Health Consultation

Emergency response to lead poisoning of cattle and potential human exposures

BERTHA, MN

BERTHA, TODD COUNTY, MINNESOTA

SEPTEMBER 18, 2007

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

Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

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Prepared By:

The Minnesota Department of Health
Environmental Health Program
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

FOREWORD

This document summarizes health concerns about lead and arsenic exposure at a farm in Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

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

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

! *Developing recommendations:* In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.

! *Soliciting community input*: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

Please write to: Community Relations Coordinator
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OR call us at: (651) 201-4897 *or* 1-800-657-3908
(toll free call - press "4" on your touch tone phone)

On the web: http://www.health.state.mn.us/divs/eh/hazardous/index.htmls

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Summary

Seven cattle, from a herd of about 20, in central Minnesota died of lead poisoning. Prior to a site visit, the source of the lead was not known. The residents of the farm consume milk from a cow in the herd. In addition, the residents consume, almost exclusively, produce and meats grown on their own and neighboring farms. The farm has a new well that showed marginally elevated lead and arsenic concentrations. At least one member of the family complained of diarrhea, and the children complained of headaches.

During the site visit it was determined that old, broken lead-acid batteries were the source of the lead poisoning. Direct exposure of the family to the lead from the batteries was unlikely, but cows' milk was a potential route of exposure. Lead concentrations in well water samples drawn during the site visit were lower than those of previous samples and decreased with flushing. Therefore, it is likely that the lead in the water is from particulates in the new well and will decrease with use or flushing. Arsenic concentrations in well water exceed the U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL). Therefore, the Minnesota Department of Health (MDH) recommends that water from this well not be used for drinking or cooking. Arsenic in the well water is likely natural. Treatment or alternate sources of drinking water are recommended.

Blood lead samples from the residents were below levels of concern. However, there were very high levels of lead in milk from a dairy cow and it is expected that tissue concentrations from some individual cattle in this herd are also likely to be elevated above levels of concern. It is expected that blood lead levels in poisoned cattle may remain above normal concentrations (less than 100 micrograms per liter (mg/L); Checkley et al. 2002) for 6 to 12 months or more. Therefore, cattle should be monitored individually to assure that blood lead levels are normal before meat or milk from the animals are consumed. Milk or meat consumed by people, repeatedly over a long period of time, should have lead concentrations at or below 15 μg/L and 75 μg/kg, respectively.

Introduction

Lead poisoning of cattle in the Midwest is not uncommon, with one survey in Iowa showing 80 episodes over less than a 5-year period (Osweiler et al. 1973). Most of the poisonings occur in the spring and early summer when the animals are looking for salts and minerals, or as a result of indiscriminate licking (Osweiler et al. 1973; Blakley and Brockman 1976; Yonge and Morden 1989; Checkley et al. 2002). Cattle may lick or consume many materials containing lead, but most frequently, poisoning occurs when cattle have access to lead paint, lead-acid battery plates or used motor oil. Lead poisoning in cattle can result in severe central nervous system effects, blindness and gastrointestinal dysfunction (Baker 1987; Checkley et al. 2002). Following exposure, high concentrations of lead can be found in the blood, liver, kidney, muscle and other tissues, and can also be found in cows' milk. Often, poisoned cattle will die within hours; however, death may not occur for up to a couple of weeks following exposure.

Human health concerns from cattle lead poisoning incidents are that direct human exposures to the lead source may be occurring, and that contaminated meat and dairy products may be consumed. Typically, when the source of contamination is identified, human exposure can be discounted or stopped. In addition, surviving cattle can be monitored to assure that lead concentrations in their tissues drop below safe levels before they are slaughtered, sold, or their milk is consumed.

Site Background and History

On June 19, 2007, a veterinarian in Eagle Bend Minnesota, contacted the Minnesota Department of Health (MDH). He was looking for help determining the cause of death of 6 cattle that had died within the prior 4 days, as well as blindness in 3 additional cattle. The cattle had recently been licking and chewing on wood that had been sliced off of telephone poles that appeared to be treated with creosote. The pile of wood was in the barnyard, and the animals had not begun licking the wood until very recently. One animal in the herd is a Holstein dairy cow. This cow supplied the family with milk. Possible exposure of the family to the toxic substance through cows' milk was a concern. In addition, the family had connected their water distribution system to a new 101-foot well on June 1. Water from the well had been tested for coliform and nitrate, and results were negative. The family was waiting for results of lead and arsenic analysis. The mother had recently been suffering from gastrointestinal symptoms and the four children had complained of headaches.

The primary source of beef, milk and dairy products for the family impacted by this event was the affected herd. The family stopped drinking milk from the cow and water from the well when the animals started to die on June 15. The family is Amish, and contacting the family directly is difficult. In addition, a second Amish family also lives on the farm. A local Todd County Public Health nurse attempted to contact the two families and take blood samples for lead testing, but was unsuccessful on June 19, 2007.

While creosote, pentachlorophenol and arsenic were considered as possible poisons in the telephone pole scraps, a veterinarian in the University of Minnesota Diagnostic Laboratory suggested that the cattle were exhibiting classic lead poisoning symptoms. On June 20, one of the previously blind beef cattle from the herd died. Blood and milk samples were taken from the cow for analyses. Results, reported the week of June 25, are shown on page 8, in the Sample Results, Table 3: Lead in Cattle. Analysis of liver samples from 2 of the first animals who died on June 15 showed 24 and 14 parts per million (ppm) lead, confirming that the cattle were being poisoned with lead. In addition, water samples from the new well (unpurged, outside hydrant near well) showed levels of lead and arsenic near levels of concern (13.9 micrograms per liter (μg/L) and 12.5 μg/L, respectively; see page 6, Sample Results, Table 2: Water Analytes). While the arsenic concentration is within the range of groundwater arsenic in this area of Minnesota, lead is not typically found in groundwater but is usually a result of a contaminated distribution system.

Site visit

On June 21, a MDH Health Assessor/Toxicologist visited the farm along with the local veterinarian, a pesticide inspector from the Minnesota Department of Agriculture (MDA), a Field Inspector from the MDH Lead Program, and 2 Todd County Public Health nurses. The farm is located off a gravel road, on a hill, with a large yard, a tool and maintenance pole barn, a pole barn for cattle and horses, a number of small sheds, a residential trailer, and a new house in the process of having siding installed. The new well is about 100 feet south of the house, 20 feet north of the old well, and 40 feet northeast of the livestock barn. The farmer has owned the farm since 1999. He had knocked down an old house near the new house and hauled it away. Since his cattle began to die, he found out from neighbors that a previous house and 2 barns on the site had burned down. However, none of these were within 40 feet of the new well, or inside of the barnyard and accessible to the animals. The new well was drilled because the casing on the old well was disintegrating, and the well was filling with silt and clay. Information from the driller on the new well is in Table 1. The cattle were mainly drinking from a swamp in the southeast corner of the farm, but when they were in the barnyard, well water was available to them.

Table 1: Geological Data

Geology	Depth (feet)	
	Minimum	Maximum
Yellow Clay and Rocks	0	30
Blue Clay and Rocks	30	50
Blue Clay	50	99
Sand	99	101

The farm has a new water distribution system, with a generator-powered electric pump and PVC piping to the barn, the house and the outdoor hydrant. The hydrant is attached to the PVC underground by galvanized pipe. There is no apparent source for the lead contamination or elevated arsenic in the well water. It is likely that the arsenic is naturally occurring. It is possible that the lead in the well water is from surface contamination that was washed into the well during drilling or the brass fittings in the hydrant and the taps could be bleeding small amounts of lead.

There were 5 horses and a number of pigs on the farm at the time of the visit. According to the farmer, none of these animals exhibited any health problems.

The piles of telephone pole scraps (Attachment 1, Photo A) had been in the middle of the barnyard, available to the animals, until the animals started to get sick. The farmer then moved the wood west of the barn, out of the fenced barnyard.

In the pasture, about 200 yards south of the barn, was a large rock pile (Attachment 1, Photo B) that had previously been used as a farm implement and building materials dump. Since moving onto the farm, the owner used a trash service and he refused to allow neighbors to dump on the rock pile. In the rock pile, in an area where the cattle had worn down the vegetation, were parts of 2 lead acid batteries that had been ground into the soil and apparently licked by the cattle (Attachment 1, Photo C). The batteries were recognized because of the presence of black plastic chips from the battery casings on the surface of the ground. Battery posts and larger lead battery parts were found mixed in the dirt. Small uniformly sized pieces of the battery plates (about 3/16x3/16x1/32 inch) were spread around an area of the soil that was about 5 feet by 3 feet. In addition, the soil had a gray dusty color that may have come from lead and lead salts. A couple of other potential sources of lead were found in the pile, including at least 1 rusty 5 gallon paint or solvent drum, and what appeared to be the inside of a gallon paint can that had either hardened or burned (Attachment 1, Photo D).

The 2 animals that were blind 2 days previous were no longer totally blind. The heifer was apparently in pain, but had been let out to pasture with the other animals. The #1 bull calf was in the pole barn. Apparently, the calf could see some out of his left eye. Blood was drawn from the calf for lead analysis (see page 8, Sample Results, Table 3: Lead in Cattle).

The farmer said that he was going to fence off the rock pile that day. To be safe, he was going to wait until the results of the most recent water tests before the family used the well for drinking water. He was also planning to wait until his vet told him he could use milk from the cow, or consume or sell the cattle.

Four water samples were taken for metals analysis and 2 water samples were taken for microbial analysis. Samples taken were: 1 metals sample in the house prior to purge; 2 metals and 2 microbial samples in the house following a 20 minute purge (one metals sample to be filtered in the laboratory); and, 1 sample from the hydrant near the well. Analytical results are on page 6, in Sample Results, Table 2: Water Analytes.

The Lead Field Inspector used a handheld X-Ray Fluorescence Meter (XRF; Niton Model 300A, Thermo Electron Corp., Billerica, MA) to confirm that the battery parts were lead, and that the telephone pole scraps did not contain lead. Surprisingly, the XRF showed that the mineral lick used by the cattle in the barnyard contained a small amount of lead. A sample from the lick was collected for metals analysis. A sample from the burned or dried paint found on the rockpile and noted above was also collected for analysis. In addition, composite soil samples were taken in concentric arcs downhill (east) of the batteries; along the cowpath near the batteries; and near the new well. Results of analyses of these samples are below (see page 15, Sample Results, Table 6: Analytes in Soil and Other Media).

The Public Health Nurses took blood samples from all 6 family members, as well as the 5 members of the other family that lives on the property. Results ranged from 1 to 4 micrograms per deciliter (μg/dL) in the 11 individuals. Blood lead concentrations greater than or equal to 10 μg/dL are considered elevated.

Chemicals of Interest

Lead

Lead is a ubiquitous toxic heavy metal that performs no known beneficial function in living systems.

Blood lead has been found to be a good indicator of an individual's body burden, or total lead exposure. Furthermore, blood lead concentrations have been shown to correlate with related adverse health effects in humans and animals. However, scientific studies have not determined threshold levels for safe environmental exposures. The Centers for Disease Control (CDC; a division of the US Department of Health and Human Services) considers individual blood lead levels (BLLs) at or above 10 µg/dl to be indicative of an elevated exposure to lead. Children under 6 years old and pregnant women are the most vulnerable to lead and are considered to have "elevated" lead levels if their blood test results are greater than 10 ug/dL.

The MDH lead program encourages primary prevention, provides guidance and support to individuals exposed to lead, and fulfills the three core public health functions of assessment, assurance, and policy/planning. More information on MDH lead activities can be found at http://www.health.state.mn.us/divs/eh/lead/index.html .

Children poisoned by lead (i.e. exposed to large amounts of lead) can suffer: brain damage and/or mental retardation, behavioral problems, anemia, liver and kidney damage, hearing loss, hyperactivity, developmental delays, and, in extreme cases, death. Additional information on the toxicity of lead is available in the Toxicological Profile, published by the Agency for Toxic Substances and Disease Registry (ATSDR; a division of the US Department of Health and Human Services; 2005a).

Arsenic

Arsenic is also a ubiquitous toxic heavy metal. Exposure to any amount of arsenic is not known to have beneficial effects in people.

Arsenic is an element that can occur naturally in rock, soil, and groundwater. Short-term or acute exposure to arsenic at high concentrations, typically much greater than concentrations found in the environment, can result in death. Repeated exposures to lower levels, including concentrations found in the environment, may result in adverse health effects or increased risk of adverse health effects. Health effects may include skin, lung and stomach cancer or disorders of the circulatory, nervous, and digestive systems.

The U.S. Environmental Protection Agency has set a Maximum Contaminant Level (MCL) for arsenic of 10 µg/L in public water supplies. While arsenic concentrations in drinking water in Minnesota are generally below the MCL, it is believed that about 15% of the private wells in Minnesota may exceed this criterion (MDH 2001). Additional information on the toxicity of arsenic is available in the Toxicological Profile (ATSDR 2005b).

Discussion

Sample Results

Well Water Data

Well water samples were taken at this farm because the source of the lead that poisoned the livestock was unknown and the farm had recently switched to a new well for household drinking water. In addition, this new well also supplied a portion of the water consumed by the cattle.

Sample results for water from the in house tap and the outside hydrant are shown in Table 2.

Table 2: Water Analytes (μg/L or ppb)

Sample date	6/18/07	6/21/07	6/21/07	6/21/07	6/21/07
Location	Hydrant	House Pre-flush	House Post-flush Filtered	House Post-flush	Hydrant Post-(house)flush
Lead	13.9	8.2	2.9	< 1	3
Arsenic	**12.5**	**28**	**13**	**11**	**15**
Barium		300	230	230	260

Bold: Exceeds the EPA MCL of 10 μg/L

Note that the lead concentrations, while initially near the EPA Action Level of 15 μg/L decreased at the later testing date. Lead concentrations also decreased following flushing at the later date. It is possible that the lead is from new brass fittings, but alternatively, these data may suggest that the well could be a source of lead. The top of the well is completely covered, and there is a new casing in the well. Therefore, it is likely that a small amount of lead, possibly in the form of small particulates or paint chips, was washed into the well when it was drilled. Additional pumping/flushing should further decrease the lead concentrations in drinking water.

Arsenic concentrations from each sample exceeded the MCL of 10 μg/L. The decrease in arsenic concentrations during flushing may suggest that there is some arsenic being released from the sedimentation filter, charcoal filter or the distribution system. However the hydrant, which is located in front of the filters and is on a short branch of the distribution system, and showed elevated arsenic in both samples. These data suggest that the aquifer at 100 feet may have naturally elevated arsenic concentrations. As noted above, about 15 percent of all wells in Minnesota are believed to have 10 μg/L or greater arsenic (MDH 2001).

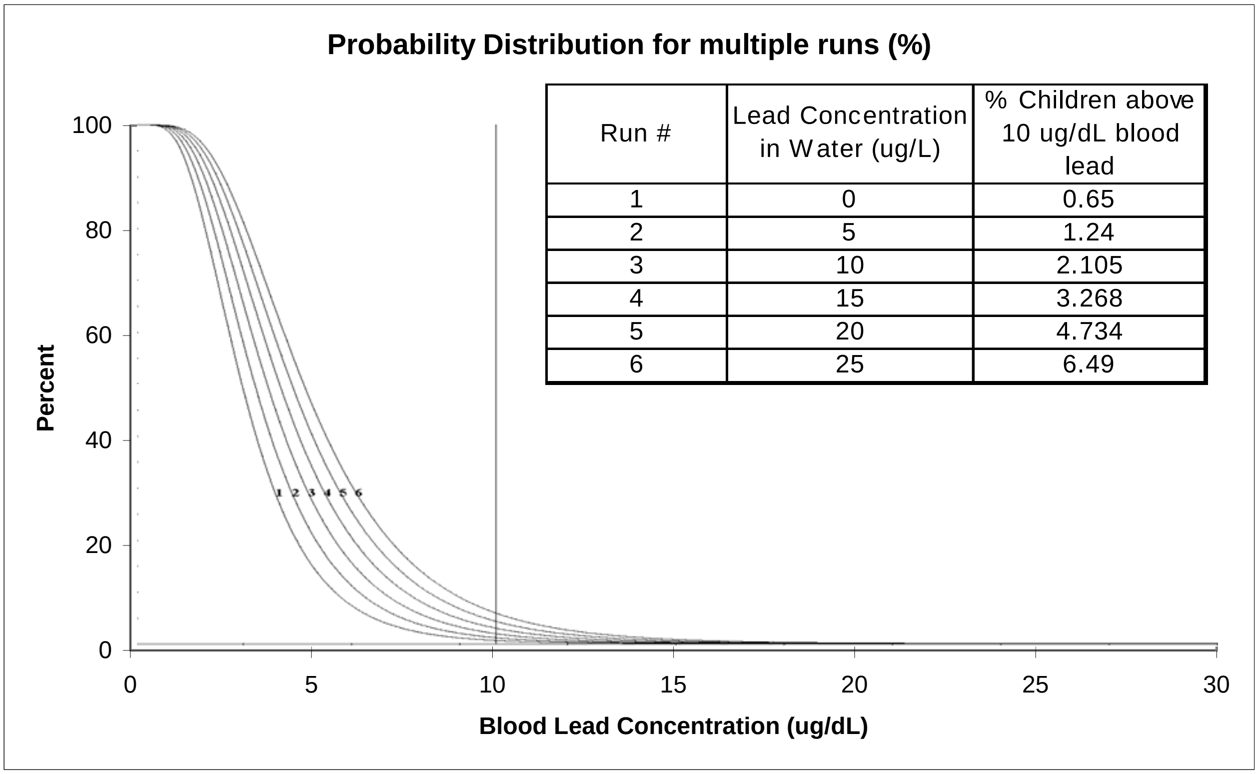
Blood Lead Data

Blood lead measurements were done for all residents of the farm because livestock had suffered lead poisoning, the source of the lead poisoning was unknown, and the residents drank milk from the dairy cow and consumed other farm animals and farm produce.

Blood lead levels for the farm family and the other family living on the property were less than 5 μg/dL for all samples. Any excess exposure due to lead in the drinking water or milk was not sufficient to raise BLLs above levels of concern (10 μg/dL; see above section).

The EPA Integrated Exposure Uptake Biokinetic Model for Lead (IEUBK; EPA 2005), using default assumptions, predicts that the blood lead concentration in a child 0-84 months old drinking water with 0 ug/L lead should be about 3.1 μg/dL. Using the same assumptions, a child in a home with 15 μg/L lead in drinking water could be expected to have about 4.2 μg/dL blood lead. Figure 1 shows a distribution plot of expected blood lead concentrations for populations of children exposed to 0, 5, 10, 15, 20 and 25 μg/L lead in drinking water. Note that there is an expected increase in the fraction of the population with greater than 10 μg/dL blood lead for each incremental increase in drinking water lead. However, the IEUBK results suggest that drinking water is not expected to be a large source of lead to a child. Ingestion of lead-containing products, such as lead paint, with high concentrations of lead is, potentially, the largest source of lead to children.

Figure 1: Integrated Exposure Uptake Biokinetic (IEUBK) Model Results



Run #	Lead Concentration in Water (ug/L)	% Children above 10 ug/dL blood lead
1	0	0.65
2	5	1.24
3	10	2.105
4	15	3.268
5	20	4.734
6	25	6.49

adapted from (EPA 2005)

Microbiological data
Well water samples and a stool sample were analyzed for microbes because of the complaint of gastrointestinal symptoms from at least one person in the farm family. Well water samples taken from the house tap following flushing on June 21 were negative for coliform. In addition, a stool sample taken on June 21 or 22 from one of the residents was negative for Norovirus, Campylobacter, Shigella, Salmonella, and E. coli.

Animal Data
Lead analyses of samples from cattle are shown in Table 3.

Liver samples from 2 of the dead animals, analyzed on June 20, showed elevated concentrations of lead. Greater than 8 mg/kg (ppm) lead in the liver is typically fatal to cattle (Merck and Co. 1991). Lead poisoning is also indicated when whole blood concentrations exceed 0.2 ppm. Two animals had blood drawn. Both animals had blood lead far in excess of 0.2 ppm. At the time the calf blood was drawn (6/21/2007), the calf appeared to be recovering from severe symptoms of lead poisoning including blindness. Up to the time of the site visit (6/21/2007) the cow had not shown symptoms of lead poisoning, but it is our understanding that a few days after the visit the cow appeared to be very sick.

Table 3: Lead in Cattle

Animal	Sample Date	**Blood (ug/L, ppb)**	**Milk (ug/L, ppb)**	**Liver (mg/kg, ppm)**
# 1 (dead)	6/15/2007			**24**
# 2 (dead)	6/15/2007			**14**
Cow	6/19/2007	**800**	**260**	
#1 Male Calf	6/21/2007	**740**		

Cows with BLLs greater than 200 µg/L typically have milk lead concentrations greater than 20 µg/L (Sharma et al. 1982; Oskarsson et al. 1992). (Note that BLLs for people are reported as µg/dL and BLLs for cattle are reported as µg/L. A lead concentration in blood of 200 µg/L is equivalent to 20 µg/dL.) The cow's blood and milk lead levels, taken at the Bertha farm on 6/19/2007, were 800 µg/L and 260 µg/L, respectively. These concentrations show that the cow was severely poisoned with lead, and survival of the animal was in doubt. Furthermore, the cow's milk was extremely contaminated. Drinking milk at 260 µg/L lead, especially for an extended period, would be detrimental to health.

Sharma et al. (1982) showed some agreement between the BLL and muscle tissue concentrations in cattle exposed to lead in feed and controls at the conclusion of a 3 month dosing period and after 3 months on a lead-free diet. However, muscle tissue concentrations in the more highly exposed cattle (566 mg/d) never appeared to exceed those in the lower dose group (166 mg/d). Liver tissue concentrations in the Sharma et al. 3 month dosing study were 7 to 20 times BLLs in cattle. In contrast, eight acutely poisoned cattle, showed a range of liver to BLL ratios from 55 to 220 (Oskarsson et al. 1992). And, in another study of data from fatal poisonings of cattle, mean liver concentrations were 29.7 (n=52, range 1.0-83.0) and BLLs were 0.78 (n=17, range 0.2-3.8) (Osweiler et al. 1973). The ratio of the mean liver concentrations to BLLs in this last study, where individual cattle are not identified (e.g. ecological evaluation), was 38:1. These data suggest that acute lead poisoning results in higher liver lead to BLL ratios than chronic lead poisoning.

With the removal of the cattle's exposure source, milk and tissue concentrations in the cattle will slowly decrease. Studies have shown a very wide range in half-life of lead in cattle blood, about 30 days to 2,000 days (Rumbeiha et al. 2001; Waldner et al. 2002). These half-lives do not appear to correlate with obvious exposure variables, but longer half-lives in some animals may be caused by the retention of solid lead in the rumen. However, there seems to be general agreement in the veterinary reports, that it takes 6 to 12 months or more for elevated BLLs to return to normal (Checkley et al. 2002). Lead levels in calves and lactating cows appear to have the shortest half-lives, possibly because the animals dilute the lead by growing or they excrete extra lead in their milk, respectively. It is assumed that milk and tissue concentrations decrease as the blood concentration decreases (Oskarsson et al. 1992); however, data are sparse.

In Minnesota, farmers are required to exercise "due diligence" to assure that contaminated meat and dairy produce does not reach the market (Minnesota Department of Agriculture 2007). However, there are no regulatory levels established for lead contamination of food produce in Minnesota; nor do the US Department of Agriculture (USDA) or the U.S. Food and Drug Agency (FDA; a division of the US Department of Health and Human Services) publish lead contamination criteria. While ingestion of paint chips or other materials containing higher concentrations of lead would result in more severe poisoning and symptoms than ingestion of contaminated meat or milk, people should avoid exposure to additional lead from any source, including diet. For children, the MDH and CDC goal is to keep BLLs as low as possible, to eliminate sources of significant lead exposure and to intervene and assist in lowering the BLLs of children with BLLs greater than 10 μg/dL. According to the CDC:

> Although there is evidence of adverse health effects in children with blood lead levels below 10 μg/dL, CDC has not changed its level of concern, which remains at levels >10 μg/dL. We believe it critical to focus available resources where the potential adverse effects remain the greatest. If no threshold level exists for adverse health effects, setting a new BLL of concern somewhere below 10 μg/dL would be based on an arbitrary decision. (CDC 2005)

In a 1994-1996 Total Diet Study, children were shown to consume about 2.5 μg lead /day. Based on CDC's levels, FDA's "tolerable" daily diet lead intake is 6 μg for children under age 6. (http://www.cfsan.fda.gov/~dms/fdalead.html)

Potential exposures through contaminated dairy products and meat

Symptoms of acute lead poisoning in cattle appear to manifest very soon after exposure (Oskarsson et al. 1992; Miranda et al. 2006). Therefore, if an animal is poisoned, and if all animals in the herd are quarantined, it is unlikely that human exposure through meat or dairy products will occur. However, if poisoning is not suspected, if the source of the lead is not found, and if the entire herd is not quarantined, human exposures may occur.

Public exposure through marketing contaminated milk and meat

Milk that is collected from farms in large bulk tanks is mixed with the milk from other cows, and contaminants in the milk from an individual cow are not likely to appreciably increase the concentration in the final product. On the other hand, if a family relies on milk and other dairy products from a single cow, or if a whole herd is poisoned, contaminant levels could reach levels of concern for the family. Meat contamination is a little different because the meat concentration is not diluted prior to marketing or consumption. Therefore, if contaminated meat makes it to market, someone will likely eat a chunk of the meat. However, it is somewhat unlikely that the same person will have many meals from the same contaminated animal. Still, contaminated meat entering the general food supply is a somewhat greater concern than contaminated milk entering the food supply.

It is unlikely that the lead battery plate chips found in the rumen of the poisoned cattle could enter the human food supply.

Exposure through animals fed contaminated feed

Animals that appear sick may be processed into feed for livestock and pets. The National Academy of Sciences/National Research Council has recommended a maximum tolerance level for lead in complete feed of 30 ppm (Association of American Feed Control Officials Incorporated 2007). According to this reference, feed concentrations up to this level should not produce unsafe residues in human food derived from an animal raised on this feed.

Sharma et al. (1982) fed dairy cows complete diets of 31.45 ppm and 9.23 ppm for 3 months. Blood concentrations reached maximums of about 0.3 ppm and 0.075 ppm for the high and low dose groups (n=4, 4). Negative effects of exposure on the animals' health were not reported. As a result of the lead exposures, lead concentrations in milk were about 60 ppb in the high dose group and 20 ppb in the low dose group and controls. Surprisingly, muscle tissue was about 20 ppb in the high dose group and control, and 60 ppb for the low dose group. However, the high dose group had livers with 725 ppb (standard deviation 91.2) lead compared with about 400 ppb for the low dose group (control, 175 ppb). (See above section for liver lead to BLL ratios.) These data suggest that feed with about 10 ppm lead should result in meat that is about 75 ppb lead or less (excluding liver). The NAS/NRC advice cited above was from the 1980s when the acceptable blood lead concentration in children was higher. In 1991 the acceptable level was lowered from 25 to 10 μg/dL. In addition, it has not been demonstrated the there is a threshold level below which lead exposure to children can be considered benign.

If contaminated animals are processed into animal feed, human exposures are possible when animals in the food supply are fed contaminated feed. In addition, if the feed is obtained from processing the entire carcass, there may be chunks of lead from the rumen passing into the feed. Animals that are fed feed with chunks of lead could be poisoned. However, without a continuous source of contaminated feed to animals in the food supply, long term human exposures that may impact health are not likely to occur.

Consumption of home-grown contaminated milk and meat

Of greatest concern is that a farm family will use milk from a contaminated cow as a single source of dairy products for the family, and / or that a farmer will eat the entire contaminated animal over an extended period of time. In these circumstances the contaminant uptake can be very significant. Using the IEUBK model, it is possible to determine lead concentrations in drinking water, milk and meat, consumed over a year, that are likely to have minimal or no impact on BLLs in farmers' children.

Using the IEUBK Model to determine drinking water, milk and meat concentrations that are likely to have minimal impact on BLLs

The IEUBK model (EPA 2005) can be used to determine likely BLLs with different types of longterm exposures to lead from air, diet, water, soil, dust, and maternal sources. The model inputs exposures and calculates resulting BLLs for 7 age groups from 6 months to 7 years. For the analyses in this report, the 6 year-old age group (72 to 84 months) will be the focus. The children in the farm family that are the subject of this report all appeared to be 6 years old or older. Using the EPA IEUBK defaults with no additional sources of exposure (see Attachment 2), the calculated geometric mean BLL for a 6 year-old is 2.5 µg/dL and it is expected that 0.165% of similarly exposed 6 year-olds will have BLLs greater than 10 µg/dL.

Figure 2 shows the affect of drinking water contamination on the modeled BLLs in all modeled age groups. In addition, for reference, the figure shows the maximum lead concentration measured in water samples from the site, and the cow's milk sample taken on June 19.

Figure 2: IEUBK Modeled - Lead in Drinking Water vs Geometric Mean Blood Lead – 7 age groups

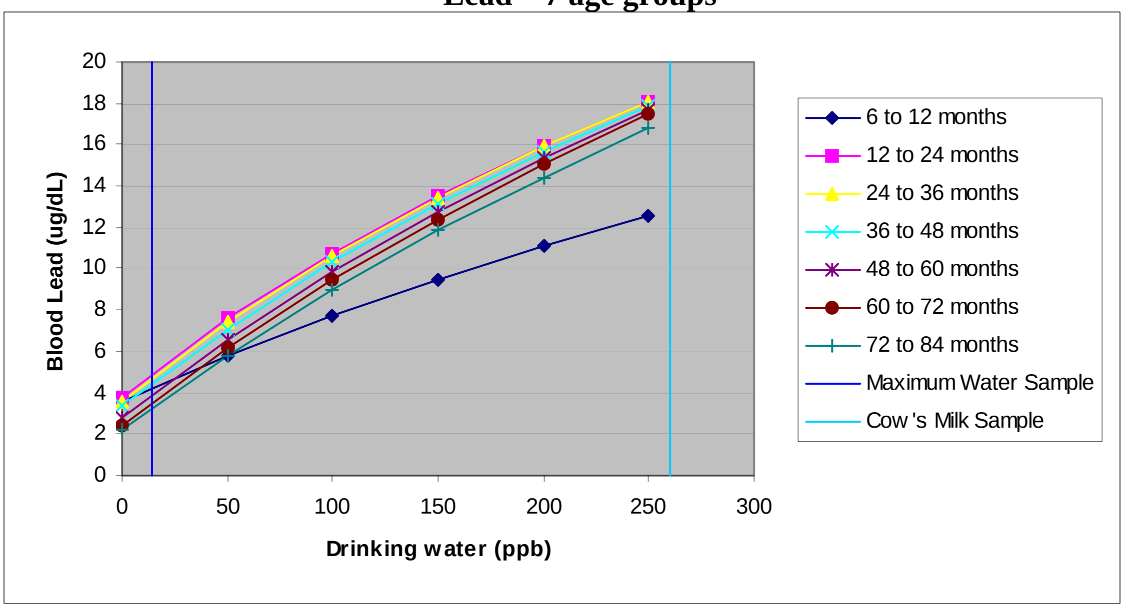
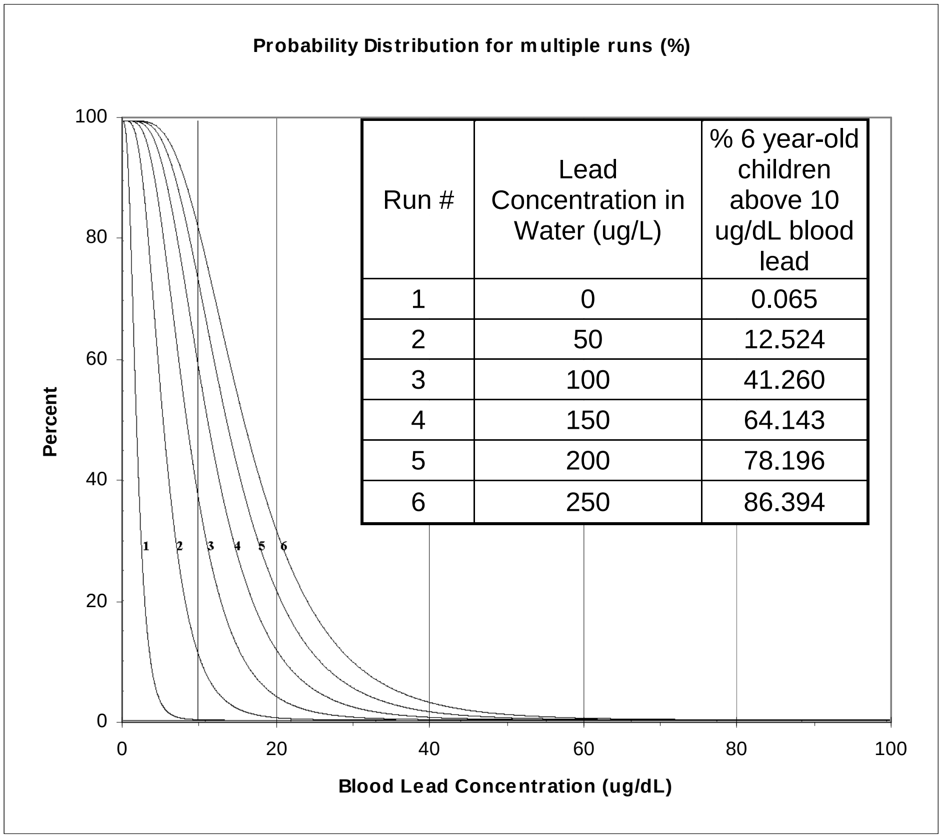


Figure 3 shows the expected distribution of BLLs for drinking water exposures from 0 ppb to 250 ppb. Note that at a drinking water concentration of 50 ppb, more than 12% of the BLLs of 6 year-olds are expected to be above 10 µg/dL. The EPA Action Level for lead in drinking water is 15 µg/L. At this level 0.988 % of the BLLs for 6 year-olds are expected to be above 10 µg/dL.

Figure 3: IEUBK modeled - Blood Lead Level Probability Distribution for Drinking Water 0 – 250 μg/L



Run #	Lead Concentration in Water (ug/L)	% 6 year-old children above 10 ug/dL blood lead
1	0	0.065
2	50	12.524
3	100	41.260
4	150	64.143
5	200	78.196
6	250	86.394

Figure 4 and Table 4 show the IEUBK Model resulting BLLs of 6 year-olds' when they consume dairy products with different concentrations of lead. It is assumed that the children consume in their diet the equivalent of 4 cups of milk per day in dairy products.

Figure 4: IEUBK modeled – Geometric Mean Blood Lead Levels in 6 year-olds Consuming Contaminated Dairy Products

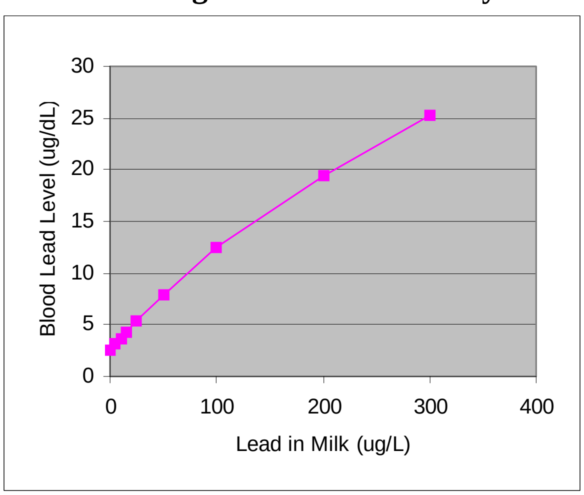


Table 4: IEUBK modeled – Blood Lead Levels and Distribution in 6 year-olds Consuming Contaminated Dairy Products

Milk Concentration (ug/L or ppb)	Total lead in 6 yr-old diet (ug/day)	Geometric Mean Blood Lead (ug/dL)	Percent of 6 year-old BLLs > 10 ug/dL (%)
300	291	25.2	97.5
200	196	19.5	92.3
100	102	12.4	67.4
50	54.3	7.9	30.8
25	30.7	5.3	9.09
15	21.2	4.2	3.41
10	16.5	3.7	1.67
5	11.7	3.1	0.64
0	7	2.5	0.17

These data suggest that if milk concentrations are 10 μg/L or greater, more than 1% of 6 year-olds consuming the equivalent of 4 cups of milk per day are likely to have BLLs greater than 10 μg/dL. In addition, daily consumption of milk with 260 μg/L milk for an extended period is expected to result in BLLs of about 23 μg/dL, or levels exceeding 10 μg/L for about 96% of the children exposed.

When children consume contaminated meat their BLLs can also increase. Figure 5 and Table 5 show the results of the IEUBK model for increasing concentrations of lead in meat from 0.05 to 0.8 μg/g (ppm).

Figure 5: IEUBK modeled – Geometric Mean Blood Lead Levels in 6 year-olds Consuming Contaminated Meat

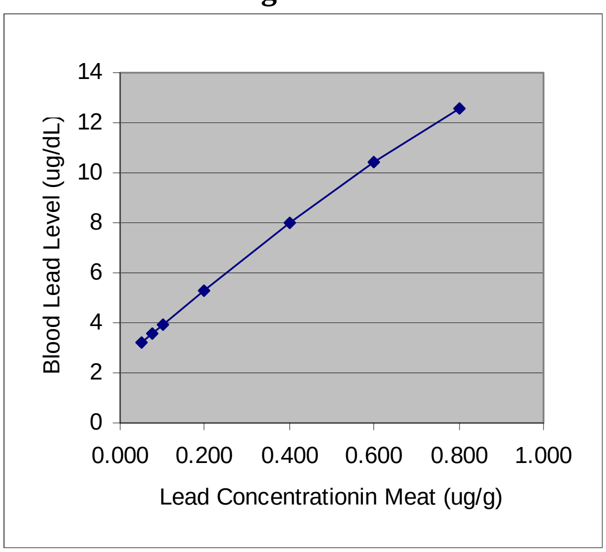


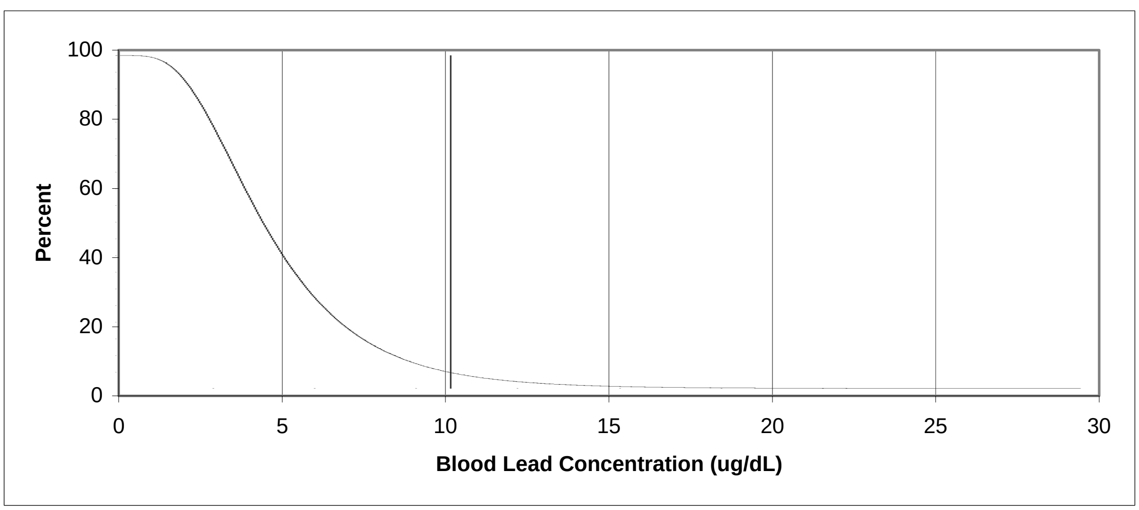
Table 5: IEUBK modeled – Blood Lead Levels and Distribution in 6 year-olds Consuming Contaminated Meat

Meat Concentration (ug/g, ppm)	Geometric Mean Blood Lead (ug/dL)	Percent 6 year-olds with > 10 ug/dL blood lead (%)
0.800	12.6	68.62
0.600	10.4	53.07
0.400	8	31.53
0.200	5.3	9.14
0.100	3.9	2.34
0.075	3.6	1.40
0.050	3.2	0.75

These data show that more than 1.4% of 6 year-olds' consuming meat with greater than 0.075 μg/g (ppm) lead will likely have BLLs greater than 10 μg/dL.

If animals are used for both dairy and meat, as is the case on this farm, exposures through contaminated dairy and meat could occur at the same time. IEUBK results of modeling 6 year-olds' consuming the equivalent of 4 cups of milk in dairy products containing 10 ppb lead and meat with 75 ppb lead Data are shown in Figure 6. These model results suggest that if children consume milk with 10 ppb lead and meat with 75 ppb, over their entire childhood, about 5.3 % of the 6 year-olds are expected to have BLLs above 10 μg/dL.

Figure 6: IEUBK Modeled - Probability Distribution for 6 year-olds' consuming dairy products @ 10 ppb and meat @ 75 ppb over a long time



Soil, Other Media Data

MDH reviews analytical data from soil or other materials for lead to identify potential sources of human exposure. Exposure of children to lead in soil at this farm is apparently not happening, given the normal blood lead in all residents. However, drinking water has lead in it, so soil samples near the well were collected and composited to determine if there is surface contamination that could have washed into the new well during construction. In addition, a composite sample was taken some 40 feet southeast of the well in the area where a barn had burned many years ago because lead paint used on the barn could have contaminated the soil. Soil samples were also taken near the rockpile to determine the extent of battery lead-contaminated soils. Lead does not move easily with water, but lead can be tracked by animals or lead can be moved along with soil that erodes.

Table 6: Analytes in Soil and Other Media (µg/g or ppm)

Media	Soil						Mineral Lick	Paint Can
Location	Well Wash Area	Site of old barn	20' arc to batteries	10' arc to batteries	3' arc to batteries	Path near rockpile / batteries	Barnyard	Rockpile
Arsenic	2.0	2.0	2.0	2.0	2.0	2.0	< 4	< 8
Barium							18	15
Cadmium							< 0.5	< 1
Chromium							7.4	120
Lead	8.8	9.1	4.6	5.8	65	7.4	1.5	22
Selenium							130	< 10
Silver							10	< 2

The results, in Table 6, show low arsenic and lead concentrations. The highest lead concentrations, found in soil collected from an arc 3 feet from the batteries in the rockpile, may be a concern if there is a reason for the cows to lick the ground at that location, but the levels are still below the Minnesota Pollution Control Agency (MPCA) Residential Soil Reference Value (SRV) for human exposure of 300 ppm (http://www.pca.state.mn.us/publications/risk-tier1srv.xls). Therefore, it is likely that removing all traces of battery plates and cleaning to a radius of 3 feet or more from the batteries should be sufficient to remove the hazard.

Mineral lick and paint can lead concentrations are not at levels of concern. The selenium concentration in the mineral lick sample seems high, but it appears to be within the regulatory range for mineral feed products of this type (Association of American Feed Control Officials Incorporated 2007).

X-Ray Fluorescence (XRF) Data

The XRF used during the site visit is a dedicated lead paint XRF. It is designed to analyze thin-layered samples, such as paint, on solid materials. Results are report as the amount of lead per surface area (mg/cm^2). Fluorescent transmission from lead below the surface layers may not read consistently. Therefore, XRF readings from materials like a mineral lick or battery plates are likely to be inconsistent and it is not clear what the instrument output is quantifying. For bulk or thick homogeneous materials, a lead concentration (lead per volume) is an easily understood measurement, but a lead per surface area measurement is ambiguous.

XRF data are shown in Table 7. These data confirm that the battery plates contain high concentrations of lead; that the surfaces of the creosote boards do not contain lead; and the data suggest that the mineral lick may contain lead. During the site visit it was suggested that the mineral lick XRF reading may have been the result of cross-sensitivity of the instrument to another mineral, but the laboratory chemical analysis confirmed the presence of lead in the mineral lick.

Table 7: X-Ray Fluorescence Data

Location	Lead (mg/cm^2)
Creosote Boards (5 or 6 boards)	0
Battery plates	73.5
Mineral Lick	0.7
Lead Paint (~40% lead)	30 - 40 *
Lead Paint Standard	1.0 *
* not measured, cited as reference data	

Additional Resources

Federal and State Agencies

The USDA, FDA and MDA are responsible for assuring that adulterated food does not enter the food supply. Lead poisoning of animals is not a federal or Minnesota reportable disease or condition. Therefore, meat from lead poisoned cattle will only stay off the market if the farmer does not market the cattle or if the cattle are identified as "downer" cattle (unable to stand or walk) when they are brought to slaughter. Similarly, milk from poisoned cows will only stay off the market if the farmer does not sell the milk. The risks from a single animal or milk from a single animal are likely to be limited due to dilution, as discussed above. But if a large herd is affected, or if the meat or milk is being processed for a small group of people, lead exposures to those people could be of health concern. The FDA, USDA and MDA are available for consultation when a herd or even individual animals are poisoned. However regulatory authority, except in the slaughterhouse, is unclear.

The FDA recommended, in response to a request from MDH about consumption of milk, that milk lead levels should be at or below 5 μg/L before it is used (U.S. Department of Health and Human Services 2007).

The FDA, USDA and MDA also regulate the sale of animals for use in feed or pet food. While tissue from lead poisoned cattle may have a high concentration of lead, the rendering process will significantly dilute the poison from a few animals. The biggest concern would likely be the inclusion of stomach contents, including chunks of lead, in the resultant meat or meal. Current regulations do not appear to protect pets, or even some animals in the food supply, from being fed feed that is adulterated by the inclusion of contaminated meal. Instead, feed processors rely on the owners of lead-poisoned animals to keep contaminated meat out of feed products.

Michigan Department of Agriculture

The Michigan Department of Agriculture considers any toxic exposure to be a reportable disease. Quarantine for cattle exposed to lead is maintained until blood concentration is less than 50 μg/L and until milk concentration in dairy cattle is below 10 μg/L (Butler 2007). The Department pays for testing and tracks the animals' recovery, typically, with testing every couple of months.

Food Animal Residue Avoidance Databank (FARAD)
FARAD is a computer-based decision support system designed to provide livestock producers, Extension specialists, and veterinarians with practical information on how to avoid drug, pesticide and environmental contaminant residue problems. Unfortunately, this service, which has been funded through the FDA and is part of a global FARAD, has recently lost funding has issued the following statement: "The members of the Food Animal Residue Avoidance Databank [FARAD] program reluctantly announce the suspension all interactive activities as of the end of business on Tuesday, May 15th, 2007, due to lack of continued funding.

"We regret having to take this step, but with no support beyond May 2007, we are having to conserve remaining resources in hopes that funding will be restored in next year's budget. " http://www.farad.org/faradeulogy.html

While FARAD was not available for use during this incident, it is possible that this resource will be available in the future.

Conclusion

Data in Table 3 show that animals in this herd that were sampled had extremely high concentrations of lead in blood and / or milk. The primary source of beef, milk and dairy products for the family impacted by this poisoning event was the affected herd. In addition, the previous sections have demonstrated that regular consumption of meat (assuming the lead concentration in meat is the same as in blood) or dairy products at concentrations found in tested animals could have resulted in lead poisoning. Even short-term consumption of dairy products from the tested cow would likely result in lead poisoning. These conditions are classified as an Urgent Public Health Hazard, as defined by the Agency for Toxic Substances and Disease Registry (ATSDR; http://www.atsdr.cdc.gov/COM/hazcat.html).

The family at this site stopped drinking milk from the cow; stopped processing milk from the cow into dairy products; and are currently monitoring blood and milk lead levels in the cattle, until they indicate that meat and milk are safe to eat. This has prevented potentially dangerous exposures to lead for all who may have consumed these products. Lead exposures to people from this event have likely been minimal. If the residents are careful about consuming meat and dairy products from this herd until after BLLs, tissue and milk concentrations have returned to low levels, additional exposures should not occur. Because there is no current route of exposure, there is currently No Public Health Hazard related to lead at this site.

Arsenic concentrations in the aquifer where the farm well is screened appear to be above the EPA MCL. Arsenic exposures at these concentrations and anticipated water consumption rates are a health hazard for long-term exposure. Showering, bathing, washing dishes, washing clothes and activities involving similar exposures are not a concern at arsenic concentrations measured in water from this farm's well. In addition, neither livestock health, nor the milk from exposed livestock, is affected when livestock regularly consume water with this level of arsenic (Kashman and Murphy 2007).

Recommendations

The Minnesota Department of Health recommends:

- Milk or dairy products from affected animals should not be consumed until lead concentrations in milk are 10 μg/L or less.
- Meat from affected animals should not be consumed until meat concentrations are, generally, 75 μg/kg or less.
- The Minnesota Department of Agriculture should establish guidelines for farmers to follow when animals are poisoned, which are protective of the farmer's family and the food supply.
- An alternate source of drinking and cooking water should be used for people when arsenic concentrations exceed 10 μg/L. Generally there are 4 options:
  1. Treat the water with one of the following:
     a. Reverse osmosis
     b. Arsenic-specific cartridge treatment
     c. Distillation

     (It is important that any treatment system is maintained according to the recommendations of the manufacturer.)
  2. Drill a new well in a different aquifer that does not have elevated arsenic concentrations. (This is probably not a reasonable option at this site because of the local geology.)
  3. Drink bottled water. (Bottled water is not always subject to rigorous contamination testing or standards.)
  4. Connect to a municipal water system. (This alternative is probably not an option for this site.)

Public Health Action Plan

If requested, MDH will assist MDA in developing guidelines for protecting farmers and for marketing dairy and meat products from animals that may have been non-fatally poisoned. MDH will provide information to the residents about how drinking water can be treated to lower arsenic exposures.

This consultation was prepared by:

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Site Assessment and Consultation Unit
Environmental Surveillance and Assessment Section
Minnesota Department of Health

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CERTIFICATION

This Emergency Response To Lead Poisoning On A Farm was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

Alan Parham
Technical Project Officer, SPS, CAPEB, DHAC, ATSDR

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

for AY

Alan Yarbrough
Chief, State Program Section, SPS, CAPEB, DHAC, ATSDR

Attachment 1

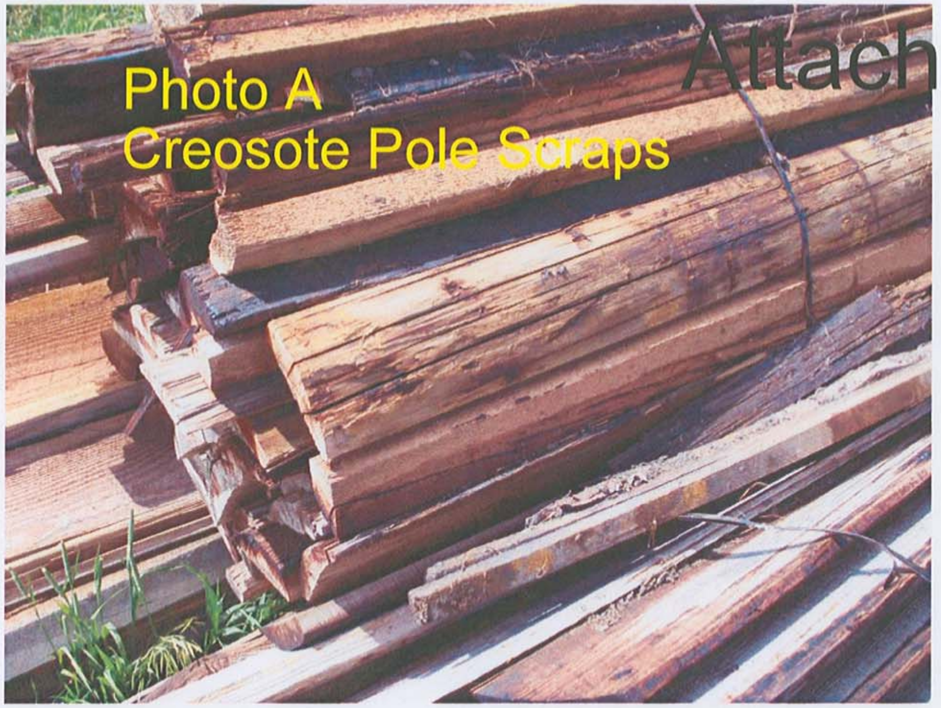
Photo A
Creosote Pole Scraps

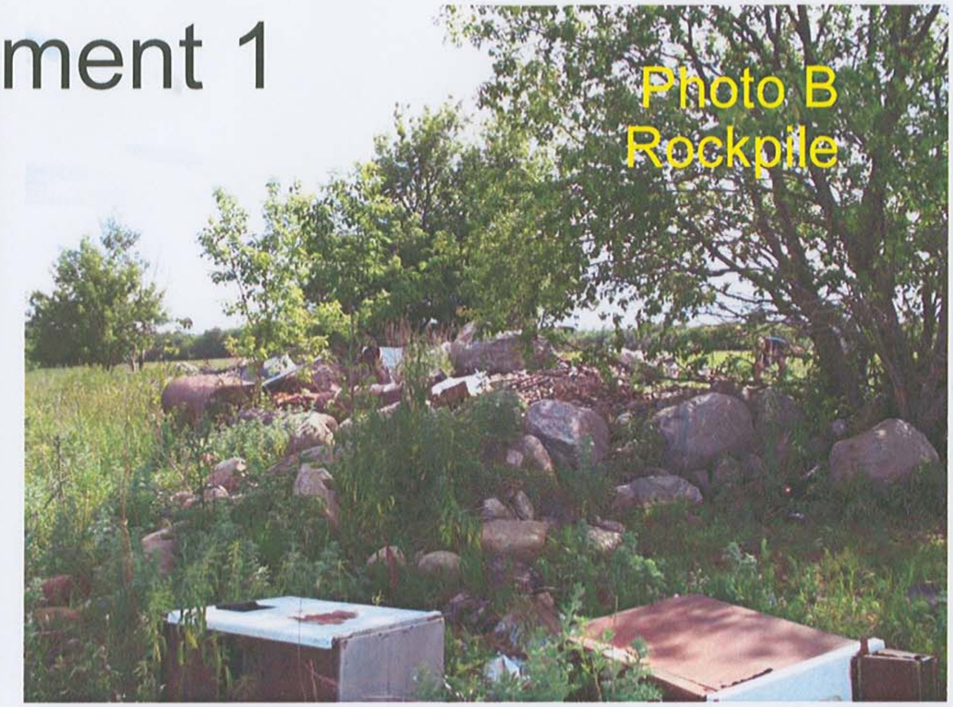
Photo B
Rockpile


Photo C
Crushed Lead-Acid Battery

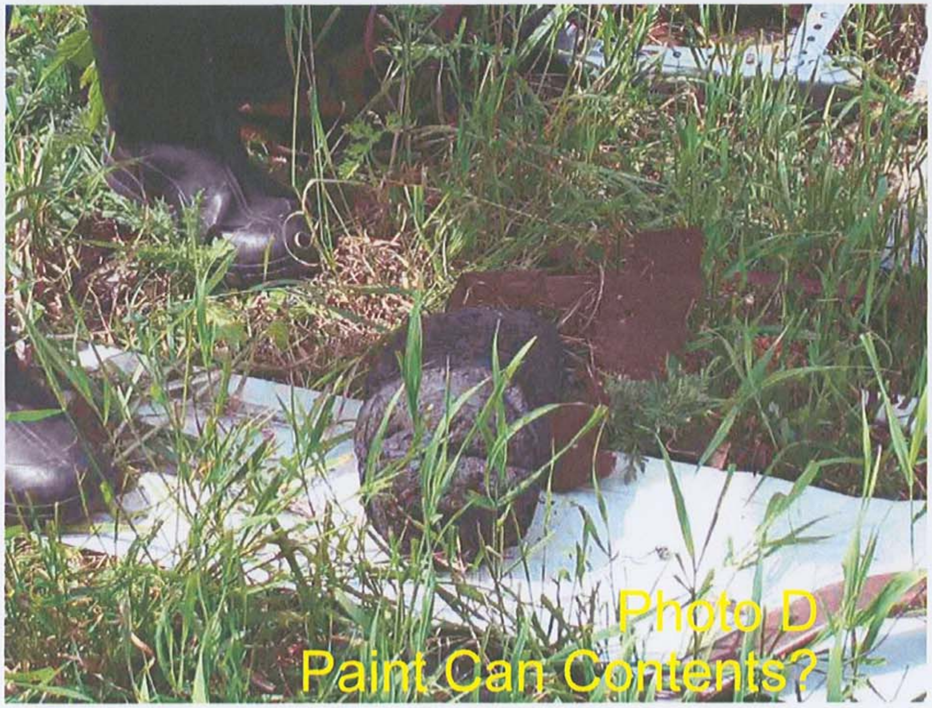
Photo D
Paint Can Contents?

Attachment 2

==

Model Version: 1.0 Build 263
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 150.000 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	200.000	150.000
1-2	200.000	150.000
2-3	200.000	150.000
3-4	200.000	150.000
4-5	200.000	150.000
5-6	200.000	150.000
6-7	200.000	150.000

Attachment 2 Continued

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.553	0.000	0.369
1-2	0.034	2.647	0.000	0.916
2-3	0.062	3.002	0.000	0.962
3-4	0.067	2.919	0.000	0.992
4-5	0.067	2.863	0.000	1.048
5-6	0.093	3.040	0.000	1.112
6-7	0.093	3.366	0.000	1.135

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	4.061	7.004	3.8
1-2	6.399	9.997	4.2
2-3	6.462	10.488	3.9
3-4	6.536	10.514	3.7
4-5	4.930	8.908	3.1
5-6	4.467	8.712	2.7
6-7	4.231	8.826	2.5