Health Consultation

DESERT VIEW ESTATES WATER SYSTEM

Evaluation of Uranium and Alpha Particles in Drinking Water

KUNA, ADA COUNTY, IDAHO

SEPTEMBER 7, 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.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

DESERT VIEW ESTATES WATER SYSTEM

Evaluation of Uranium and Alpha Particles in Drinking Water

KUNA, ADA COUNTY, IDAHO

Prepared By:

Idaho Division of Health
Bureau of Community and Environmental Health and
Agency for Toxic Substances and Disease Registry
Division of Regional Operations

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 collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

Summary

Background
For several years, the drinking water from the wells that serve the Desert View Estates subdivision have been found to have levels of uranium that are approximately 2-3 times higher than the 2004 EPA safe drinking water standard for uranium. The Desert View Estates Water Corporation continues to test these wells and report the findings to the Idaho Department of Environmental Quality (IDEQ) as required by law. The Bureau of Community and Environmental Health (BCEH) was asked by subdivision residents to evaluate the levels of uranium in their drinking water and determine if there might be any health effects from exposure to uranium through drinking the water at Desert View Estates.

What is uranium?
Uranium is a naturally-occurring mildly-radioactive element that is commonly found in rocks, soil, and water. The amount of uranium in Idaho drinking water varies widely. However, in most cases, drinking water in Idaho meets EPA's safe drinking water standard.

Why does Desert View Estates' water have higher levels of uranium?
Factors that may explain the levels of uranium found in Desert View Estates' water include naturally high levels of uranium-containing rock in this geographic area and high concentrations of uranium at the depths where the wells are drilled. The Desert View Estates Water Corporation has proposed drilling a new, deeper well in an attempt to find water with a lower level of uranium. However, the new well is not expected to be operational until approximately 2009.

How can uranium affect my health?
While the uranium at levels found in Desert View Estates' water is slightly radioactive, there is no evidence that these levels would cause cancer. Numerous human and animal studies support this finding.

The greatest health risk from large intakes of uranium is damage to the kidneys. At the levels of uranium found in drinking water at Desert View Estates, the concern is for young children. At the current levels, the uranium poses a *public health hazard* to children because they may experience some minor kidney damage; however, it is not expected that there would be outward symptoms of this damage. Once exposure has stopped, the kidneys return to normal function and any damage is generally reversed. For adults, it is possible that similar kidney changes could occur, such that an *indeterminate public health hazard* exists; however, at the levels present in this water it is unlikely. If any changes did occur in adults, they would also reverse once exposure stopped. If you are concerned about kidney damage to you or your children, please contact your health care provider.

Can uranium affect plants, livestock or household animals?
Uranium can be absorbed and concentrated in some plants, including vegetables, if the water or the soil contains uranium. Root vegetables (e.g., radishes, carrots, potatoes) and leafy greens (e.g., lettuce, spinach) absorb the most uranium. At levels found in the Desert View Estates water, it is suggested that residents do not grow these vegetables unless clean soil and an alternative water source are used. Fruit trees and other fruits (including tomatoes) do not absorb much uranium and are not considered to pose a health concern.

Animals including livestock, chickens and household pets that drink water containing uranium are not expected to have any noticeable health effects from the water. Chickens and other animals that drink the water that are used for human consumption are fine for adults to eat in moderate quantities. The eggs that chickens produce are also safe for adult consumption. Children should be limited in their consumption of these chicken products due to their lower body weight in comparison to the amount they eat.

What does BCEH recommend?
Until the new Desert View Estates' community well has been installed and uranium levels reduced, BCEH recommends the following:

- Children, particularly young children, should not drink the tap water or consume food prepared using the tap water.
- Children should only drink an alternative source of water, such as bottled water.
- There is no reason to believe that bathing, washing clothes, or household cleaning with the water poses a risk to health.
- 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 tap water. Other vegetables and fruits do not significantly concentrate uranium and may be grown for consumption using the tap water.
- Chickens and eggs raised on uranium-containing water can be consumed and do not represent a health risk to adults. Consumption of chicken and eggs from the community by children should be limited.
- 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.
- If you are concerned about you or your children's health, please talk with your health care provider.

Residents with further questions or concerns are encouraged to contact Dr. Kai Elgethun, BCEH at 208-334-5682 or elgethun@dhw.idaho.gov

Purpose and Statement of Issues

In July 2006, a resident of Desert View Estates subdivision located in Kuna, Idaho expressed concern to the Bureau of Community and Environmental Health (BCEH) about the presence of uranium in the subdivision's water system. To gather information on the levels of uranium in the water system, BCEH contacted the Idaho Department of Environmental Quality (IDEQ). IDEQ, the agency responsible for ensuring that public and community water systems are in compliance with water quality standards, confirmed that the three wells at Desert View Estates have consistently tested above the federal drinking water standard for uranium. IDEQ also noted that since December 2004, Desert View Estates has been under a consent order from IDEQ to resolve the problem of naturally-occurring uranium in the community's drinking water supply.

In April 2007, BCEH was asked by the Desert View Estates Water Corporation (DVEWC) shareholders to give a brief presentation at the annual board meeting regarding health effects of uranium exposure. At this meeting, shareholders requested that BCEH conduct a health consultation to better address the concerns of shareholders. The purpose of this document is to answer the community's questions regarding the amount of uranium in their drinking water.

Natural uranium is a chemical substance that is slightly radioactive. Scientists have never detected harmful effects in humans (such as cancer) from the radiation associated with low levels of natural uranium, although some may be possible. Scientists have, however, seen effects in humans from the chemical properties of uranium. A few people have developed signs of kidney disease after intakes of large amounts of uranium. Animals have also developed kidney disease after being treated with large amounts of uranium. Since natural uranium is only weakly radioactive, it is not likely to cause cancer. No human cancer of any type has ever been reported as a result of exposure to natural uranium in water. Enriched uranium that is used to produce nuclear energy and is used in nuclear warheads has been shown to cause human cancer, but it is much more strongly radioactive than natural uranium.

The federal drinking water standard for uranium is the Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) which is set at 30 µg/L (micrograms per liter). The amount of uranium that has been measured in drinking water in different parts of the United States by EPA is generally less than 1.5 µg/L. EPA has found that the levels of uranium in water in different parts of the United States are extremely low in most cases, and that water containing these low levels of uranium is safe to drink. Heating or boiling water does not remove uranium or lessen its radioactivity.

While most exposure to uranium in the Kuna 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. When a person eats

food and drinks liquids containing uranium, most of it is excreted from the body in feces within a few days and never enters the blood. The small portion of uranium that enters the blood leaves the body through the urine within a few days. 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, mainly in their bones.

Background

In December 2001, the EPA set a new MCL for uranium of 30 µg/L in water systems that became effective in 2004. Since the sampling event in April 2003, the drinking water from the wells that serve the Desert View Estates subdivision has exceeded the current (2004) MCL. Since 2004, levels have been approximately 2-3 times higher than the MCL. The Desert View Estates Water Corporation has continued to test these wells and report the findings to the IDEQ as required by law.

Site Description

Desert View Estates is a semi-rural housing subdivision located approximately 4 miles east of the town of Kuna in western Ada County (Figures 1 and 2). Most home lots are approximately 1 acre in size. There are 220 homes in the subdivision that receive drinking and irrigation water from a dedicated water system fed by three wells. DVEHOA has received a loan from IDEQ to drill a new, deeper well to supply the subdivision with drinking water. However, this well will not be online until 2009 at the earliest. The existing three wells will continue to be used for outdoor irrigation in the community after the new drinking water well is in service.

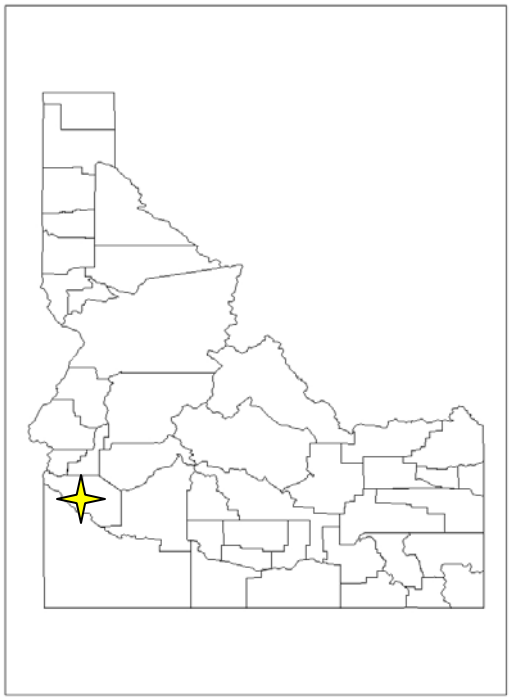

Figure 1: Map of Idaho showing location of Desert View Estates in Ada County.

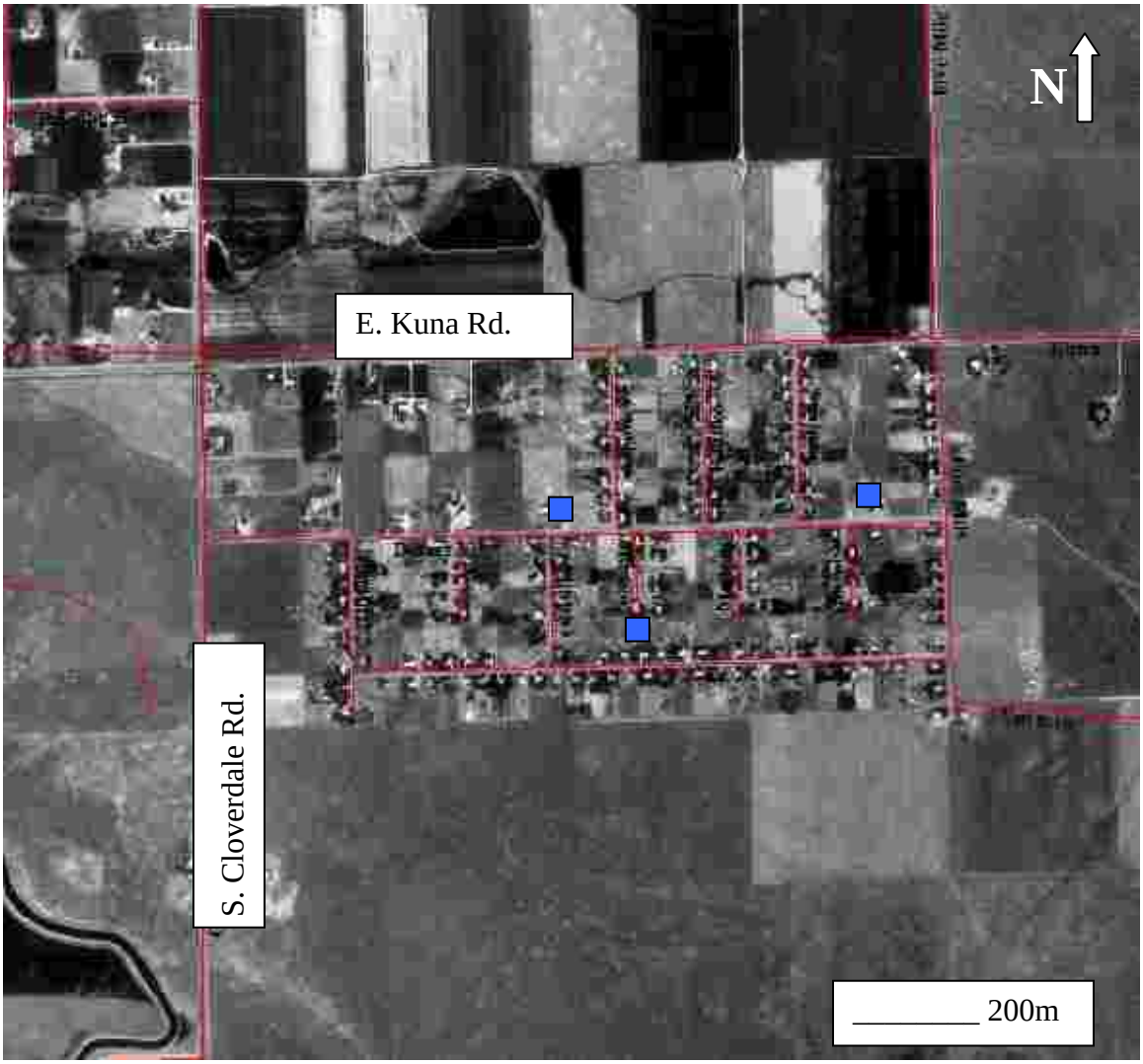

Figure 2: Aerial photograph of Desert View Estates. Blue squares represent locations of the 3 active wells.

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 dissolving out of rocks and soil that the water runs through. Natural uranium is radioactive but poses little radioactive danger because it gives off very small amounts of radiation; thus, cancer risk due to radioactivity is normally not a concern. However, natural uranium can pose a chemical health risk due to its ability to damage the kidneys.

Route of Exposure

Drinking the water appears to be the only feasible route of significant exposure to uranium at Desert View Estates. However, eating the plants irrigated by the water or eating the animals or the animal products, such as eggs, may contribute 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 are being exposed to uranium.

EPA Drinking Water Standards

The EPA is responsible for setting drinking water standards, called Maximum Contaminant Levels or 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.

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. Annual average gross alpha activity at Desert View Estates did not exceed the MCL in any given year, and in most cases were approximately zero, so further discussion of this measure is not warranted.

Sampling

Samples were collected by Desert View Estates Water Corporation 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.

Results

Reference values and values used in calculations are shown in Appendix A. Uranium concentrations (in µg/L) for the 3 drinking water wells are shown in Tables 1-3. The average concentration (by individual well) over 5 years of periodic sampling of the 3 wells ranged from 63.9-73.9 µg/L, and the maximum concentration ranged from 84-108 µg/L. The average concentration for the 3 wells consistently exceeded the MCL, at levels that were more than double the MCL.

The dose calculations in Tables 1-3 are for children since children are the most susceptible population. 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 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 from which well the water was drawn. These values are evaluated below in the next section.

Table 1: Uranium concentrations in Well #2, 2002-2007.

		Uranium (MCL = 30 µg/L)	
Date	**Source**	**µg/L**	**% of MCL***
8/28/02	WELL #2	0.1	0.3
4/21/03	WELL #2	84.0	280.0
8/13/04	WELL #2	76.0	253.3
10/6/04	WELL #2	79.0	263.3
6/13/05	WELL #2	83.0	276.7
8/1/05	WELL #2	69.0	230.0
11/7/05	WELL #2	72.0	240.0
3/8/06	WELL #2	70.0	233.3
8/17/06	WELL #2	82.0	273.3
11/17/06	WELL #2	66.0	220.0
3/6/07	WELL #2	61.0	203.3
6/7/07	WELL #2	81.0	270.0

Average	68.6	228.6
Average Estimated Dose (mg/kg/day) child	0.0046	
Maximum Estimated Dose (mg/kg/day) child	0.0056	

Table 2: Uranium concentrations in Well #3, 2002-2007.

		Uranium (MCL = 30 µg/L)	
Date	**Source**	**µg/L**	**% of MCL***
8/28/02	WELL #3	0.1	0.3
4/21/03	WELL #3	90.0	300.0
8/13/04	WELL #3	73.0	243.3
10/6/04	WELL #3	89.0	296.7
6/13/05	WELL #3	88.0	293.3
8/1/05	WELL #3	90.0	300.0
10/17/05	WELL #3	47.5	158.3
10/24/05	WELL #3	61.0	203.3
11/7/05	WELL #3	89.0	296.7
3/8/06	WELL #3	3.0	10.0
6/7/06	WELL #3	106.0	353.3
8/17/06	WELL #3	108.0	360.0
11/17/06	WELL #3	99.0	330.0
3/6/07	WELL #3	91.0	303.3

Average	73.9	246.3
Average Estimated Dose (mg/kg/day) child	0.0049	
Maximum Estimated Dose (mg/kg/day) child	0.0072	

Table 3: Uranium concentrations in Well #4, 2002-2007.

		Uranium (MCL = 30 µg/L)	
Date	**Source**	**µg/L**	**% of MCL***
8/28/02	WELL #4	0.1	0.3
4/21/03	WELL #4	57.0	190.0
8/13/04	WELL #4	56.0	186.7
10/6/04	WELL #4	51.0	170.0
6/13/05	WELL #4	71.0	236.7
8/1/05	WELL #4	60.0	200.0
11/7/05	WELL #4	92.0	306.7
3/8/06	WELL #4	74.0	246.7
6/7/06	WELL #4	79.0	263.3
8/17/06	WELL #4	75.0	250.0
11/17/06	WELL #4	62.0	206.7
3/6/07	WELL #4	90.0	300.0

Average	63.9	213.1
Average Estimated Dose (mg/kg/day) child	0.0043	
Maximum Estimated Dose (mg/kg/day) child	0.0061	

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 developed an oral exposure MRL for intermediate exposure duration only. However, according to ATSDR, 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 Drinking Water Standard MCL, as well. So the MRL concentration for children is in agreement with the MCL, indicating protectiveness for both adults and children with chronic exposure.

The average concentration for the 3 wells was consistently more than double the MCL. Using the average values, there is cause for concern, especially for children. Using the maximum values (as high as 108 μg/L), there is even greater concern. Similar doses given to rabbits have been shown to produce changes in kidney tubular function (Kurttio et al. 2002). The particular animal tested is the New Zealand white rabbit and 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. Following this repair, tissue appeared no different than undamaged kidney tissue. The type of kidney damage caused by uranium thus appears to be completely reversible.

Average exposure levels to adults drinking the water at Desert View Estates are almost the same as the MRL concentration for adults, about 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 raise fruits and vegetables using the water and had concerns about the uranium uptake of plants into edible tissues. 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 Desert View Estates, 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. It is anticipated that soils watered with the Desert View 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 108 μg/L is used in these calculations to give a protective estimate of risk.

Leafy Greens and Root Vegetables

Because 1 L of water weighs 1 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 108 μg/Kg or 324 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.

Doses of metals such as uranium are most often expressed in milligrams (mg) per kilogram (kg) of body weight ingested per day. An adult dose from consumption of a typical amount of lettuce irrigated with the water at Desert View Estates would be approximately 0.86×10^{-4} mg/kg/day. A child dose from eating lettuce would be approximately 0.8×10^{-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 23 times lower for adults and 25 times lower for children. If all other sources of dietary uranium were eliminated, a 154 lb (70 kg) adult would need to eat 1.02 pounds of lettuce per day and a 33 lb (15 kg) child would need to eat 0.19 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 overall daily uranium dose.

An adult dose from consumption of a typical amount of potatoes irrigated with the water at Desert View Estates consumption would be 0.28×10^{-3} mg/kg/day. A child dose from eating potatoes would be 0.7387×10^{-3} mg/kg/day. The MRL, by comparison, is 2×10^{-3} mg/kg/day, thus the potato uranium concentration is about 7 times lower for adults and 2.5 times lower for children. If all other sources of dietary uranium were eliminated, a 154 lb (70 kg) adult would need to eat 0.95 pounds of potatoes per day and a 33 lb (15 kg) child would need to eat 0.18 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 overall daily uranium dose.

Squashes, 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. 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 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 certainly 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 raise chickens using the water and had concerns about the uranium concentration of chicken meat and eggs. 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. Jeff Fromm of IDEQ (Fromm 2006), an adult would have to consume 6.6 lbs (3 kg) of

chicken products in one day, and a child would have to consume 2.8 lbs (1.29 kg) in one day to equal a typical dose from drinking water containing uranium at the MCL. At the maximum water concentration (108 µg/L), an adult would have to consume 1.78 lbs of chicken products per day, and a child would have to consume 0.78 lbs of chicken products per day to receive this same dose. See Appendix C for detailed calculations.

The biotransfer factors are not strictly correct from a mass balance standpoint, since 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 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. Children could be at greater risk than adults from certain kinds of exposure to hazardous chemicals. A child's lower body weight and higher intake rate results in a greater dose of hazardous chemical 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 children.

Conclusions

1. Uranium in drinking water from the 3 wells serving the Desert View Estates municipal water system poses *a public health hazard* to children who consume the water and food products produced using the water at the current measured concentrations.
2. Eating leafy vegetables and root vegetables grown using the water can significantly 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 the MRL such that *an indeterminate 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 that reduces the uranium level in drinking water to below the MCL is necessary to eliminate the health concerns from uranium exposure.

Recommendations

- Children, particularly young children, should not drink the tap water or consume food prepared using the tap water.

- Children should only drink an alternative source of water, such as bottled water.
- There is no reason to believe that bathing, washing clothes, or household cleaning with the water poses a risk to health.
- 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 tap water. Other vegetables and fruits do not significantly concentrate uranium and may be grown for consumption using the tap water.
- Chickens and eggs raised on uranium-containing water can be consumed and do not represent a health risk to adults. Consumption of chicken and eggs from the community by children should be limited.
- 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.
- 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 bottled water only, to prepare all foods for children using bottled water only, and to limit feeding children leafy greens, root vegetables, and chicken products grown using the water.
2. Residents should be advised that heating or boiling the water does not reduce the amount of uranium.
3. All residents served by this water system will be sent this health consultation via direct mailing.
4. This health consultation will also be available at the public library in Kuna, and from the Desert View Estates home owners' association.
5. All residents will be invited to a public meeting to ask questions about the findings.
6. All residents will be encouraged to drink bottled water until the new well is operational.
7. Residents will be encouraged to contact BCEH with further questions.

Authors of Report

Kai Elgethun PhD, MPH
State Public Health Toxicologist
Health Assessor
Idaho Division of Health
Bureau of Community and Environmental Health

Reviewers of Report

Richard Kauffman, MS
Senior Regional Representative, Region 10
Division of Regional Operations
Agency for Toxic Substances and Disease Registry

Jim Vannoy, MPH
Program Manager
Idaho Division of Health
Bureau of Community and Environmental Health

Cameron Stephenson, MPH
Health Educator
Idaho Division of Health
Bureau of Community and Environmental Health

Kara Stevens
Section Manager
Idaho Division of Health
Bureau of Community and Environmental Health

Elke Shaw-Tulloch, MHS
Bureau Chief
Idaho Division of Health
Bureau of Community and Environmental Health

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for uranium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for ionizing radiation. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

DOE. 2003. A Compendium of Transfer Factors for Agricultural and Animal Products. Pacific Northwest National Laboratory. Prepared for the U.S. Department of Energy. PNNL-13421. June 2003.

DOE. 1999. Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program. Prepared by the University of Tennessee, Knoxville, Tennessee for the U.S. Department of Energy, Office of Environmental Management. Bechtel Jacobs Company LLC. BJC/OR-271. April 1999.

EPA. 1997. Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa.

Fromm, Jeff. 'Acute risks from uranium in drinking water'. IDEQ internal memo to Jerri Henry, May 12, 2005.

Fromm, Jeff. 'Uranium in poultry and eggs from chickens provided water high in uranium'. IDEQ internal memo to Jerri Henry and Brandon Lowder, August 2, 2006.

Hayes AC, Fresquez PR and WF Whicker. Uranium uptake study, Nambe, New Mexico: Source Document. LA-13614-MS: Los Alamos National Laboratory, October 2000.

IAEA. 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Tech. Rep. Series No. 364. International Atomic Energy Agency, Union of Radioecologists. Vienna, Austria.

Kurttio P, et al. 2002. Renal effects of uranium in drinking water. Environ Health Perspect 110(4): 337–42.

NAS. 1972. Water for Livestock Enterprises, pp. 304-318 in *Water Quality Criteria 1972*, PB-236-199, National Academy of Sciences.

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) * (324 μg uranium /kg food) = 0.086 μg uranium/kg body weight/day = 0.86×10^{-4} mg/kg/day.
Child
(0.000247 kg food/kg body weight/day) * (324 μg uranium/kg food) = 0.080 μg uranium/kg body weight/day = 0.8×10^{-4} mg/kg/day.

Potato
Adult
(0.000882 kg food/kg body weight/day) * (324 μg uranium/kg food) = 0.28×10^{-3} mg/kg/day.
Child
(0.00228 kg food/kg body weight/day) * (324 μg uranium/kg food) = 0.7387 μg uranium/kg body weight/day = 0.7387×10^{-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:

$BTF_{water-muscle}$ = 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.

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

C_{water} = 100 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) = 20 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 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 × 20 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 × 20 µg/kg = 0.4 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, Desert View Estates Water System - Evaluation of Uranium and Alpha Particles in Drinking Water in Kuna, Idaho, 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.

Robert B. Knowles, M.S. REHS
Technical Project Officer, DHAC, CAPEB
Division of Health Assessment and Consultation
Agency for Toxic Substances & Disease Registry

Gregory V. Ulirsch for AW
Alan W. Yarbrough, M.S.
Team Lead, DHAC, CAPEB
Division of Health Assessment and Consultation
Agency for Toxic Substances & Disease Registry

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.