Division of Public Health Services

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

July 9, 2015

[redacted]

Dear [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 5/12/2015. ADHS conducted an evaluation to determine if the water can be used for drinking, cooking, laundry, showers, and washing dishes. 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. For the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Available Environmental Data

The water sample was analyzed for volatile organic compounds (VOCs) and metals (i.e. chromium and lead). The Turner Laboratories, Inc. (ADHS License AZ0066) used EPA methods to determine the concentrations of VOCs, and metals (i.e. chromium and lead). The lowest concentration that can be detected (i.e. detection limit) for lead and all VOCs is 0.0005 milligrams per liter (mg/L). The lowest concentration that can be detected for chromium is 0.03 mg/L.

The results showed that all chemicals are under their respective detection limit, except bromodichloromethane (0.0012 mg/L), bromoform (0.0028 mg/L), and dibromochloromethane (0.0028 mg/L). The concentration of total trihalomethanes (TTHMs) is 0.0068 mg/L. This is the sum of the concentrations of the following chemicals: chloroform (ND: not detected in the water sample, assumed to be 0 mg/L), bromodichloromethane (0.0012 mg/L), bromoform (0.0028 mg/L), and dibromochloromethane (0.0028 mg/L).

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 media 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.

Typical potable water exposures to contaminants include dermal exposures from bathing and showering, and ingestion exposures from drinking and using water for cooking. Metals 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). ADHS further evaluated the completed exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration or frequency to result in adverse health effects.

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		
Drinking water	Drinking water	Residences, tap	Ingestion, skin contact, inhalation	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.

ADHS typically uses CV as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination do not pose a risk to human health. If, however, a contaminant is found at levels that are greater than its CV, ADHS designates the pollutant as a *contaminant of concern*, and examines potential human exposures in greater detail.

The potential for exposed persons to experience adverse health effects depends on many factors such as: 1) the amount of chemical to which a person is or has been exposed; 2) the length of time a person is exposed; 3) the route by which a person is exposed (i.e. inhalation, ingestion, or dermal absorption); 4) the health condition of the person; 5) the nutritional status of the person; and 6) if the person is exposed to other chemicals (e.g. chemicals at the work place or chemicals in cigarettes).

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.) The results were also compared to Maximum Contaminant Levels (MCLs) which are enforceable drinking water standards set by the Environmental Protection Agency (EPA). MCL is the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (MCLGs: the level of a contaminant in drinking water below which there is no known or expected risk to health) as feasible using the best available treatment technology and taking cost into consideration.

Bromodichloromethane and dibromochloromethane were selected for further evaluation because the measured concentrations exceeded the CREGs (see Table 2). Bromoform was not selected for further evaluation because the measured concentration did not exceed the heath-based comparison values for noncancer or cancer health effects.

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	MCL[a] (mg/L)	Is it a Contaminant of Concern?
Bromodichloromethane	0.0012	0.2 – EMEG[b]	0.00056 – CREG[c]	0.08[d]	Yes
Bromoform	0.0028	0.2 – EMEG	0.0044 – CREG	0.08[d]	No
Dibromochloromethane	0.0028	0.9 – EMEG	0.00042 – CREG	0.08[d]	Yes
Total Trihalomethanes (TTHMs)	0.0068	—	—	0.08[d]	—

a. MCL: Maximum Contaminant Level, developed by US EPA, is an enforceable standard set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (MCLGs, the level of a contaminant in drinking water below which there is no known or expected risk to health) as feasible using the best available treatment technology and taking cost into consideration.
b. 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.

c. 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.
d. MCL is for total trihalomethanes (TTHMs): chloroform + bromodichloromethane + bromoform + dibromochloromethane

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

Bromodichloromethane (BDCM)

Overview: Bromodichloromethane is a colorless liquid, which is found evaporated in air or dissolved in water. Most BDCM in the environment is formed as a byproduct when chlorine is added to drinking water to kill disease-causing organisms. Small amounts of BDCM are also made in chemical plants for use in laboratories or in making other chemicals. A very small amount (less than 1% of the amount coming from human activities) is formed by algae in the ocean (ATSDR 1989).

Non-Cancerous Health Effects

Exposure to high levels of BDCM for a long time can cause problems in the central nervous system, kidney and liver. The detected concentration of BDCM (0.0012 mg/L) is below the noncancer comparison values (0.2 mg/L). Therefore, ADHS does not expect to see noncancer adverse health effects among the exposed population.

Cancerous Health Effects

Based on the available data and ATSDR's scientific methods, ADHS conducted a cancer risk evaluation to determine if use of the water by residents for domestic purposes over many years could result in an increased risk of cancer.

The U.S. Department of Health and Human Services (DHHS) has determined that BDCM is reasonably anticipated to be a human carcinogen (ATSDR 1989). EPA has identified BDCM as a probable human carcinogen. Ingestion of BDCM can increase the risk for developing cancers of kidney, large intestine, and liver in experiment animals. EPA has calculated an oral cancer slope of 0.062 $(mg/kg/day)^{-1}$ (IRIS 2015). A cancer risk is estimated by multiplying the EPA cancer slope factor with the estimated exposure dose (Cancer Risk = Exposure Dose x Slop Factor). 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 risk range of 1 in 1,000,000 to 10,000 (10^{-6} to 10^{-4}) for hazardous sites.

The estimated additional cancer from consuming BDCM-containing water for 33 years (exposure from birth to 21 years old as children and 12 years as an adult) was: 1.4×10^{-6}. Resident may also expose to volatile organic compounds (VOCs) during showering/bathing. When showering a person might be exposed from breathing the portion of the VOCs that is released into the air, and from absorbing the chemical through the skin. Studies in humans have shown that the internal dose of trihalomethanes from showering can be comparable to the exposure dose resulting from the water ingestion (ATSDR 2005). The ingestion exposure was doubled to account for the additional exposure from inhalation and skin contact during showering/bathing. The estimated cancer risk from all exposure pathways was 2.8×10^{-6} and represents a possible 3 excess cancer cases in a population of 1,000,000 over a lifetime. According to EPA, it is considered to be protective of public health if the estimated excess lifetime cancer risk is below or within the range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}).

Dibromorchloromethane (DBCM)

Overview: Dibromochloromethane is a byproduct of chlorine disinfection of raw source water before domestic use. The general population is exposed to DBCM via the ingestion of drinking water, from inhalation of the volatilized compound from shower and bath water, and by dermal contact when bathing or showering (ATSDR 2005).

Non-Cancerous Health Effects

Laboratory animal studies showed that the liver is the critical target organ for DBCM toxicity. The detected concentration of DBCM (0.0028 mg/L) is below the noncancer comparison values (0.9 mg/L). Therefore, ADHS does not expect to see noncancer adverse health effects among the exposed population.

Cancerous Health Effects

EPA has identified DBCM as a possible human carcinogen based on limited animal evidence of an increase in liver tumors. EPA has calculated an oral cancer slope of 0.084 $(mg/kg/day)^{-1}$ (IRIS 2015). ADHS conducted a cancer risk evaluation to determine if use of the water by residents for domestic purposes over many years could result in an increased risk for cancer.

The estimated additional cancer from consuming DBCM-containing water for 33 years (exposure from birth to 21 years old as children and 12 years as an adult) was: 4.4×10^{-6}. The ingestion exposure was doubled to account for the additional exposure from inhalation and skin contact during showering/bathing. The estimated cancer risk from all exposure pathways was 8.8×10^{-6} and represents a possible 4 excess cancer cases in a population of 1,000,000 over a lifetime. According to EPA, it is considered to be protective of public health if the estimated excess lifetime cancer risk is below or within the range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}).

The overall cancer risk from exposure to BDCM and DBCM is estimated to be $6.6\text{x}10^{-6}$ (= 2.8×10^{-6} + $3.8\text{x}10^{-6}$), which is within the EPA's target risk range.

Conclusion/Recommendation

Based on the above, with the current water condition, residents are not expected to develop noncancer or cancer health effects if the water is used for domestic purposes (i.e. drinking, showering or bathing).

None of the detected concentrations of BDCM, DBCM, or bromoform exceeded its health-based, noncancerous comparison value. The detected bromoform concentration is below the health-based cancerous comparison value. The estimated cancer risks of BDCM, DBCM and combined were all within EPA's target risk range of 10^{-6} to 10^{-4}.

Chloroform, BDCM, DBCM, and bromoform are known collectively as trihalomethanes (THMs). These compounds are formed as a result of chlorine disinfection of drinking water to destroy potential disease-causing microorganisms. Federal regulations controlling THMs in drinking water have set a MCL for total trihalomethanes (TTHMs) of 0.8 mg/L. The measured TTHM is 0.0068 mg/L.

If you have any questions, please contact me at (602) 803-3740 or linh@azdhs.gov.

Sincerely,

Hsini Lin, ScD, MSPH
Environmental Toxicologist

References:

1. Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for Bromoform and Chlorodibromomethane. Atlanta, GA: US Department of Health Services, Public Health Service.
2. Agency for Toxic Substances and Disease Registry (ATSDR). 1989. Toxicological Profile for Bromodichloromethane. Atlanta, GA: US Department of Health Services, Public Health Service.
3. Integrated Risk Information System (IRIS). Last access: 6/16/2015