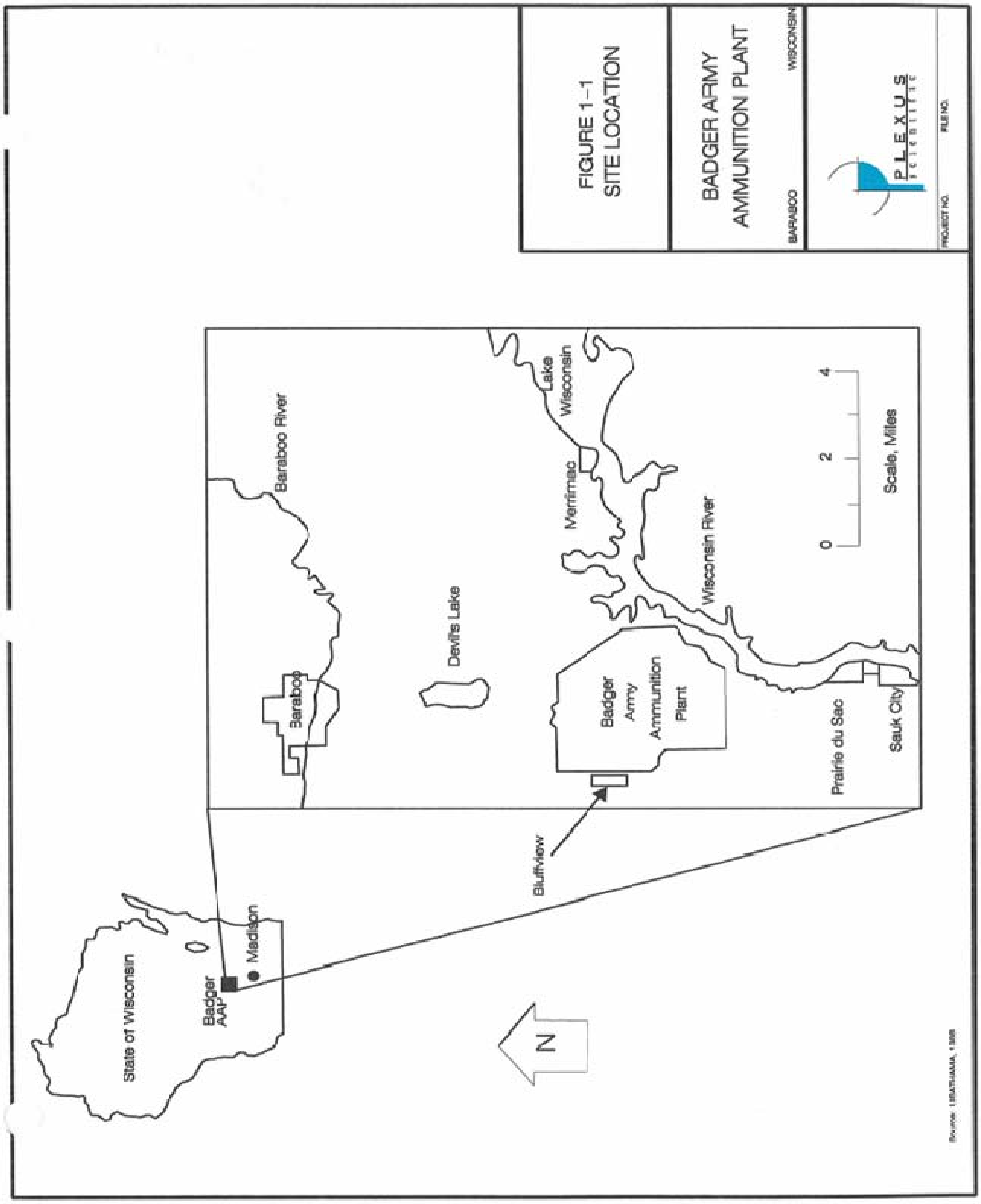

Figure 1: Badger Army Ammunition Plant Overview. (Source: Plexus Scientific Corporation. December 2004. Environmental Site Assessment, Badger Army Ammunition Plant, Baraboo, Sauk County, Wisconsin. Columbia, Maryland: Plexus.)

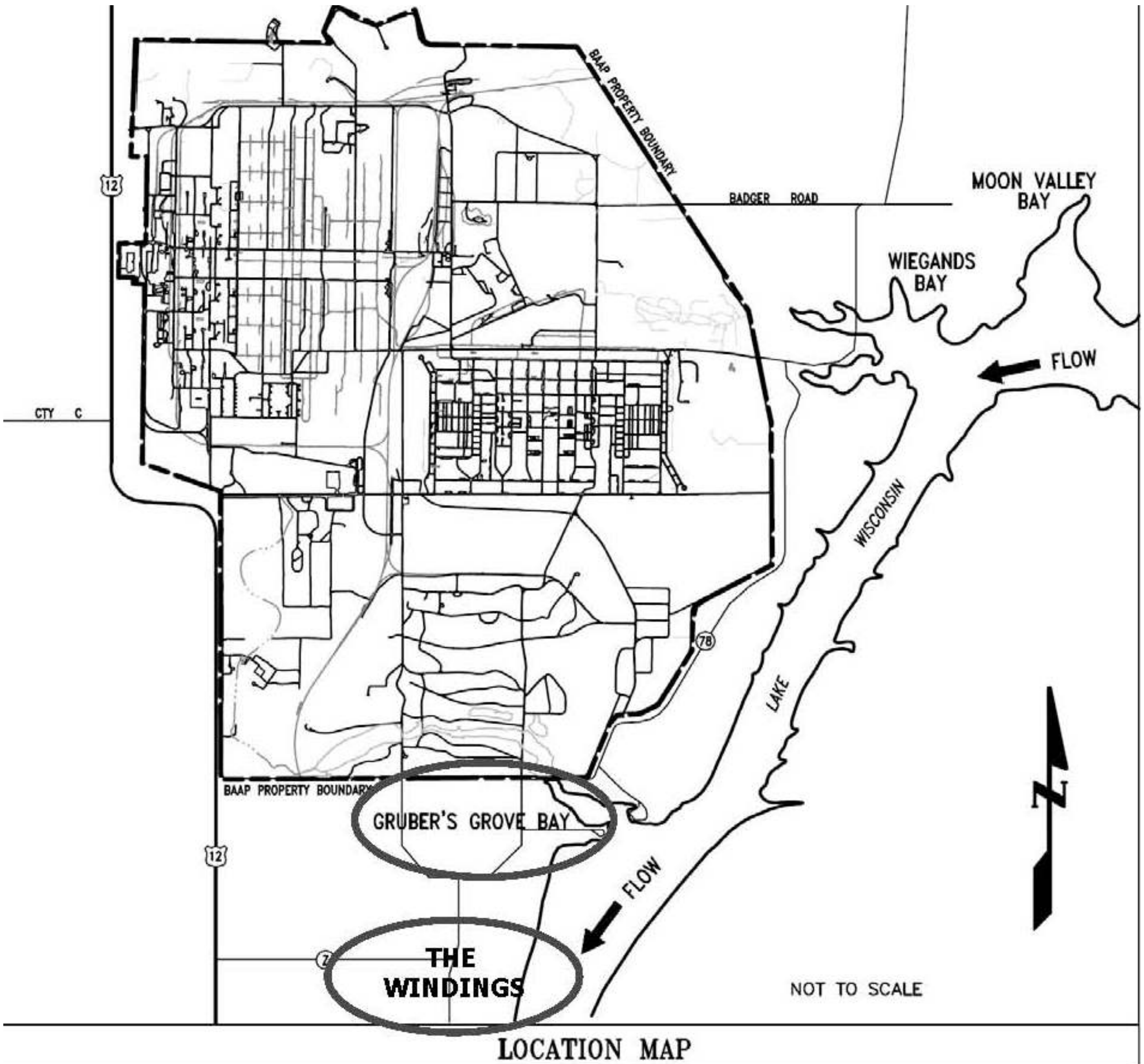

Figure 1: Badger Army Ammunition Plant. (Source: Shaw Environmental, Inc. February 9, 2005. Comprehensive Field Sampling Plan, Gruber's Grove Bay 2005 Residual Sediment Investigation. Badger Army Ammunition Plant, Baraboo, Sauk County, Wisconsin. Centennial, Colorado: Shaw)

Appendix B: Response to Public Comments

This health consultation was released for a 30-day public comment period, from June 9 to July 9, 2006. DHFS received one set of comments at the end of this public comment period. These comments were reviewed and taken into account in preparing the final release of this health consultation. The specific comments and responses appear below.

1. Comment: "Page 1, paragraph 2, fourth sentence. "DHFS supports the ongoing...testing of nearby private wells to 'prevent exposure to DNT and to' ensure people are not drinking unsafe levels of DNT. As DNT is a suspected human carcinogen, the goal must be no exposure - not limited exposure. According to ATSDR, 'for substances causing cancer (carcinogens), no safe level of exposure exists, since any exposure could result in cancer' [ATSDR, *A Toxicology Curriculum for Communities, Trainer's Manual,* September 2002, pages 16-17]. Moreover, there is NO health-based information specific to children, infants, and the human fetus so again, the goal of monitoring should be, where ever possible, ELIMINATE exposures." "Page 7, paragraph 1, last sentence. The sentence should be corrected to read: '…to ensure that the public is not being exposed to ANY level of DNT in drinking water.'"

   Response: While it is desirable to prevent or halt people from ingesting water that contains toxic chemicals, this is not always possible. Consequently, drinking water guidelines are set at levels to be protective of human health, including the most sensitive individuals. Under a process fully described in Wisc. Stat. 160 (2004), DNR has adopted NR140 Enforcement Standards (ES) for over 125 chemicals that "provide adequate safeguards for public health." When determining the ES for a carcinogen with no other established drinking water guidelines, such as 2,4- and 2,6-dinitrotoluene, Wisc. Stat. 160 requires the ES be based on a cancer risk level of 1-in-1,000,000, which is an "acceptable probability of risk." The use of a 1-in-1,000,000 risk level for setting an acceptable drinking water standards for carcinogens is also uniformly used by other state and federal agencies. As illustrated by the section "Toxicological Implications of DNT", the Wisconsin Enforcement Standards are designed to provide safeguards and to be protective of public health and welfare when people are using groundwater as their primary source of a drinking water.

2. Comment: "Page 9, Cancer and DNT. The 1990 WDOH study found elevated rates of male ureter/kidney cancers in populations near Badger."

   Response: The 1990 review of cancer did find an elevated number of deaths than expected in the BAAP area for male kidney/ureter cancer and female non-Hodgkin's lymphoma. However, in a 1998 follow-up report by DHFS, the 1990 data was updated and re-analyzed and no cancers were found to be elevated in populations near BAAP, including ureter and kidney cancers. More detailed information can be obtained from this 1998 DHFS report.

3. Comment: "The report should include specific recommendations for monitoring private wells for associated degradation products of DNT, especially as they may result in a synergistic or additive health effect. Toxicity of DNT Isomers. This section does not discuss the toxicity of potential degradation compounds, yet Table 2 suggests several of these may be more toxic than the parent product, DNT. **This appears to be a serious omission.**" "Recommendation addition of Item 3. DHFS fails to recommend testing of private wells and monitoring wells for products listed in Table 2. **This appears to be a serious omission**."

Response: The following text was added to the discussion related to DNT degradation compounds: "For the compounds listed in Table 2, all are specifically targeted for in laboratory analysis of water samples from BAAP, except for 1,3-dinitrobenzene and the three isomers of nitrotoluene. The Army's contractor informed DHFS that the presence of the other four compounds in a groundwater sample would be described in the laboratory analytical report is as 'tentatively identified compound', or TIC. A review of laboratory data for private wells regularly tested in the Badger-area did not find detections of these degradation compounds." Since these DNT degradation compounds are either specifically targeted for or appear as tentatively identified compounds in laboratory analysis of water samples, at this time DHFS does not recommend making changes to the laboratory analytical parameters.

In response to the recommendations comment, the following text was added to action items section: "DHFS will continue discussions with the Army and other agencies about DNT-degradation compounds and groundwater at BAAP."