Health Consultation

Evaluation of 1,4-Dioxane Water Sampling Results from a Groundwater Well

PIMA COUNTY HEALTH DEPARTMENT

TUCSON, PIMA COUNTY, ARIZONA

Prepared by the

Arizona Department of Health Services

December 1, 2014

HEALTH CONSULTATION

Evaluation of 1,4-Dioxane Water Sampling Results from a Groundwater Well

PIMA COUNTY HEALTH DEPARTMENT

TUCSON, PIMA COUNTY, ARIZONA

Prepared By:

Arizona Department of Health Services

Office of Environmental Health

Environmental Health Consultation Services

Executive Summary

Introduction:	This report was written in response to a request from the Pima County Health Department and the Pima County Department of Environmental Quality (PDEQ) to evaluate human health risks from exposure to 1,4-Dioxane in groundwater from a privately owned drinking water well (known as PW-13) that supplies water to a public drinking water supply in the Tucson area. PW-13 is one of seven wells currently sampled annually as part of the Private Well Monitoring Program, which provides well owners with ongoing information about the water quality of their wells. Sampling results at PW-13 have shown concentrations of 1,4-Dioxane above EPA's Regional Screening Level, which is 0.35 µg/L. The Pima County Health Department and PDEQ have asked the Arizona Department of Health Services (ADHS) to analyze the data from PW-13 and determine whether there are any potential health risks associated with drinking water with these concentrations of 1,4-Dioxane.
Conclusions:	This health consultation evaluated the potential health risks associated with the exposure to groundwater collected from well PW-13 . With the available information, ADHS concluded: 1. *Non-cancer:* 1,4-dioxane in the groundwater from well PW-13 is not expected to harm people's health, because the levels are below the screening value (EMEG), which is protective of human health, and 2. *Cancer:* the estimated cancer risk was 2.70×10-6 and represents a possible 2-3 excess cancer cases in a population of 1,000,000 over a lifetime. EPA has established a target risk range of 1 in 1,000,000 to 10,000 (10-6 to 10-4) for hazardous waste sites. The estimated cancer risk did not exceed EPA's target risk range, and can be qualitatively characterized as very low.
Basis for Decision:	Although residents may be exposed to 1,4-dioxane by ingestion, inhalation, and skin contact, the detected concentrations of 1,4-dioxane were below the health screening values for acute and noncancerous adverse health effects. The estimated theoretical excess cancer risk calculated for 1,4-Dioxane concentrations at PW-13 is 2.70 x 10-6, which can be qualitatively characterized as very low.
Next Steps	ADHS recommends continuing to monitor levels of 1,4-dioxane in well PW-13 to ensure that concentrations of 1,4-dioxane in drinking water do not exceed levels protective of public health.
For More Information:	*If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3118 if you have questions about the information in this report.*

Purpose

This report was written in response to a request from the Pima County Health Department and the Pima County Department of Environmental Quality (PDEQ) to evaluate human health risks from exposure to 1,4-Dioxane contaminated groundwater from a privately owned well that supplies water to a public drinking water system in the Tucson area. Testing on this well, known as PW-13, began in 2002 as part of the Private Well Monitoring Program, and sampling results have shown concentrations of 1,4-Dioxane above EPA's Regional Screening Level (RSL) over the past 12 years. PW-13 supplies drinking water to approximately 150 people, and also supplies water to a mobile home park.

Background and Statement of Issues

PW-13 is one of seven wells currently sampled annually as part of a well sampling program. PDEQ began sampling the private wells in 1998 with funding from EPA and the Arizona Department of Environmental Quality (ADEQ). In 2002, the program was formalized into the Private Well Monitoring Program with funding from EPA and the Tucson Airport Authority (TAA) to provide private well owners with ongoing information about the water quality of their wells. While users of PW-13 have not raised concerns, the Unified Community Action Board (UCAB) in Tucson is interested in protecting community members from receiving contaminated water. UCAB was formed to address the public health of minority or low-income communities near the Tucson International Airport Area (TIAA) Superfund site.

In 2013, the EPA classified 1,4-Dioxane as "likely to be carcinogenic to humans" by all routes of exposure (EPA 2014). Sampling results at PW-13 have shown concentrations of 1,4-Dioxane above EPA's Regional Screening Level, which is 0.35 µg/L. The Pima County Health Department and PDEQ have asked the Arizona Department of Health Services (ADHS) to analyze the data from PW-13 and determine the health risks associated with these concentrations of 1,4-Dioxane.

Discussion

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.

Environmental Data

ADHS reviewed the laboratory results submitted by PDEQ for 1,4-Dioxane concentrations at PW-13. Two analytical methods were used to quantify 1,4-Dioxane concentrations. From 2002 to 2011, EPA Method 8270C [Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) with Selected Ion Monitoring (SIM)] with a detection limit of 1.0 µg/L was used. Analysis was performed at various locations, including Turner, Aerotech Environmental Laboratories, Test America, Columbia Analytical Services, and Xenco Laboratories. After the EPA determined the RSL for 1,4-Dioxane to be 0.35 µg/L, EPA Method 522 [Determination of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry (GC/MS) with Selected Ion Monitoring (SIM)] with a

detection limit of 0.07 µg/L was used. Analysis was performed at Eurofins-Eaton Analytical Services in Monrovia, California from 2012 to 2014.

Each year, two samples were collected at PW-13. The tap was sampled first without flushing to characterize a well owner's exposure. The well head was also sampled after flushing the borehole volume to characterize the concentration in the aquifer. The concentrations for 1,4-Dioxane were typically within 0.2 µg/L of each other at these two locations at PW-13. The concentrations presented in Table 1 below are an average of the two samples collected.

Table 1. 1,4-Dioxane Concentrations in in micrograms per liter (µg/L) from PW-13

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Conc. (µg/L)	1.7	1.8	1.5	1.9	1.7	2.3[1]	2.0	<1	ND[2]	ND[2]	1.6	2.2	2.0

[1] The 2007 sample result was an estimate, because the percent recovery for the sample should be between 38.6% and 88.3%. The percent recovery for that particular sample was 35.7%. However, a Level IV Data Validation was conducted in order to ensure that the result was reliable. Samples from all other years between 2002 and 2014 had a percent recovery between 38.6% and 88.3%.
[2] Not detected.

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 groundwater 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, and (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.

For this case, complete and potential exposure pathways may result from people using water containing 1,4-dioxane from PW-13, either for drinking or domestic purposes or both. Typical exposures to chemicals include: ingestion from drinking and cooking, and inhalation and skin contact from bathing or showering. However, inhalation and skin contact are not significant pathways due to the physical/chemical properties of 1,4-Dioxane. The estimated Henry's Law constant (4.88×10^{-6}) and its miscibility in water may result in potential volatilization, but transfer from water to air is negligible (DiGuiseppi 2007; EPA 2014). Dermal absorption is also minimal because of the relatively short contact

time, and because 1,4-Dioxane in water does not easily penetrate the skin. The primary means of exposure to 1,4-Dioxane in contaminated groundwater is therefore via oral ingestion.

Table 2. Exposure Pathway Evaluation

Location	Exposure Pathway Elements					Time Frame	Type of Exposure Pathway
	Source	Media	Point of Exposure	Route of Exposure	Estimated Exposed Population		
PM-13	TIAA Superfund site	Groundwater	Residence tap	Ingestion, inhalation, dermal contact	Residents	Past	Completed
						Current	Completed
						Future	Potential

Comparison of Health-based Comparison Values

The health-based comparison values (CVs) are screening tools used with environmental data relevant to the exposure pathways. The health-based CVs are concentrations of contaminants that the current public health literature suggests are "harmless." These comparison values are quite conservative, because they include ample safety factors that account for the most sensitive populations. ADHS typically uses comparison values as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination are "safe" or "harmless." If, however, a contaminant is found at levels that are greater than its comparison value, ADHS designates the pollutant as a contaminant of interest and examines potential human exposures in greater detail.

Comparison values are based on extremely conservative assumptions. Depending on site-specific environmental exposure factors (e.g. duration and amount of exposure) and individual human factors (e.g. personal habits, occupation, and/or overall health), exposure to levels greater than the comparison value may or may not lead to a health effect. Therefore, the comparison values should not be used to predict the occurrence of adverse health effects. To evaluate potential health risks from 1,4-Dioxane concentrations, ATSDR has developed Environmental Media Evaluation Guides (EMEGs) and Cancer Risk Evaluation Guides (CREGs).

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 exams potential human exposures in greater detail.

EMEGs represent concentrations of substances in water, soil, and air to which human may be exposed without experiencing adverse health effects. Substances found at concentrations below EMEGs are not expected to pose public health hazards. A substance found at concentrations above EMEGs does not necessarily mean that the substance poses a health risk, but does require further evaluation before drawing a public health conclusion. ATSDR makes three assumptions when deriving EMEGs: 1)

exposures are occurring through contact to a single medium, 2) exposures are occurring to a single substance, and 3) only non-carcinogenic health effects will occur. It is important to remember that EMEGs are screening values only, and not indicators of adverse public health effects (ATSDR 2005).

CREGs are media-specific comparison values that are used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's cancer slope factor (CSF), a target risk level (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents a theoretical risk of 1 excess cancer cases in a population of 1 million. CREGs consider lifetime (70 year) exposure to chemicals. In developing the CREGs, ATSDR assumes that 1) exposures occur through contact to a single medium, 2) exposures occur to a single substance, and 3) only cancer health effects will occur. It is important to remember CREGs should serve only as a screening tool and not as an indication that cancer is expected or predicted (ATSDR 2005).

Public Health Implications

1,4-Dioxane is a manmade compound primarily used as an industrial solvent or solvent stabilizer that prevents the breakdown of chlorinated solvents during manufacturing processes. In the Tucson area, it was used as a stabilizer in industrial solvents in aircraft manufacturing facilities within the Tucson International Airport Area (TIAA) Superfund site from the 1940s to the 1970s (City of Tucson 2014). The well in question is on the periphery of the 1,4-Dioxane plume emanating from the TIAA Superfund site. The 1,4-Dioxane groundwater plume map and the location of PW-13 can be seen in Appendix A.

General Toxicological Information of 1,4-Dioxane:

1,4-Dioxane is irritating to the eyes and respiratory tract, and it may also cause damage to the central nervous system, liver, and kidneys (CA Water Board 2014). It is classified by the International Agency for Research on Cancer (IARC) as a Group 2B carcinogen, meaning it is possibly carcinogenic to humans because it is a known carcinogen in other animals.

Site-specific Assessment:

Non-cancer Health Effects: The chronic EMEG for 1,4-Dioxane is 3,500 ppb (equivalent to 3,500 µg/L) for adults and 1,000 ppb for children (ATSDR 2006). Since the concentrations stated in the lab results are well below these values, ADHS would not expect to see non-cancer health risks from these concentrations of 1,4-Dioxane and no further discussion of non-cancer health effects is warranted.

Carcinogenic effects: The CREG for 1,4-Dioxane is 0.35 µg/L, assuming a target risk level of 10^{-6}. The highest 1,4-Dioxane concentration measured at PW-13, 2.3 µg/L, was used for risk assessment. The CREG has been exceeded consistently at PW-13, so a cancer risk analysis is necessary. To determine the estimated cancer risk, the exposure factor is first calculated. Then, the exposure dose is calculated and multiplied by the oral slope factor for 1,4-Dioxane, which is 0.1 per mg/kg/day (EPA IRIS 2013). To quantify exposures, ADHS made several assumptions regarding dose intake: Adults residing in the area are assumed to drink 2 liters of water per day for 30 years from PW-13. The cancer risk can then be qualitatively characterized. The calculations are shown in Appendix B. The estimated cancer risk was 2.70×10-6 and represents a possible 2-3 excess cancer cases in a population of 1,000,000 over a lifetime.

Table 3. Estimated Cancer Risk for 1,4-Dioxane

Sampling Location	1,4-Dioxane Concentration (µg/L)	Exposure Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	Estimated Cancer Risk	Qualitative Cancer Risk
PW-13	2.3	2.70×10^{-5}	0.1	2.70×10^{-6}	Very Low

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, which translates to 50,000 men and slightly more than 33,333 women in a population of one million. 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 waste sites. The estimated cancer risk did not exceed EPA's target risk range.

Child Health Considerations

ADHS considers children in its evaluations of all exposures, and we use health guidelines that are protective of children. No data describe the effects of exposure to 1,4-Dioxane on children or immature animals. In general, ADHS assumes that children are more susceptible to chemical exposures than are adults. Children six years old or younger may be more sensitive to the effects of pollutants than adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. The comparison values (CVs) used in this health consultation were developed to be protective of susceptible populations such as children.

Acute Toxicity: EPA (2011) issued a one-day Health Advisory (HA) of 4,000 µg/L for a 10-kg and a ten-day HA of 400 µg/L for a 10-kg child. None of the detected levels exceeded the EPA's health advisory.

Conclusions

This health consultation evaluated the potential health risks associated with the exposure to groundwater collected from well PW-13 . With the available information, ADHS concluded:

3. *Non-cancer:* 1,4-dioxane in the groundwater from well PW-13 is not expected to harm people's health, because the levels are below the screening value (EMEG), which is protective of human health, and
4. *Cancer:* the estimated cancer risk was 2.70×10-6 and represents a possible 2-3 excess cancer cases in a population of 1,000,000 over a lifetime. EPA has established a target risk range of 1 in 1,000,000 to 10,000 (10-6 to 10-4) for hazardous waste sites. The estimated cancer risk did not exceed EPA's target risk range, and can be qualitatively characterized as very low.

Recommendations

ADHS recommends continuing to monitor levels of 1,4-dioxane in well PW-13 to ensure that concentrations of 1,4-dioxane in drinking water do not exceed levels protective of public health.

References

ATSDR (2005). Appendix F: Derivation of Comparison Values. Public Health Assessment Guidance Manual (January 2005 Update).

ATSDR (2005). Appendix G: Calculating Exposure Doses. Public Health Assessment Guidance Manual (January 2005 Update).

ATSDR (2006). Agency for Toxic Substances and Disease Registry, Toxicological Profile for 1,4-Dioxane, July 2006.

California Water Resources Control Board (2014). Groundwater Information Sheet: 1,4-Dioxane. Available at: http://www.waterboards.ca.gov/gama/docs/coc_1_4_dioxane.pdf. Last access: October 31, 2014.

City of Tucson (2014). 1,4-Dioxane Information. Available at: http://www.tucsonaz.gov/water/1_4-dioxane. Last access: October 31, 2014.

DiGuiseppi W and Whitesides, C (2007). Treatment Options for Remediation of 1,4-Dioxane in Groundwater. Environmental Engineer: Applied Research and Practice. Vol. 2 p. 1-7.

EPA (2014). Technical Fact Sheet – 1,4-Dioxane, January 2014.

EPA (2014). Tucson International Airport Area: Pacific Southwest, Region 9: Superfund. Available at: http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/vwsoalphabetic/Tucson+International+Airport+Area. Last access: October 31, 2014.

EPA IRIS (2013). 1,4-Dioxane Quickview. Available at: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0326. Last access: October 31, 2014.

IARC (1987). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 71. Available at: http://monographs.iarc.fr/ENG/Monographs/vol71/mono71-25.pdf. Last access: October 31, 2014.

Pima County (2014). Private Well Monitoring Program (TIAA Superfund). Available at: http://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=167886. Last access: October 31, 2014.

Preparers of Report

Arizona Department of Health Services, Office of Environmental Health

Kaleb Tsang, Public Health Risk Assessor

Reviewers of Report

Arizona Department of Health Services, Office of Environmental Health

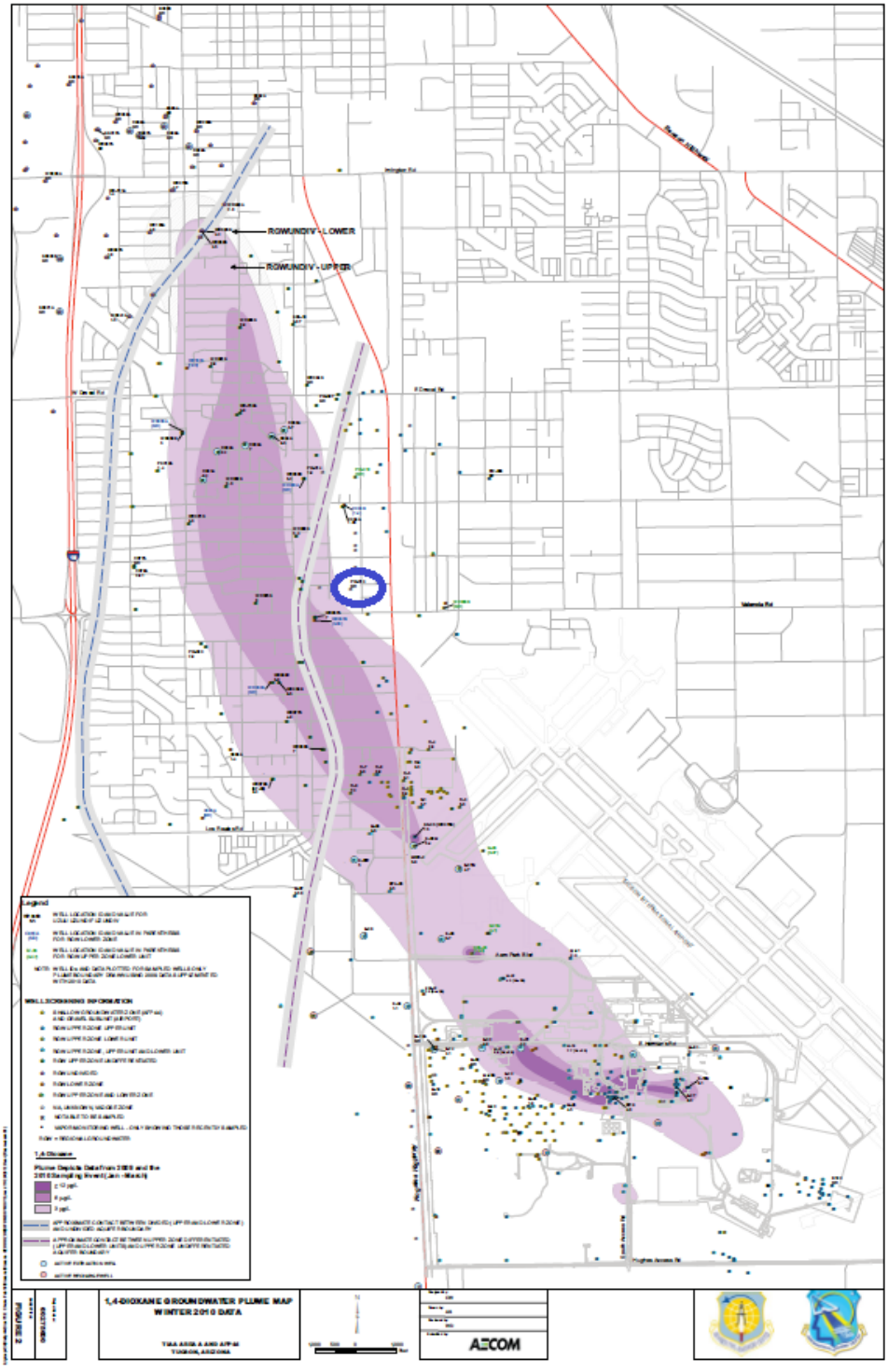
Jennifer Botsford, MSPH, Program Manager

Amber Asburry, MPH, Program Evaluator

Appendices

Appendix A: 1,4-Dioxane Groundwater Plume Map

Blue circle = Location of PW-13



Appendix B: Calculations for Cancer Risk from Water Ingestion

$$EF = \frac{F\ x\ ED}{AT} = \frac{350\ \frac{days}{year}\ x\ 30\ year}{70\ year\ x\ 365\ \frac{days}{year}} = 0.411$$

F = frequency of exposure (days/year) = 350 [It is assumed residents will use their drinking water source 350 days per year, to account for vacations.]

ED = exposure duration (years) = 30 [national upper-bound time (90th percentile) at one residence (ATSDR)]

AT = averaging time (ED x 365 days/year) [ED = 70: lifetime; by convention (ATSDR)]

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

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/L) [See Data section for values.]
IR = intake rate of contaminated water (L/day) = 2
EF = exposure factor (unitless) = 0.411
BW = body weight (kg) = 70

Estimated Cancer Risk = Exposure Dose x Oral Slope Factor