Division of Public Health Services

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DOUGLAS A. DUCEY, GOVERNOR
CARA M. CHRIST, DIRECTOR

May 19, 2016

[redacted]

Dear Ms. [redacted],

RE: Drinking Water Analytical Results

The Arizona Department of Health Services (ADHS) received your request to evaluate the quality of the water collected from your home on 5/3/2016. The sample was analyzed by the Legend Technical Services, Inc. The testing result showed that the arsenic level in the water sample was 1.18 milligrams per liter (mg/L). You indicated that the water is not used for drinking or cooking, and wanted to know if the water can be used for other purposes, such as drinking water for horses, filling the swimming pool, and for bathing and showering. ADHS conducted an evaluation and the following summarizes our methodology and assessment results.

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. Third, for the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) a source of contamination
2) a medium such as soil or ground water through which the contaminant is transported
3) a point of exposure where people can contact the contaminant
4) a route of exposure by which the contaminant enters or contacts the body
5) a receptor population

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In eliminated pathways, at least one of the five elements is or was

missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

The groundwater is used to fill the swimming pool and for domestic purposes, except drinking and cooking. Typical domestic water exposures to contaminants include inhalation and dermal exposures during bathing/showering, and ingestion exposures from drinking and using water for cooking. Adults and children may also ingest water incidentally from daily activities such as showering, bathing, teeth brushing and washing dishes.

Metals (such as arsenic) tend not to be absorbed through the skin, and are not likely to be inhaled by people as aerosol while showering because they are not volatile (i.e. do not evaporate). Therefore, based on the usages of the water, ADHS evaluated the exposures by incidental ingestion from daily activities and swimming.

Table 1. Exposure pathway analysis.

Exposure Pathway Elements					Time frame	Type of Exposure Pathway
Source	Media	Point of exposure	Route of exposure	Potentially exposed population		
Groundwater Well	Groundwater	Residence tap	Incidental Ingestion	Residents	Past	Completed
					Current	Completed
					Future	Potential

Comparison to Health-based Comparison Values for Groundwater Sample

Health-based comparison values (CVs) are screening tools used to evaluate environmental data relevant to exposure pathways. The comparison values are quite conservative, and usually include uncertainty factors that account for the most sensitive populations. Adverse health effects are not expected to occur if an exposure concentration/dose is below a CV. However, an exposure concentration/dose at or above the CV does not mean adverse effects will occur. Rather, it means that there is a need to conduct a site-specific exposure scenario evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure.) Therefore, CVs should not be used to predict the occurrence of adverse health effects without looking at site-specific conditions. CVs are only used to help determine what contaminants need to be evaluated in more detail.

The analytical results were compared to the CVs such as Environmental Media Evaluation Guides (EMEGs) and Cancer Risk Evaluation Guides (CREGs) which are developed by the Agency of Toxic Substances and Disease Registry (ATSDR). EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic health effects based on ATSDR evaluation. CREGs are estimated contaminant concentrations that would be expected to cause no more than one additional cancer in a million persons exposed during their lifetime.

Table 2. Selection for the contaminant of concern

Chemical	Detected Concentration (mg/L)	Non-cancer Comparison Value (mg/L) – Type	Cancer Comparison Value (mg/L) – Type	Is it a Contaminant of Concern?
Arsenic	1.18	11 – EMEG[a]	0.023 – CREG[b]	Yes

a. EMEG: Environmental Media Evaluation Guide for children, developed by ATSDR, is an estimated contaminant concentration in a media where non-cancerous health effects are unlikely.
b. CREG: Cancer Risk Evaluation Guide, developed by ATSDR, is a media-specific comparison value that is used to identify concentrations of cancer causing substances that are unlikely to result in an increase of cancer rates in an exposed population after a lifetime of exposure.

Arsenic is selected for further evaluation because its concentration is above its health-based comparison values developed for drinking water. Because the well water is not used for drinking, in order to evaluate the potential health effects, ADHS further calculated the daily exposure doses from incidental ingestion such as brushing teeth, washing dishes etc.

Public Health Implications*: This section will provide general toxicological information and site-specific exposure evaluation.*

Arsenic is a naturally occurring element widely distributed in the earth's crust and can be found in air, water, and soil. Arsenic exists as inorganic arsenic, organic arsenic and arsine gas. In general, organic arsenic is less toxic than inorganic arsenic. The general population is likely to be exposed to arsenic through food and water ingestion. Several studies have linked ingestion of inorganic arsenic to increases in skin cancer and cancer in the liver, bladder, and lungs. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans (ATSDR 2007).

Incidental Ingestion

Non-Cancerous Health Effects

A Minimal Risk Level (MRL) is an estimate of daily human exposure to a substance that is not likely to pose a measurable risk of adverse noncancerous health effects. ATSDR established a chronic Minimal Risk Level (MRL) of 0.0003 mg/kg/day based on the incidence of Blackfoot Disease (a gangrene of the extremities) and dermal lesions (hyperkeratosis and hyperpigmentation) in a population exposed to high levels of arsenic in well water in Taiwan.

The estimated daily dose from incidental ingestions are listed below. It showed that the estimated daily exposure doses for children from daily activity and swimming exceeded the MRL. The estimated daily exposure dose for adults from daily activity did not exceed the MRL. The estimated daily exposure dose for adults from swimming was slightly above the MRL.

Exposure Scenario	Receptor	Estimated Daily Exposure Dose (mg/kg/day)	ATSDR MRL (mg/kg/day)
Incidental ingestion from daily activity[1]	Children	0.0038	0.0003
	Adults	0.00014	
Incidental ingestion from swimming[2]	Children	0.0022	
	Adults	0.0004	

1. Children (ages 0-6 years old) were assumed to incidentally ingest 50 mL of water per day; adults were assumed to incidentally ingest 10 mL of water per day.
2. Adults and children were assumed to ingest 100 mL of water per day (i.e. 50 mL/hour × 2 hour/day) from swimming based on ATSDR's recommendation (ATSDR 2005). It also assumed that they spend 100 days per year in the swimming pool.

Cancerous Health Effects

EPA has calculated an oral cancer slope of 1.5 $(mg/kg/day)^{-1}$ for arsenic (EPA 2012). ADHS conducted a cancer risk evaluation by using EPA cancer slope factor with the estimated exposure dose. Based on the arsenic concentrations found in your report, estimated adult cancer risks from incidental ingestions from daily activities and swimming were $1x10^{-4}$ and $2.6x10^{-4}$, respectively. These calculated values may not represent actual risk, but allows regulatory and public health officials a way to identify potential cancer risks.

Cancer risks are explained in terms of the likelihood that an additional case of cancer will occur in a population. For example, one additional cancer case in 1,000,000 exposed individuals indicates that there is a very low cancer risk. Cancer is a common illness, with many different forms that result from a variety of causes; not all are fatal. According to the American Cancer Society, men have almost a 1 in 2 lifetime risk of developing cancer, and for women the risk is a little more than a 1 in 3 lifetime risk. This translates to about 500,000 men and a little more than 333,333 women in a population of one million people. Lifetime risk refers to the probability that an individual, over the course of a lifetime, will develop cancer. EPA has established a target excess lifetime cancer risk range of 1 in 1,000,000 to 10,000 (10^{-6} to 10^{-4}) for hazardous waste sites. For example, 10^{-4} excess lifetime cancer risk indicates that there can be one additional cancer case (due to the exposure to the contaminant) in 10,000 exposed individuals. The estimated cancer risks due to incidental ingestion from daily activity and swimming exceeded the EPA's target risk range.

Based on the available information, ADHS does not recommend using the water for daily activities (such as bathing, showering, and washing dishes) and swimming. The water should be only used for flushing toilets and for house cleaning.

Plant Uptake: Fruits and Vegetables

Plants can accumulate arsenic from arsenic-containing soil and water. The amount of arsenic that will accumulate in plant tissues is determined by the soil type, the parts of plants (i.e. roots, leaves, or fruit), and the type of plants. Study showed that arsenic concentration of 1.4 mg/L in irrigation water can inhibit the growth of watermelon plants. Using arsenic-containing water for irrigation may cause arsenic to build up in soil and uptake into plants and vegetables. Therefore, ADHS does not recommend using this water for irrigating gardens.

Horse

Our literature review results found that the upper safe level of water with arsenic for horses or livestock should not exceed 0.2 mg/L. Therefore, ADHS does not recommend using this water for horses.

Based on the evaluation, ADHS does not recommend using the water for

- Daily activities (such as bathing, showering, and washing dishes) and swimming. The water should be only used for flushing toilets and for house cleaning.
- Irrigating gardens.
- Feeding Horses.

If you have any questions, please contact me at linh@azdhs.gov.

Sincerely,

Hsini Lin, ScD, MSPH
Environmental Toxicologist

References:

1. Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for arsenic. Atlanta, GA: US Department of Health Services, Public Health Service.
2. Pineda-Chacon et al. (2014) Arsenic distribution in *Citrullus lanatus* plant irrigated with contaminated water in One Century of the Discovery of Arsenicosis in Latin America (19140-2014)
3. *Livestock water quality: a field guide for cattle, horses, poultry and swine* by North Dakoda State University. Available at: https://www.ag.ndsu.edu/waterquality/livestock/Livestock_Water_QualityFINALweb.pdf

Appendix A

Water Incidental Ingestion Exposure Dose Equation

$$D = \frac{C\ x\ IR\ x\ EF}{BW}$$

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/L)
IR = intake rate of contaminated water (L/day)
EF[1] = exposure factor (unitless)
BW[2] = body weight (kg)

[1] For daily activities, exposure factor assumed to be 350 days / 365 days per year for non-cancer risk, 30 year x 350 days / 70 year x 365 days for cancer risk
[2] Adult body weight assumed to be 80 kg; children body weight assumed to be 15 kg.