Health Consultation

MISSION CREEK WATER SYSTEM

Evaluation of Uranium and Alpha Particles in Drinking Water
Serving Mt. Hall School and Surrounding Areas

BOUNDARY COUNTY, IDAHO

JUNE 9, 2008

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.

LETTER HEALTH CONSULTATION

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Evaluation of Uranium and Alpha Particles in Drinking Water Serving Mt. Hall School and Surrounding Areas

BOUNDARY COUNTY, IDAHO

Prepared By:

Idaho Division of Health
Bureau of Community and Environmental Health
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Foreword

The State of Idaho, Idaho Division of Health (IDOH), Bureau of Community and Environmental Health (BCEH) jointly prepared this public health consultation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to environmental contaminants. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The health consultation is an approach used by ATSDR and IDOH to respond to requests from concerned residents for health information on hazardous substances in the environment. The health consultation process evaluates sampling data, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

Purpose and Statement of Issues

In November 2007, the Bureau of Community and Environmental Health (BCEH) was asked by the Idaho Department of Environmental Quality (IDEQ) office in Coeur d'Alene to consult with them about sampling data from the Mission Creek Water System. The Mission Creek Water System is a small system that serves the Mount Hall Elementary School and approximately 32 homes in Boundary County. IDEQ, who is responsible for ensuring that public and community water systems in Idaho are in compliance with water quality standards, provided BCEH with sampling data and confirmed that samples from the Mission Creek Water System were above the federal drinking water standard for uranium. According to IDEQ, the Mission Creek Water System has been out of compliance with the National Primary Drinking Water Standards since September 2002 and IDEQ had requested that the system manager address the problem of naturally-occurring uranium in the community's drinking water supply. The Environmental Protection Agency (EPA) sets water quality standards or Maximum Contaminant Levels (MCLs) that are protective of human health. The MCL for uranium is 30 µg/L (micrograms per liter). EPA has found that the levels of uranium in water in different parts of the United States are extremely low in most cases (generally less than 1.5 µg/L), and that water containing these low levels of uranium is safe to drink (EPA 2000; ATSDR 1999). Heating or boiling water does not remove uranium or lessen its radioactivity. Reverse osmosis and certain ion exchange treatment systems can be installed to lower high uranium levels to below the MCL, though it should be noted that none are currently certified for this purpose (NSF 2008).

Naturally occurring uranium is a metal that is slightly radioactive. It is not to be confused with other forms of uranium, such as enriched uranium which is highly radioactive and used primarily in nuclear energy and warheads. Because of its low level of radioactivity, natural uranium is not expected to increase the rate of cancer among those exposed to it in water. In fact, no human cancer of any type has ever been reported as a result of exposure to natural uranium in water (ATSDR 1999). However, natural uranium can cause other adverse health effects in people. In studies of people exposed to uranium in drinking water, researchers have noted that a few people have developed signs of kidney disease after intakes of large amounts of uranium (Pavlakis et al. 1996; others). Other studies have found that animals have also developed kidney disease after being treated with large amounts of uranium (Gilman et al. 1998; others). At the levels present in the Mission Creek area, uranium in water can potentially be toxic to the kidneys, but is not sufficiently radioactive to cause any other health effects.

While most exposure to uranium in the Mission Creek area is from drinking water, there is also the possibility that plants and animals exposed to water containing uranium could concentrate the uranium. People could then be exposed to additional uranium if they eat the plants, animals or animal products, such as eggs. However, because of the nature of uranium, not much of it stays in animal tissues or in most vegetables (Hayes et al. 2000). When a person eats food and drinks liquids containing uranium, most of it never enters the blood and is excreted from the body in the feces within a few days. Most of the small portion of uranium that does enter the blood leaves the body through the urine within a few days. Still, a small amount can stay in the bones, kidneys, or in other soft tissues and may stay there for years. Most people have about 1/5,000th of the weight of an aspirin tablet of uranium in their bodies, stored mainly in their bones (ATSDR 1999).

Background

In December 2001, the EPA set a new MCL for uranium of 30 μg/L in water systems that became effective in 2004 (EPA 2000). Since sampling for uranium first began in September 1998, the drinking water from the Mission Creek System Water System's well has consistently exceeded the current (2004) MCL.

Site Description

Figure 1: Map of Idaho showing location of the Mission Creek Water System in Boundary County.

The Mission Creek Water system serves the Mount Hall Elementary School (public: Boundary County School District) and several homes in the area. The school is located 16 miles north of Bonners Ferry, 10 miles south of the Canadian border, and has an enrollment of approximately 175 students and 30 faculty and staff. The approximate location of this area is shown in Figure 1. The system operates from a single well. Figure 2 shows the location of the school in relation to Highway 1, Mission Creek, and the Kootenai River.

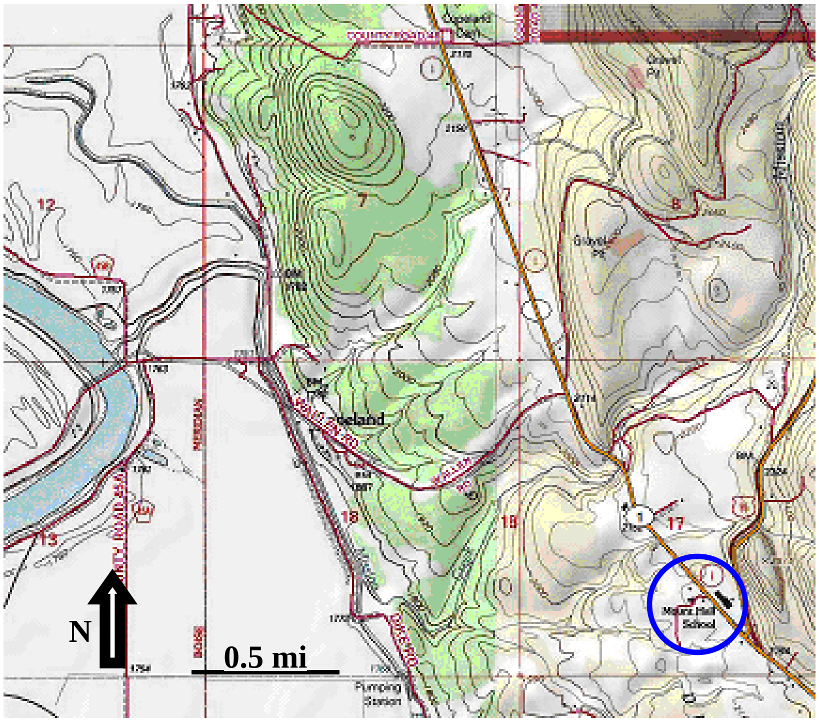

Figure 2: Topographic map of the Mission Creek area showing the location of the Mount Hall School (circled in blue). The well for the Mission Creek Water System lies upstream (due north) of the school.

Source of Contamination

Uranium is a natural and commonly occurring radioactive element. It is found in very small amounts in nature in the form of minerals, but may be processed into a silver-colored metal. Rocks, soil, surface and underground water, air, plants and animals all contain varying amounts of uranium. Uranium in water comes from different sources. Most of the uranium in water comes from uranium dissolved out of rocks and soil through which the water runs (ATSDR 1999).

Route of Exposure

Drinking the water appears to be the only feasible route of significant exposure to uranium at Mission Creek. However, eating plants irrigated by the water or eating animals or animal products, such as eggs, may contribute somewhat to exposure. Exposure through the skin or through breathing, such as would occur while showering, is not believed to be a significant concern. Since it is known that there is uranium in the community's well water and that residents use the water for drinking, irrigation, and watering their animals, a completed pathway for exposure exists. In other words, it is known that people who use the community water supply are being exposed to uranium.

EPA Drinking Water Standards

As stated before, the EPA is responsible for setting the MCLs. The MCL is the highest level of a chemical that is permitted in public drinking water systems. MCLs are set as close to Maximum Contaminant Level Goals (MCLGs) as feasible using the best available treatment technology and taking cost into consideration. MCLGs are the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals while MCLs are enforceable standards (EPA, February 2006; November 2006). The MCLG for uranium in drinking water is zero, since any amount of uranium is believed to have some adverse effect on the body. However, because uranium is found throughout the United States and eliminating it completely from drinking water systems is not practical due to the expense, the MCL is set at 30 μg/L and is considered to be protective to health for both children and adults (EPA 2000).

Some amount of radioactivity exists whenever uranium is present. Several radioactive elements may be present in water, though uranium is the most common and plentiful one. These elements emit alpha particles—a type of ionizing radiation—and can cause cancer at high levels. When radiation levels are very high, the gross alpha test is a "total" measurement of alpha emitting particles, including radium and uranium. The MCL for gross alpha is measured in picocuries per liter (pCi/L) and is set at 15 pCi/L. There is a unique protocol for interpreting samples in comparison to the MCL. The uranium alpha particle activity is subtracted from the gross alpha activity to determine whether the MCL has been met. If the gross alpha activity exceeds 15 pCi/L after subtraction, further analysis is required (EPA 2000). Annual average gross alpha activity at Mission Creek was only calculated in 2006, when gross alpha was sampled twice in one year. The average value was 53 pCi/L. Total uranium analysis was not performed at in 2006 but was completed shortly thereafter. When the uranium activity was subtracted from the gross alpha value as is the normal protocol, gross alpha activity did not exceed the MCL. Since gross alpha activity did not exceed the MCL - in fact it was approximately zero - there is no public health risk, so no further discussion of gross alpha is necessary.

Sampling

Samples were collected by the Mission Creek Water System starting in 2002 in accordance with IDEQ protocol for water systems in Idaho.

Analysis

Water samples were received by Analytical Labs, Inc. of Boise and sent to the Idaho State Lab and Energy Labs, Inc., of Billings, MT. Samples were analyzed for total uranium using EPA method 200.8, and analyzed for gross alpha using EPA method 900.0 (EPA 1997a).

Results

Reference values and values used in calculations are shown in Appendix A. Uranium concentrations (in μg/L) for the Mission Creek Water System are shown in Table 1. The concentrations from periodic sampling of the system ranged from 38 to 72 μg/L, with an average over the years of 64 μg/L. The concentrations consistently exceeded the MCL, at levels that were approximately double the MCL.

The dose calculations in Table 1 are for children since they are the population most at risk for health effects. The dose calculations use estimates of daily consumption (1 liter of water) and a body weight of 33 lbs (15 kg) for a child. The average dose received by a child could range from 0.0043-0.0049 milligrams per kilogram of body weight per day (mg/kg/day) of uranium, and the maximum dose received by a child could range from 0.0056-0.0072 mg/kg/day, depending on which well the water was drawn. These values are evaluated in the next section.

Table 1: Uranium concentrations in Mission Creek Water System, 1998-2007.

		Uranium (MCL = 30 μg/L)	
Date	**Source**	**μg/L**	**% of MCL**
9/8/2002	WELL #1	38	127
12/15/2004	WELL #1	63	210
2/9/2005	WELL #1	68	227
5/13/2005	WELL #1	67	223
12/16/2005	WELL #1	69	230
3/7/2007	WELL #1	68	227
6/28/2007	WELL #1	72	240
9/10/2007	WELL #1	66	220
10/17/2007	WELL #1	68	227
	Average	64	193
	Average Estimated Dose (mg/kg/day) child-All Day	0.0043	
	Average Estimated Dose (mg/kg/day) child-School Day	0.0022	
	Maximum Estimated Dose (mg/kg/day) child-All Day	0.0048	
	Maximum Estimated Dose (mg/kg/day) child-School Day	0.0024	

To determine if the level of uranium in the water is a health risk for children, it is assumed that children are consuming 1L of water ('All Day') from the uranium-containing source. If children are exposed only at school ('School Day') (approximately 8 hours per day, or half of their waking hours), the consumption of uranium-containing water would only be approximately 0.5 L per day for 5 days per week instead of 1L per day for 7 days per week.

Discussion

ATSDR uses comparison values called Minimal Risk Levels (MRLs). An MRL is defined as an estimate of daily human exposure to a substance that is likely to be without appreciable adverse health effects. ATSDR has three kinds of MRLs that are defined very precisely: acute MRLs are based on 1-14 days of exposure, intermediate MRLs are based on 15-364 days of exposure, and chronic MRLs are based on 365 days and longer exposure. ATSDR has only developed an oral exposure intermediate exposure MRL for uranium. However, according to ATSDR (1999), the intermediate MRL should be protective for chronic exposure also, because the renal toxicity of uranium exposure is more dependent on the dose than on the duration of the exposure. The intermediate MRL is 2×10^{-3} mg/kg/day; this value is an order of magnitude greater than the EPA chronic reference dose (RfD). With standard exposure assumptions for adults, water ingestion rate of 2 L/day and a body weight of 154 lbs (70 kg), a uranium concentration that would provide an intake of 2×10^{-3} mg/kg/day for an adult can be calculated. This concentration is 70 µg/L. For a child weighing 33 lbs (15 kg) and ingesting 1L/day, the concentration providing the MRL is 30 µg/L. This happens to be the EPA MCL for uranium, as well; thus, the MRL concentration for children is in agreement with the MCL, indicating protectiveness for both adults and children with chronic exposure.

The average concentration of the Mission Creek Water System well was consistently more than double the MCL. Using the average values, there is cause for concern for children, both those children drinking all of their water from the Mission Creek system, and those children drinking the water only at school. If children are exposed only at school ('School Day') (approximately 8 hours per day, or half of their waking hours), the consumption of uranium-containing water would only be approximately 0.5 L per day, but this still yields a daily exposure that exceeds the MRL. It could be argued that since children are only at school 5 out of 7 days per week, that their exposure is lessened by approximately 28%, but the dose is computed on a 'per day' basis, so this modifier may not be significant. Similarly, it could be argued that children are only in school for 75% of the year; however, the 9 months they are in school constitute an intermediate term for exposure.

It is possible that in some sensitive human populations, kidney tubular function could be altered by doses of uranium near the MRL. Doses of approximately 30 times the MRL have been shown to produce changes in kidney tubular function (Gilman et al. 1998) in animal studies. The particular animal used to in this study was the New Zealand white rabbit which is known to be very sensitive to uranium toxicity. In a number of studies on different animal species, as well as in occupationally exposed workers (based on tissue examination at autopsy), renal damage was overcome by regeneration of tubular epithelium (Bentley et al. 1985; others). Following this repair, tissue appeared no different than undamaged kidney tissue. In humans, renal function rapidly returned to normal in a matter of days following cessation of exposure to workers (Zhao and Zhao 1990). The type of kidney damage caused by uranium thus appears to be completely reversible.

Average exposure levels to adults drinking the water at Mission Creek are below the MRL concentration for adults, at 70 μg/L. Exposure to this level will probably not be harmful in adults; however, it is a concern for children.

Plant Uptake: Fruits and Vegetables

Some residents may raise fruits and vegetables using the water from the Mission Creek Water System and have concerns about the uranium being taken up by the plants and stored in the parts that are eaten. The following discussion is guided by a study conducted by the Los Alamos National Laboratory (Hayes et al. 2000). In the study, a test garden was planted, and the uranium uptake and concentration of 4 different types of vegetables was tested: radishes (root vegetables), lettuce (leafy greens), squash (squash, melons, zucchini, etc) and tomatoes (vegetables that are really fruits). At a uranium water concentration similar to that at Mission Creek, the radishes and lettuce concentrated the uranium significantly. When harvested, the radishes and lettuce had about 3 times as much uranium as the water used on them. Note that these calculations do not take into account how much uranium is already in the soil and available for uptake in addition to what is taken up from the water. Actual uranium uptake might therefore be higher than these estimates since it is anticipated that soils watered with the Mission Creek well water would have appreciable concentrations of uranium in them. It is possible and likely for uranium to concentrate at various depths near the soil surface. The rate and efficiency of uptake from soil into vegetables appears to be significantly slower than that directly from water, but it does occur. See Appendix B for complete calculations. The highest detected uranium concentration of 72 μg/L is used in these calculations to give a protective estimate of public health risk.

Leafy Greens and Root Vegetables

Because 1 L of water weighs 1 kilogram (Kg), it is possible to directly convert from μg/L to μg/Kg. Thus, either of these vegetables could be expected to contain as much as 3 x 72 μg/Kg or 216 μg uranium/Kg of vegetable. The amount of these vegetables eaten must also be considered when deciding if any realistic risk exists. The EPA has published estimates of ingestion rates of many vegetables for adults and children. The vegetable of each type that Americans eat the most were chosen for use in risk estimates presented here. Lettuce is the most-consumed leafy green, while potatoes are the most-consumed root crop.

An adult dose from consumption of a typical amount of lettuce irrigated with the Mission Creek well water would be approximately 0.57×10^{-4} mg/kg/day. A child dose from eating lettuce would be approximately 0.53×10^{-4} mg/kg/day. The most-protective MRL concentration (that for children), by comparison, is 2×10^{-3} mg/kg/day, thus the lettuce uranium concentration is about 35 times lower for adults and 38 times lower for children.

If all other sources of dietary uranium were eliminated, a 154 lb (70 kg) adult would need to eat 1.53 pounds of lettuce per day and a 33 lb (15 kg) child would need to eat 0.29 pounds of lettuce per day to receive a dose comparable to the MRL. While this is not likely, other sources of dietary uranium must be considered before deciding that this level is acceptable, as it could certainly contribute to the overall daily uranium dose.

An adult dose from consumption of a typical amount of potatoes irrigated with the Mission Creek well water consumption would be 0.19×10^{-3} mg/kg/day. A child dose from eating potatoes would be 0.48×10^{-3} mg/kg/day. The MRL for uranium is 2×10^{-3} mg/kg/day, thus the potato uranium concentration is about 10 times lower for adults and 4 times lower for children. If all other sources of dietary uranium were eliminated, a 154 lb (70 kg) adult would need to eat 1.43 pounds of potatoes per day and a 33 lb (15 kg) child would need to eat 0.27 pounds of potatoes per day to receive a dose comparable to the MRL. While this is not likely for adults, this is certainly plausible for children. Again, other sources of dietary uranium must be considered before deciding that this level is acceptable, as it could certainly contribute to the overall daily uranium dose.

Squash, Tomatoes, and Similar Vegetables

Based on the Los Alamos study (Hayes et al. 2000), the squash and tomatoes had much less uranium in them than what was in the water, thus they are not expected to concentrate sufficient amounts of uranium to pose any risk. It is reasonable to expect tree fruit to behave similarly to the tomatoes given that tomatoes are in fact fruit; however, this study did not consider fruit.

Summary

Though eating normal amounts of these vegetables grown with the Mission Creek Water System water alone does not cause anyone to be exposed above the MRL, it is possible that an entire meal of just vegetables could exceed the MRL. Eating these vegetables in combination with drinking and/or cooking with the water could contribute to an exposure in excess of the MRL. Based on this evidence, it is prudent to avoid eating too much of the root vegetables and leafy greens grown using the community water. Other crops are not expected to concentrate sufficient amounts of uranium to pose any risk.

Chickens and Eggs

Some residents may raise chickens using the water and may have concerns about the uranium concentration of chicken meat and eggs. Dr. Jeffrey Fromm of IDEQ performed calculations to assess these exposures in reference to another community water system in SW Idaho (Fromm 2005, 2006). To determine what sort of uptake might occur and what levels might be present in edible tissues, two U.S. Department of Energy (DOE) documents were consulted (1999, 2003) as well as several other reports (NAS 1972; IAEA 1994). The daily dose of uranium from consumption of poultry and eggs (referred to also as ‘chicken products’ collectively) for both adults and children is significantly less than the dose from drinking water that contains uranium at the MCL of 30 µg/L (which is also the MRL). Based on the analysis performed by Dr. Fromm, an adult would have to consume 9.9 lbs of chicken products in one day, and a child would have to consume 4.2 lbs in one day to equal a typical dose from drinking water containing uranium at the

MCL. At the maximum water concentration (72 µg/L), an adult would have to consume 2.67 lbs of chicken products per day, and a child would have to consume 1.17 lbs of chicken products per day to receive this same dose. See Appendix C for detailed calculations.

Since the biotransfer factors are not strictly correct from a mass balance standpoint, because all of the uranium cannot go into both muscle and eggs, this may overestimate the dose from either poultry or eggs. Potential differences in gastrointestinal absorption of uranium from food versus water were not taken into consideration in this analysis. It is not known whether this might over- or underestimate the absorbed dose of uranium from poultry and eggs. There appears to be an adequate margin of safety, even if the estimated dose is slightly underestimated.

Based on these values it is not likely that poultry or eggs are a significant contributor to uranium exposure provided that another (uranium-free) source of drinking water is consumed by people eating these chicken products.

Child Health Considerations

In communities where there are concerns regarding exposures to hazardous chemicals, the many physical differences between children and adults demand special emphasis. In this study, children are the main focus of our concern. Children drinking this water are at greater risk than adults from exposure to uranium in water. A child's lower body weight and higher intake rate per unit body weight results in a greater dose of uranium per unit of body weight. The levels of uranium in the current water system are high enough to be considered a public health hazard for all young children, those who weigh 15 kg or less.

Conclusions

1. Uranium in drinking water from the Mission Creek Water System poses *a public health hazard* to children who consume the water and food products produced using the untreated water at the current measured concentrations. The health effect of concern is reversible kidney tubule damage due to the chemical toxicity. Despite being weakly radioactive, the naturally-occurring uranium in the water does not pose a cancer risk. Since the school has recently installed a reverse osmosis system, there is *no public health hazard* to children at the school, but the hazard remains for children in area households.
2. Eating leafy vegetables and root vegetables grown using the water can contribute to children's total uranium exposure and consumption should be limited.
3. Eating poultry and eggs grown using the water may contribute to children's total uranium exposure and consumption should be limited.
4. Adults may be exposed to uranium at levels close to but below the MRL such that *no apparent public health hazard* exists for adults who consume the water alone or who consume both the water and food grown using the water.
5. A new system or permanent treatment system that reduces the uranium level in drinking water to below the MCL is necessary to eliminate the health concerns from uranium exposure.

6. Children who previously drank the water but are no longer drinking it are expected to regain normal kidney function within weeks of cessation, and are not expected to sustain long-term damage. Parents of children who are continuing to drink the untreated water at home should consult with their physician to decide if kidney function testing is warranted. It is likely easier and less expensive for parents to supply these children with an alternative source of water.

Recommendations

1. Children, particularly younger children, should not drink the tap water from the Mission Creek Water System unless it has been properly treated using a system such as reverse osmosis. A treatment system is now installed at the Mt. Hall School. If treatment is not possible in households, then children should be given bottled water or provided water from a source that meets federal drinking water standards.
2. Children should not consume food prepared using the tap water from the Mission Creek Water System unless it has first been treated using a system such as reverse osmosis or distillation or is from a source known to meet federal drinking water standards.
3. There is no reason to believe that bathing, washing clothes, or household cleaning with the water poses a health risk.
4. Uranium residue is left in soil that has been watered with uranium-containing water. Therefore, root vegetables and leafy greens from soil previously watered with uranium-containing water should be consumed in moderation by adults, even if purified water is used to water the new plants. However, the contaminated soil can be replaced with new soil at root depth (approximately two feet). The consumption of these vegetables by children should also be limited if grown using untreated water from the Mission Creek Water System. Other vegetables and fruits do not significantly concentrate uranium and may be grown for consumption using the tap water.
5. Chickens and eggs raised on uranium-containing water can be consumed and do not represent a health risk to adults. Children's consumption of the chickens and their eggs should be limited.
6. The new well water system should be put into operation as soon as is practical so that the community's exposure to uranium can be reduced.
7. If you are concerned about you or your children's health, please talk with your health care provider.

Public Health Advice/Public Health Action Plan

1. Parents will be advised to give children treated water, bottled water, or water that meets federal standards to drink, to prepare all foods for children using treated water, bottled water, or water that meets federal standards , and to limit feeding children leafy greens, root vegetables, and chicken products grown using the water.
2. School officials have installed a reverse osmosis treatment system at Mt. Hall School and are now providing water that meets federal standards.

3. Parents of children who are continuing to drink the untreated water at home should consult with their physician to decide if kidney function testing is warranted. It is likely easier and less expensive for parents to supply these children with an alternative source of water.
4. Residents should be advised that heating or boiling the water does not reduce the amount of uranium.
5. All residents served by this water system will be sent this health consultation via direct mailing.
6. This health consultation will also be available at the Mount Hall School library, the Bonners Ferry library, and directly from BCEH.
7. All residents will be invited to a public meeting to ask questions about the findings.
8. All residents will be encouraged to drink treated water, bottled water, or water that meets federal standards until the new well is operational.
9. Residents will be encouraged to contact BCEH with further questions.

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Appendix A: Reference Values for Calculations

Parameter	Value	Units	Comments
Uranium	30	μg/L	US EPA Maximum Contaminant Level for Drinking Water
Alpha particles	15	piC/L	US EPA Maximum Contaminant Level for Drinking Water
Ingestion Rate—Adult	2	L/day	
Ingestion Rate—Child	1	L/day	
Ingestion Rate--Infant	0.64	L/day	
Body Weight--Adult	70	kg	
Body Weight--Child	15	kg	Approx. 5 years old
Body Weight--Infant	4.5	kg	
NOAEL	none		
LOAEL	2.8	mg/kg/day	Based on renal toxicity in the New Zealand white rabbit
RfD	2.0×10^{-4}	mg/kg/day	Chronic exposure; Based on NOAEL
ATSDR Intermediate MRL	2.0×10^{-3}	mg/kg/day	15-364 days of exposure
Health outcome considered			Kidney damage

Appendix B:
Exposure Calculations, Leafy Greens and Root Vegetables

- *The following are the highest estimates for daily per body weight lettuce and potato consumption as published by EPA:*

Lettuce ingestion rate, adult = 264 mg/kg/day
Lettuce ingestion rate, child = 247 mg/kg/day

Potato ingestion rate, adult = 88 mg/kg/day
Potato ingestion rate, child = 223 mg/kg/day

- *Dose Calculations*

Lettuce
Adult
(0.000264 kg food/kg body weight/day) * (216 μg uranium /kg food) = 0.057 μg uranium/kg body weight/day = 0.57×10^{-4} mg/kg/day.
Child
(0.000247 kg food/kg body weight/day) * (216 μg uranium/kg food) = 0.053 μg uranium/kg body weight/day = 0.53×10^{-4} mg/kg/day.

Potato
Adult
(0.00088 kg food/kg body weight/day) * (216 μg uranium/kg food) = 0.19 μg uranium/kg body weight/day = 0.19 x 10^{-3} mg/kg/day.
Child
(0.00223 kg food/kg body weight/day) * (216 μg uranium/kg food) = 0.48 μg uranium/kg body weight/day = 0.48 x 10^{-3} mg/kg/day.

Appendix C:
Exposure Calculations, Poultry Meat and Eggs
(Fromm, 2006)

- *The U.S. EPA has published estimates of annual ingestion rates of poultry and eggs for adults and children (EPA, 1997):*

Egg ingestion rate, adult = 14.9 kg/yr
Egg ingestion rate, child = 2.3 kg/yr

Poultry ingestion rate, adult = 35.8 kg/yr
Poultry ingestion rate, child = 5 kg/yr

- *Dose Calculations*

Uranium concentrations can be estimated in chicken muscle tissue and chicken eggs using the following equation (DOE, 1999):

$$C = BTF_{water-tissue} \times C_{water} \times IR_{water} \times f_w$$

In which:

C = Concentration of uranium in either poultry muscle (C_p) or eggs (C_e); (µg/kg)
BTF = Biotransfer factor from water to poultry muscle or from water to eggs (day/kg)
C_{water} = Concentration of uranium in water (µg/L)
IR_{water} = Ingestion rate of water in L/day by chicken (L/day)
f_w = Fraction of water ingested that is contaminated (unitless)

For this analysis variables had the following values:

$BTF_{water\text{-}muscle}$ = 1 Bq/kg poultry muscle per Bq/d intake (IAEA, 1994 as reported in DOE 2003). As this transfer factor is unity, meaning that all of the uranium activity ingested by the animal is assumed to be transferred to muscle, it is very conservative. For the current analysis this value was converted to 1 µg/kg poultry muscle per µg/day intake, or 1 day/kg on a wet weight basis.

$BTF_{water\text{-}egg}$ = 1 day/kg also, based on the same source as above

C_{water} = 72 µg/L

IR_{water} = 0.2 L/day. Daily water ingestion by chicken (NAS, 1972).

f_w = 1, as all water ingested is assumed to be contaminated.

Based on these assumptions:

Estimated concentration of uranium in both eggs and poultry (C_e and C_p) = 14.4 µg/kg

Converting these yearly ingestion rates to daily ingestion rates, it can be seen that the daily dose of uranium from consumption of poultry and eggs for both adults and children is significantly less than the dose from drinking water that contains uranium at the MCL of 30 µg/L.

Adults: 14.9 kg eggs/yr × 1 yr/365 days = 0.04 kg eggs/day

35.8 kg poultry/yr × 1 yr/365 days = 0.09 kg poultry/day

0.13 kg eggs and poultry/day × 14.4 µg/kg = 2.6 µg Uranium/day

This dose of uranium can be compared to a dose of 60 µg/day from drinking 2 L of water per day containing uranium at the MCL of 30 µg/L.

Children: 2.3 kg eggs /yr × 1 yr/365 days = 0.0063 kg eggs/day

5 kg poultry/yr × 1 yr/365 days = 0.014 kg poultry/day

0.02 kg eggs and poultry/day × 14.4 µg/kg = 0.29 µg Uranium/day

This dose can be compared to the dose of 30 µg/day a child would receive from drinking 1 L of water at the MCL.

Certification

This health consultation, Mission Creek Water System—Evaluation of Uranium and Alpha Particles in Drinking Water Serving Mt. Hall School and Surrounding Homes, was prepared by the Idaho Division of Health (IDOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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Appendix D: Glossary

Acute Occurring over a short time.

Agency for Toxic Substances and Disease Registry (ATSDR)
The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.

BCEH Bureau of Community & Environmental Health.

Carcinogen A substance that causes cancer.

Chronic Occurring over a long time (more than 1 year).

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

Contaminant A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Drinking Water Equivalent Level (DWEL)
Intermediate drinking water quality parameter, derived from the RfD. The DWEL is multiplied by a percentage of the total daily exposure contributed by drinking water (often 20 percent) to determine the MCLG.

Dose The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

EPA The U.S. Environmental Protection Agency.

Exposure Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute**], of intermediate duration [**intermediate**], or long-term [**chronic**].

FDA The U.S. Food and Drug Administration.

Hazardous substance Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.

Health Advisory (HA) Health Advisories (HA's) provide information on contaminants that do not have an MCL but that can cause human health effects and are known or anticipated to occur in drinking water.

IDEQ The Idaho Department of Environmental Quality.

IDHW The Idaho Department of Health & Welfare.

Indeterminate public health hazard The category used in ATSDR’s health consultation documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Ingestion rate The amount of an environmental medium which could be ingested typically on a daily basis. Units for ingestion rate are usually liter/day for water, and mg/day for soil.

Lowest Observed Adverse Effect Level (LOAEL) The lowest tested dose of a substance that has been reported to cause measurable adverse health effects in people or animals.

Maximum Contaminant Level (MCL) Enforceable drinking water quality standard set by US Environmental Protection Agency (EPA).

Maximum Contaminant Level Goal (MCLG) Non-enforceable drinking water quality standard, used to determine the MCL.

Media Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Monitoring wells Special wells drilled at locations on or off a hazardous waste site so groundwater can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.

No apparent public health hazard A category used in ATSDR’s health consultation reports for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No Observed Adverse Effect Level (NOAEL) The highest tested dose of a substance that has been reported to have no measurable adverse health effects on people or animals.

No public health hazard A category used in ATSDR’s public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Oral Reference Dose (RfD) An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.

Organic Compounds composed of carbon, including materials such as solvents, oils, and pesticides which are not easily dissolved in water.

Public Health Hazard A category used in ATSDR's health consultation reports for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances that could result in harmful health effects.

Route of exposure The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor A number that is used to account for uncertainty in the data and/or severity of the health effect when calculating an oral RfD or other level or dose to which humans can safely be exposed. Safety factors generally range from 1-100.