Health Consultation

ARSENIC IN WIND LAKE PRIVATE WELLS
TOWN OF NORWAY, RACINE COUNTY, WISCONSIN

Prepared by the
Wisconsin Department of Health Services

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Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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Summary and Statement of Issues

The Wisconsin Division of Public Health (DPH), Department of Health Services, was contacted by the Wisconsin Department of Natural Resources (DNR) and the Western Racine County Health Department (WRCHD) regarding well water serving a school and daycare in the Town of Norway, Racine County, containing elevated levels of naturally occurring arsenic. DPH conducted a coordinated response with DNR and WRCHD to investigate private wells in the area. DPH made free water testing available for fourteen metals (including arsenic) to 121 area homes served by private wells. The 121 homes are located near the school and daycare that have a history of arsenic in the well water.

Seventy area residents submitted water samples for analysis; 22 of those samples had elevated levels of arsenic, ten had elevated levels of lead, and four had elevated levels of copper. DPH categorized drinking water exposures from a total of 26 residential wells as *"a public health hazard"* due to high levels of arsenic, copper or lead. DPH recommended that the Wind Lake area residents with elevated levels of metals take actions to obtain an alternative safe source of drinking water. DPH held a public meeting on November 11, 2008, and discussed the results with area residents. DPH is currently working with DNR and WRCHD to ensure interested residents find available options to obtain a safe supply of drinking water. In addition, DPH is working to increase awareness of the need to test the well water in this area.

Background

In July 2008, DNR and the WRCHD contacted DPH regarding elevated levels of arsenic in groundwater in the Wind Lake area of the Town of Norway, Racine County. In particular, elevated levels of arsenic had regularly been detected in two public drinking water wells that serve a Wind Lake public school and privately operated daycare center. Since 1990, the Lakeview School, at 26335 Fries Lane, has regularly had arsenic levels in its drinking water well ranging from 18 to 24 μg/L (micrograms per liter). This is above the Wisconsin Public Health Groundwater Quality Enforcement Standard (ES) of 10 μg/L for arsenic (Wisconsin Administrative Code NR 140). For the Lots for Tots Day Care Center, 7345 South Loomis Road, well water tests since 1995 have detected arsenic ranging from 10 to 32 μg/L. In January 2006, the U.S. Environmental Protection Agency (EPA) lowered the maximum level of arsenic allowed in public water supplies from 50 to 10 μg/L, and shortly afterwards, DNR revised the Wisconsin ES in accordance with the EPA.

In the Wind Lake area, once it was confirmed that the arsenic level exceeded 10 μg/L at each of the facilities, students and staff were provided with bottled drinking water and quarterly public notification of the problem status. Each facility is currently engaged in remediation planning with the DNR.

Elevated arsenic levels in well water at the school and day care appear to come from a natural geological source. These wells are located approximately one-third of a mile apart. No apparent industrial, commercial, agricultural or other anthropogenic sources for arsenic have been identified in the Wind Lake area. Bahr et al. (2004) showed that in southeastern Wisconsin approximately 10 percent of wells that draw groundwater from specific hydrogeological

formations are expected to have arsenic levels that exceed 10µg/L. Despite this, a number of data gaps exist regarding the number of private wells in southeastern Wisconsin that draw drinking water from these formations and have elevated arsenic levels.

Due to elevated arsenic levels in well water at the school and day care center, concerns were raised that similar arsenic levels may be found in other wells that supply drinking water in the greater Wind Lake area. Wind Lake is an unincorporated community of 5,202, but, according to the U.S. Census (2000), has a population and housing density that is more similar to nearby villages than other rural towns in western Racine County. Despite these community characteristics, the Wind Lake area is not served by a public drinking water system or utility, and the primary source of drinking water for area homes and businesses is from private wells. If 10 percent of area wells are over the ES for arsenic, an estimated 500 people could be affected. Based on the possibility that some Wind Lake residents may have unknowingly been drinking well water with arsenic levels above the drinking water standard, WRCHD, DNR and DPH collaborated to investigate the occurrence of metals in private wells in the immediate vicinity of the school and day care center.

Methods

The Town of Norway identified 121 private wells in Wind Lake within one-quarter mile of the school or daycare. DPH funded testing costs for the 121 residents using the Wisconsin State Laboratory of Hygiene (SLH) in Madison, Wisconsin. On September 2, 2008, WRCHD sent letters to these 121 property owners inviting their participation in a study of arsenic in private well water. The inorganic water sample kits were made available through the nearby offices of the Town of Norway. Residents were asked to collect a water sample from a sampling tap upstream of any water treatment devices in their homes and after the well had been thoroughly purged.

All samples were analyzed by SLH using inductively coupled plasma-atomic emission spectrometry (EPA Method 200.7), for trace elements in water. Samples were also analyzed for turbidity by standard method 2130B.

Results

Twenty-five residents from within one-quarter mile of both the public school and daycare submitted samples for analysis. Nearly 50% (12 of 25) of these samples contained arsenic levels above the ES. After holding a public meeting to discuss and publicize the issue, the remaining free test kits were made available to any interested resident in the Wind Lake area. Between September and December, an additional 45 area residents submitted samples for analysis. All results were reported to property owners in letters from DPH. The SLH analyzed a total of 92 samples from 70 different private wells.

The analytical results for water samples found 22 of 70 (31%) wells with arsenic levels at or above the ES of 10 µg/L (Table 1). The arsenic concentrations found in well water at or above the ES ranged from 10 to 27 µg/L. In addition to arsenic, water from 10 wells had lead at levels above the ES of 15 µg/L. Water from four wells had copper at a level above the ES of 1,300

µg/L; the highest being 38,600 µg/L. Although Wisconsin does not currently have an ES for aluminum, the water test results of two wells indicated aluminum levels above the Wisconsin's Interim Health Advisory Level (HAL) of 180 µg/L. Well water results from two wells also reported exceedances of the ES for cadmium, manganese, and nickel.

Table 1: Wind Lake Private Well Testing
Comparison Value Exceedances
September to November 2008
All units in micrograms per liter (µg/L)

Metal	Range Detected µg/L	Laboratory Reporting Limit	Frequency of Detection	Comparison Value µg/L	Number ≥ Comparison Value
Arsenic	nd – 27*	5	33/70	10[1]	22
Lead	nd – 1,780*	3	21/70	15[1]	10
Copper	nd – 38,600*	2	58/70	1,300[1]	4
Aluminum	nd – 316*	3	56/70	180[2]	2
Cadmium	nd – 16*	0.5	2/70	5[1]	1
Manganese	nd – 1,190*	0.5	63/70	300[3]	1
Nickel	nd – 43*	1	14/70	40[4]	1
Chromium	nd – 7	1	3/70	100[4]	0
Cobalt	nd – 9	1	4/70	40[4]	0
Vanadium	nd – 4	1	14/70	30[4]	0

Notes: nd – not detected
– exceeds ES or Health Advisory Level
[1] DNR ES and US EPA maximum contaminant level (MCL)
[2] DPH Interim Health Advisory Level
[3] EPA Health Advisory Level
[4] DNR ES

Metals analyzed by SLH but without known adverse health affects are listed in Table 2. Some of these metals have secondary Public Welfare[1] standards. Nearly all of the Wind Lake area wells exceed one or more of these Public Welfare standards. The area residents commonly have problems with staining of laundry and plumbing fixtures and the water may have an off-taste or offensive odor. Often it is these noticeable problems with their water that drive well owners to seek treatment or an alternative source for drinking water.

1 Wisconsin's Public Welfare standards for groundwater quality are set based on taste, appearance or staining problems, and do not have any adverse health effects associated with them. While there are no standards for calcium or magnesium, these are often tested for in groundwater as high levels can give an indication that there may be something unusual occurring in groundwater.

Table 2: Wind Lake Private Well Testing
Public Welfare Level Exceedances
September to November 2008
All units in micrograms per liter (µg/L)

Metal	Range Detected µg/L	Laboratory Reporting Limit	Frequency of Detection	Public Welfare Level	Number ≥ Public Welfare
Iron	nd – 313,000*	100	59/70	300	49
Manganese	nd – 1,190*	0.5	63/70	50	16
Zinc	nd – 8,270*	1	66/70	5,000	2
Calcium	nd – 141,000	100	61/70	None	n/a
Magnesium	nd – 70,900	100	66/70	None	n/a

Notes: n/a – not available
nd – not detected
* – exceeds Public Welfare Standard

Discussion

Based on the possibility that some Wind Lake residents may have unknowingly been using well water with arsenic levels above the drinking water standard, WRCHD, DNR and DPH collaborated to investigate private wells in the immediate vicinity of the school and day care center. The results of the testing showed that 31 of 70 area wells had levels of metals including arsenic, lead, copper, aluminum, cadmium, manganese or nickel, above their respective ES or advisory level. The results for each metal, the potential adverse health effects, and the number of completed exposure pathways are discussed in greater detail by metal below.

DPH sent individualized results letters to all the participants in this study. These contained advice and information specific to the metals found in their water. It is DNR and DPH policy to advise any private well owner with an exceedance of an ES or advisory level to seek an alternative source of safe drinking water. DPH is also working with DNR to ensure interested residents determine the best available options to obtain a safe supply of drinking water. In consultation with the DNR, the results of this study paired with sub-surface geologic information indicate the presence of geologic formations containing groundwater without elevated levels of metals that is accessible in some, but not all locations in the Wind Lake area.

In summary, DPH found that residents served by 26 of 70 (37%) Wind Lake area private wells were being exposed to arsenic, lead, and copper at levels associated with possible long-term health effects (e.g., certain cancers, gastrointestinal tract problems, and nervous system effects for arsenic, copper, and lead). However, most area wells remain un-tested. If the remaining un-tested wells in the Wind Lake area have similar levels of these metals at the same frequency found to date, an estimated additional 2,000 area residents may be consuming drinking water containing metals at levels associated with possible long-term health effects. Residents served

by 39 of 70 Wind Lake area residential wells used for drinking water contained low levels of metals with known adverse health effects.

The process of establishing the Wisconsin ES and the EPA Maximum Contaminant Levels for Drinking Water (MCLs) incorporates many factors, including human health effects. Peer-reviewed science and data support an intensive technological evaluation, which includes many factors. The factors include: occurrence in the environment; human exposure and risks of adverse health effects in the general population and sensitive subpopulations; analytical methods of detection; technical feasibility; and impacts of regulation on water systems, the economy and public health. Thus, while all drinking water standards are intended to protect human health, standards vary in the amount of cushion between the established standard and expected adverse health effects.

Arsenic

Of the 70 residential wells tested, the water of 22 wells had an inorganic arsenic level that exceeded the ES of 10 µg/L. Further testing revealed that three owners had treatment systems that were successful in lowering the arsenic concentration in the water used for drinking and cooking to a non-detect level. When contacted, DPH learned that one of the residences was not utilizing the water for drinking or cooking due to aesthetic problems with the water. Since no exposure is currently occurring for these four residences, DPH classified these four water supplies as "*no public health hazard.*" However, this could change if the treatment systems fail or future owners are not made aware of the problems with the well water and discontinue the use of the treatment systems. The health effects of arsenic and the remaining 18 residential wells with arsenic levels above the ES are discussed further below.

The ES is typically a threshold which stops drinking water consumption at levels well below those known to cause adverse health effects. However, for arsenic, population studies indicate that long-term exposure to arsenic in drinking water at levels near the ES is associated with adverse health effects. While DPH always recommends that people reduce or halt their exposure to drinking water with a contaminant at or above its ES, arsenic is of special concern. The levels found in the remaining 18 wells are associated with an unacceptable risk of long-term health effects (e.g., certain cancers). The exposures from these wells, therefore, poses a "*public health hazard.*"

Consumption of inorganic arsenic can cause many adverse health effects and long-term exposure to elevated arsenic levels in drinking water is known to increase risks of skin, bladder, lung, liver, colon, and kidney cancer (ATSDR 2007a). Inorganic arsenic has long been recognized as a human poison, and very large oral doses (above 60,000 µg/L) can result in death. Arsenic has been extensively studied and many other adverse health effects, including blood vessel damage, high blood pressure, nerve damage, anemia, and skin changes are known to be associated with the ingestion of inorganic arsenic. Drinking water containing arsenic between 300 and 30,000 µg/L can cause stomach ache, nausea, vomiting and diarrhea. Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles of feet and torso. In addition, certain skin cancers have been linked to long-term exposures of arsenic in drinking water. Oral exposure data from population studies indicate that

these lesions typically begin to manifest at arsenic exposure levels between 0.002 and 0.02 mg/kg/day (roughly 70 to 700 μg/L in drinking water, for an adult).

The relationship between arsenic exposure and other health effects is less clear. Some recent studies have linked arsenic with Type 2 diabetes mellitus. In a study of US adults exposed to arsenic in drinking water, Navas-Acien (2008) found that after adjusting for biomarkers of seafood intake, total urine arsenic was associated with an increased prevalence of type 2 diabetes. Coronado-González (2007) conducted a case-control study in Mexico of 400 participants whose drinking water sources contained 20-400 μg/L inorganic arsenic. Inorganic arsenic exposure was measured through total arsenic concentration in urine and subjects with intermediate total exposure had a two-fold increased risk of diabetes. Subjects with higher exposure had nearly a three fold increased risk. The authors believe this data provides additional evidence that inorganic arsenic exposure may cause Type 2 diabetes. Wang et al. (2008), studied villagers in an arsenic-endemic area China and a nearby control site. They found an association between arsenic exposures and increased urinary NAG (*N*-acetyl-β-glucosaminidase). Increased NAG levels in the urine are an early indication of renal disease.

EPA has classified inorganic arsenic as a "human carcinogen" based on sufficient evidence from a number of human studies, including an increased incidence of skin cancer observed among populations drinking water with high levels of inorganic arsenic. In evaluating the human carcinogenic potential of ingesting inorganic arsenic, the EPA has calculated a drinking water unit risk of $5x10^{-5}(\mu g/L)^{-1}$(EPA 1995). The drinking water unit risk is intended as an upper bound estimate of the increased cancer risk of consuming water containing 1 μg/L of arsenic for a lifetime. The unit risk, based on skin cancer, of $5x10^{-5}(\mu g/L)^{-1}$ translates to an upper bound estimate of 50 excess skin cancers per 1,000,000 in population. For people consuming drinking water with 20 μg/L of arsenic for a lifetime, an upper bound of the excess cancer risk would be 1,000 excess cancers per 1,000,000 in population (or 1 per 1000). A study of the health outcomes of more than 2,000 Wisconsin families exposed to inorganic arsenic through their private wells was conducted by DPH in 2002 (Knobeloch 2002). Skin cancer rates were highest among people who had had long-term exposure to arsenic-contaminated water and who also smoked cigarettes. This combined effect of arsenic from water and cigarette use was slightly more than additive.

The EPA drinking water unit risk for arsenic is currently under re-assessment. The re-assessment began in 2003 and may be completed by the end of 2009. The National Research Council (NRC) was asked by the EPA's Office of Water to independently review studies on the health effects of arsenic published since the previous NRC report in 1999 (NRC 2001). The NRC Subcommittee to Update the 1999 Arsenic in Drinking Water Report, performed an evaluation and analysis of the data from south-western Taiwan. The subcommittee's review indicated that the lifetime excess cancer risks in the US for bladder and lung cancers combined, at arsenic concentrations in drinking water between 3 and 20 μg/L, are estimated to be between 9 and 72 per 10,000 people based on US background cancer incidence data. Since the levels of arsenic-contaminated water being consumed in drinking water by 18 of the Wind Lake area residences represents an approximate 1-in-1000 to 7 -in- 1000 theoretical excess lifetime risk of bladder and lung cancer and may cause other adverse health effects at the levels being consumed, DPH has categorized these 18 resident's water as *"a public health hazard."*

Lead
Ten water samples collected from private residences in the Wind Lake study contained levels of lead above the ES. When contacted, DPH learned that the residences with the two highest levels of lead in water (1,780 and 664 µg/L) were not consuming their water. Therefore, no exposure to lead via drinking water had occurred for those two residences. Since no exposure had occurred, DPH classified these two residential water supplies as "*no public health hazard*" for the current owners. However, this could change if future owners are not made aware of the problems with the well water.

Lead is a naturally occurring toxic metal. It may be found in its pure form or in combination with other minerals. Lead has no nutritional value, but is very valuable in manufacturing. In industry, lead is used in the production of batteries, solder, paints, ammunition, sheet metal, and other metal alloys. Lead is often found in house paint sold before 1978. Since 1978, paint sold for residential use can contain no more than 600 parts per million lead. Most lead is now used to manufacture car batteries. Other lead sources include bullets, fishing weights, curtain weights, some glazed ceramics, and plumbing solders made before 1986.

Lead is a well known developmental neurotoxin, and also affects the kidneys, blood formation, reproduction, humoral immunity, and the peripheral nervous system (ATSDR 2007b). Long-term lead exposure for working adults is associated with decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead may also cause anemia. In pregnant women, high levels of exposure to lead may cause miscarriage. According to ATSDR there is no conclusive proof that lead causes cancer, however both the U.S. Department of Heath and Human Services and EPA have determined that lead is a probable human carcinogen. Children are more sensitive to the effects of lead than adults, and studies show that even low lead levels that do not affect adults can be detrimental to a child's cognitive development. The current ES for lead was set at 15 µg/L to be protective of children. Since the levels being consumed by 8 of the area residences was above the ES and no safe level of lead exposure has been determined, DPH has categorized these 8 resident's water as *"a public health hazard."*

Copper
Four water samples collected in the Wind Lake study detected levels of copper above the ES. The source of copper in the residents' water is likely from the copper pipes or plumbing fixtures in the home. When contacted, DPH learned that three of the residences were not utilizing the water for drinking or cooking due to aesthetic problems with the water. Therefore no exposure to copper via drinking water was occurring for those three residences. Since no exposure was occurring, DPH classified these three residential water supplies as "*no public health hazard*" for the current owners. However, this could change if future owners are not made aware of the problems with the well water.

Copper is a common element found in food and water sources and trace amounts are required in human diet because it is an essential nutrient in enzyme function and metabolism. However, animal and human studies found that exposures to excess copper in drinking water results in gastrointestinal distress and further, that copper concentrations as low as 3,100 µg/L in drinking

water can cause gastrointestinal effects in people. These studies suggest that the gastrointestinal tract is the most sensitive organ system to elevated levels of copper. Episodes of nausea, vomiting, stomach cramps, diarrhea and abdominal pain have been reported shortly after drinking water with elevated copper. Long-term, excessive exposure to copper has also been linked to liver and kidney damage. The current ES of 1,300 µg/L is intended to protect against the adverse health outcomes associated with exposure to copper-contaminated drinking water but assumes normal dietary copper intake (ATSDR 2004). The Wind Lake residential well owner was consuming water that contained copper at 1740 µg/L. Since this level is near the level known to cause short-term gastrointestinal effects in some people, and may also have adverse long-term effects, DPH has categorized this resident's water as *"a public health hazard."*

Aluminum

Laboratory analyses of samples collected in the Wind Lake study detected an elevated level of aluminum in the well water of two residences. When contacted, one resident was not cooking or drinking the water because of other aesthetic concerns about their water, so no exposure to aluminum via drinking water was occurring for one of the residences. Since no exposure was occurring, DPH classified this residential water supply as "*no public health hazard"* for the current owners. However, this could change if future owners are not made aware of the problems with the well water.

Chronic exposure to aluminum can result in an accumulation in the body over time. Long-term oral exposure to high-levels of aluminum has been associated with reduced kidney function and neurodegenerative effects in humans, though there is limited data that can be generalized for the population as a whole. Animal studies of oral exposure to aluminum indicate that the nervous system is the most sensitive target of aluminum toxicity. In some studies, exposure to elevated aluminum levels in drinking water has been positively associated with the prevalence of Alzheimer's disease. However, the data to date are not sufficient to suggest that aluminum is a causative factor for Alzheimer's disease but aluminum may play a role in the development of this disease. DPH has issued an Interim health advisory level of 180 µg/L based on an assessment of the level at which aluminum begins to measurably bioaccumulate in the body, but the level of 316 µg/L is not likely to result in other adverse health effects (ATSDR 2006). Therefore, DPH has categorized the residential well owner who is consuming the water containing aluminum as *"no apparent public health hazard."*

Cadmium, Manganese and Nickel

The well water of two residential wells sampled as part of this study was responsible for the cadmium, manganese and nickel exceedances of the ES. However, when contacted, neither owner was utilizing the well water for drinking or cooking purposes. The owners were not consuming their water because of noticeable aesthetic problems with the water. Since no exposure was occurring, DPH classified these wells as "*no public health hazard"* for the current owners. However, this could change if future owners are not made aware of the problems with the well water.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight, higher intake rate and faster metabolism results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

Arsenic

Children are exposed to arsenic in many of the same ways that adults are. Since children tend to eat or drink less of a variety of foods and beverages than do adults, ingestion of contaminated food or juice or infant formula made with arsenic-contaminated water may represent a significant source of exposure. Children who are exposed to inorganic arsenic may exhibit many of the same adverse health effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Prenatal and early childhood exposures to arsenic can increase the risk of lung cancer and respiratory disease in later life. There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults. There is also some evidence that suggests that long-term exposure to inorganic arsenic may result in lower IQ scores (see Appendix 1, for a child-specific public health statement).

Lead

Children are more sensitive to the health effects of lead than adults. No safe blood lead level in children has been determined. Lead affects children in different ways depending on the level of exposure. High levels of lead exposure may increase the risk of children developing anemia, kidney damage, colic, muscle weakness, and brain damage. Lower levels of lead exposure may affect development, and behavior and even lower levels of lead exposure can affect a child's cognitive abilities and physical growth. Fetal exposure to lead is associated with premature birth and low birth weight. Fetal and early childhood exposure to lead has also been linked to decreased cognitive development and reduced intelligence in early childhood, and evidence suggests that these effects may persist into adulthood (see Appendix 2, for a child-specific public health statement).

Copper

Similar to the adverse health outcomes reported in adults, children exposed to excess levels of copper may experience gastrointestinal distress. Some studies suggest that infants and children may be more sensitive to the gastrointestinal effects of copper than are adults due to differences in metabolism. For children who have a certain genetic susceptibility, exposure to excess copper is linked to two syndromes characterized by liver damage, Indian childhood cirrhosis and idiopathic copper toxicosis. We do not know if copper can cause birth defects or other

developmental effects in humans. Animal studies suggest that ingestion of high levels of copper may cause a decrease in fetal growth.

Conclusions

- Residents served by 26 (37% of tested wells) Wind Lake area private wells were identified as being exposed to arsenic, lead, or copper at levels associated with possible long-term health effects (e.g., certain cancers, gastrointestinal tract problems, and nervous system effects for arsenic, copper, and lead). DPH has therefore classified the exposures from these wells as "*a public health hazard.*"

- Many area wells remain un-tested. Consequently, DPH is unable to evaluate all of the potential pathways via area residential wells and classifies the un-sampled wells as an "*indeterminate public health hazard.*" If the remaining un-tested wells in the Wind Lake area have problems with these metals at the same frequency found to date, an estimated additional 2000 area residents may be consuming drinking water containing metals at levels associated with possible long-term health effects.

- Residents served by 44 (63% of tested wells) Wind Lake area residential wells used for drinking water contained low levels of metals. DPH concludes that although some exposure is occurring as a result of the metals in drinking water, the exposures are not at levels likely to cause adverse health effects and thus do no not pose a public hazard. Because of the exposure to low levels of some metals, DPH has classified these residential wells as "*no apparent public health hazard.*"

Recommendations

- DPH recommends that well owners with elevated levels of metals discuss their well test results with their health care providers and have their exposure history recorded in their medical record.
- DPH recommends that well owners with elevated levels of metals take actions to obtain a safe source of drinking water.
- Follow-up testing should be done to ensure that the measures taken result in a safe source of water.
- DPH recommends encouraging well owners in the greater Wind Lake area to have their well water sampled for metals at least once in addition to yearly tests for nitrates and bacteria.

Public Health Action Plan

- DPH sent individualized results letters to all the participants in this study containing advice and information specific to the metals found in their water.
- DPH held an informational meeting on November 11, 2008, on the results of the study. Staff from the DNR, WRCHD, and DPH presented information on the test results; options for residents affected by high levels of arsenic and other metals in their wells, and answered questions about health effects of arsenic and other metals.
- DPH is also working with DNR to ensure interested residents determine the best available options to obtain a safe supply of drinking water.
- DPH will develop and provide residents with an arsenic in drinking water information packet they can share with their health care provider.
- DPH will continue to communicate and collaborate with the staff at the DNR and WRCHD to address public health questions and concerns relating to arsenic in well water.
- DPH will continue to promote the awareness among area residents of the need to test their private wells due to the presence of metals, including arsenic in groundwater.
- DPH will continue to offer free metals testing to Wind Lake area residents who request it.

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Appendix 1. How can arsenic affect children? A public health statement from the Agency for Toxic Substances and Disease Registry's *Toxicological Profile for Arsenic* (ATSDR 2007).

1.6 HOW CAN ARSENIC AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Children are exposed to arsenic in many of the same ways that adults are. Since arsenic is found in the soil, water, food, and air, children may take in arsenic in the air they breathe, the water they drink, and the food they eat. Since children tend to eat or drink less of a variety of foods and beverages than do adults, ingestion of contaminated food or juice or infant formula made with arsenic-contaminated water may represent a significant source of exposure. In addition, since children often play in the soil and put their hands in their mouths and sometimes intentionally eat soil, ingestion of contaminated soil may be a more important source of arsenic exposure for children than for adults. In areas of the United States where natural levels of arsenic in the soil and water are high, or in areas in and around contaminated waste sites, exposure of children to arsenic through ingestion of soil and water may be significant. In addition, contact with adults who are wearing clothes contaminated with arsenic (e.g., with dust from copper- or lead-smelting factories, from wood-treating or pesticide application, or from arsenic-treated wood) could be a source of exposure. Because of the tendency of children to taste things that they find, accidental poisoning from ingestion of pesticides is also a possibility. Thus, although most of the exposure pathways for children are the same as those for adults, children may be at a higher risk of exposure because of normal hand-to-mouth activity.

Children who are exposed to inorganic arsenic may have many of the same effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Thus, all health effects observed in adults are of potential concern in children. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. We do not know if absorption of inorganic arsenic from the gut in children differs from adults. There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults.

There is some evidence that inhaled or ingested inorganic arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of inorganic arsenic that cause illness in pregnant females can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

In animals, exposure to organic arsenic compounds can cause low birth weight, fetal malformations, and fetal deaths. The dose levels that cause these effects also result in effects in the mothers.

Appendix 2. How can lead affect children? A public health statement from the Agency for Toxic Substances and Disease Registry's *Toxicological Profile for Lead* (ATSDR 2007).

1.6 HOW CAN LEAD AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Studies carried out by the Centers for Disease Control and Prevention (CDC) show that the levels of lead in the blood of U.S. children have been getting lower and lower. This result is because lead is banned from gasoline, residential paint, and solder used for food cans and water pipes. However, about 310,000 U.S. children between the ages of 1 and 5 years are believed to have blood lead levels equal or greater than 10 μg/dL, the level targeted for elimination among young children in the Unites States by 2010.

Children are more vulnerable to lead poisoning than adults. Children are exposed to lead all through their lives. They can be exposed to lead in the womb if their mothers have lead in their bodies. Babies can swallow lead when they breast feed, or eat other foods, and drink water that contains lead. Babies and children can swallow and breathe lead in dirt, dust, or sand while they play on the floor or ground. These activities make it easier for children to be exposed to lead than adults. The dirt or dust on their hands, toys, and other items may have lead particles in it.
In some cases, children swallow nonfood items such as paint chips; these may contain very large amounts of lead, particularly in and around older houses that were painted with lead-based paint. The paint in these houses often chips off and mixes with dust and dirt. Some old paint contains as much as 50% lead. Also, compared with adults, a bigger proportion of the amount of lead swallowed will enter the blood in children.

Children are more sensitive to the health effects of lead than adults. No safe blood lead level in children has been determined. Lead affects children in different ways depending on how much lead a child swallows. A child who swallows large amounts of lead may develop anemia, kidney damage, colic (severe "stomach ache"), muscle weakness, and brain damage, which ultimately can kill the child. In some cases, the amount of lead in the child's body can be lowered by giving the child certain drugs that help eliminate lead from the body. If a child swallows smaller amounts of lead, such as dust containing lead from paint, much less severe but still important effects on blood, development, and behavior may occur. In this case, recovery is likely once the child is removed from the source of lead exposure, but there is no guarantee that the child will completely avoid all long-term consequences of lead exposure. At still lower levels of exposure, lead can affect a child's mental and physical growth. Fetuses exposed to lead in the womb, because their mothers had a lot of lead in their bodies, may be born prematurely and have lower weights at birth. Exposure in the womb, in infancy, or in early childhood also may slow mental development and cause lower intelligence later in childhood. There is evidence that these effects may persist beyond childhood.

Children with high blood lead levels do not have specific symptoms. However, health workers can find out whether a child may have been exposed to harmful levels of lead by taking a blood

sample. They can also find out how much lead is in a child's bones by taking a special type of x-ray of the finger, knee, or elbow. This type of test, however, is not routine.

CERTIFICATION

This Health Consultation for Arsenic in Wind Lake Private Wells was prepared by the Wisconsin Department of Health 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 completed by the Cooperative Agreement partner.

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

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