Health Consultation

EVALUATION OF PRIMARY METALS IN PRIVATE DRINKING WATER WELLS IN THE WALKER AREA

PRESCOTT, YAVAPAI COUNTY, ARIZONA

EPA FACILITY ID: AZ5120090068

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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.

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Prepared By:

Arizona Department of Health Services
Office of Environmental Health
Environmental Health Consultation Servicer

Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
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Purpose

In September 2005, some concerned Walker residents contacted the Arizona Department of Health Services (ADHS) in regards to the quality of groundwater in the area. The residents petitioned ADHS to perform well water tests to determine the character of the water, and whether there is any potential health risk associated with consuming or using the water. In response to the concerned community members and in agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), ADHS collected water samples from the site and completed a health consultation. This health consultation evaluates if the levels of lead and other metals in the private wells in Walker area pose any adverse health effects.

Background and Statement of Issues

Walker is located approximately 10 miles southeast of Prescott, Arizona, along the Lynx Creek. The main road is Walker Road which originates in Prescott, Arizona. The area is within the unincorporated boundaries of Yavapai County, and consists of a mixture of private and federal owned land. The Prescott National Forest surrounds the area, and the private properties are located on Patented Mining Claims within the Prescott National Forest boundaries (Hasty and Humble 2002).

The Walker Mining District was established in the 1860's after the discovery of gold and silver in the region. The area was heavily prospected with several larger mines and hundreds of smaller mines being worked since that time. The largest mine in the area, the Sheldon Mine, removed several hundred thousand tons of ore for processing over the course of its lifetime. Other smaller mines removed lesser amounts of materials. The overburden materials were often piled directly upon the properties or deposited in the most convenient place. Because of the topography, which consists of steep canyons with both annual and perennial streams at their bases, the mine wastes often ended up in these streams. Mine adits (horizontal shafts dug into the side of a hill) were often dug adjacent to these waters, with the waste rock ending up in the water (Hasty and Humble 2002).

Approximately 300 properties and mining claims are present in the Walker Mining District area. Most of the properties contain residences that consist of homes and/or mobile homes. Walker residents expressed concern that they might be negatively affected by possible contamination of their private well water from abandoned mines and a recently bioremediated mine (Blue John Mine) in the area. A visual inspection of the area found that the occupied properties generally have private drinking water well sources. There are a few properties that appear to share private drinking water sources. There are no water systems in the area that have enough service connections to constitute a regulated drinking water system.

The private wells have not been directly linked to any hazardous waste sites. However, there are numerous abandoned mines in the area. Two of the mines in the Walker area (Blue John Mine and Sheldon Mine) have been added to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) database. Numerous Mines are under the listing of "Hassayampa/Lynx Creek Abandoned Mines." Appendix A shows a more complete list of CERCLA hazardous waste sites in the Prescott area.

Discussion

Sample Collection and Analysis

ADHS collected total of 31 water samples from 28 wells and 1 spring in the Walker area. Twenty-three water samples were collected in March 2006 and 8 samples were collected in April 2006. First-drawn, untreated water samples were collected from outside faucets of the residences. The water samples were stored in nitric-acid preserved water sample bottles provided by the Arizona Department of Health Services, Bureau of State Laboratory Services, Office of Environmental and Analytical Chemistry.

The Arizona State Laboratory analyzed the water samples for lead and other primary metals by the United States Environmental Protection Agency (US EPA) Methods 200.7 or 200.9. The laboratory reports indicated, "All quality control data is within the laboratory's acceptance limits as indicated in the *Quality Assurance Plan for Analytical Chemical Services* and/or the individual standard operating procedure for the test performed".

Exposure Pathway Evaluation

ADHS identified the exposure pathways to determine if and how residents might be exposed to chemicals in the water. There are five elements are considered in the evaluation of exposure pathways:

- A source of contamination
- Transport through an environmental medium
- A point of exposure
- Route of exposure
- A receptor population

Exposure pathways are classified as completed, potential, or eliminated. Completed pathways exist when the five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring now. Potential pathways are those that may have occurred in the past or present, or could occur in the future. In eliminated pathways, at least one of the five elements is and was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

Completed and potential exposure pathways may result from people using the water for domestic purposes. Typical domestic water exposures to metals include dermal exposures from bathing and showering, and ingestion exposures from drinking and using water for cooking. Table 1 shows the completed and potential exposure pathway elements.

Table 1. Complete and Potential Exposure Pathways

Exposure Pathway Elements					Time	Type of Exposure Pathway
Source	**Media**	**Point of Exposure**	**Route of Exposure**	**Estimated Exposed Population**		
Groundwater Well	Groundwater	Resident: Tap	Ingestion Skin contact	Approximately 58 Residents*	Past	Potential
					Current	Completed
					Future	Potential

* Estimated based 2 residents per household

Selecting Chemicals of Interest

ADHS assesses a site by evaluating the level of exposure in exposure pathways to determine if residents are being exposed to chemicals at levels of public health concern. An exposure pathway defines how a chemical may enter a person's body and potentially cause adverse health effects. The evaluation includes use of comparison values (CVs), which are screening tools used with environmental data relevant to the exposure pathways. CVs are conservatively developed based on the available scientific data and the most sensitive groups (e.g. children).

If public exposure concentrations related to a site are below the corresponding CV, then the exposures are not considered of public health concern and no further analysis is conducted. However, while concentrations below the CV are not expected to lead to any observable adverse health effect, it should not be inferred that a concentration greater than the CV will necessarily lead to adverse health effects. 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 above the comparison value may or may not lead to a health effect. Therefore, the CVs should not be used to predict the occurrence of adverse health effects.

The CVs used in screening analyses including (1) Environmental Media Evaluation Guides (EMEGs), (2) Reference Dose Media Evaluation Guides (RMEGs), and (3) Maximum Contaminant Levels (MCLs). The ATSDR develops EMEGs and RMEGs based conservative assumptions about exposure. EMEGs and RMEGs which represent concentrations of substances in water, soil, or air to which daily human exposure is unlikely to result in adverse health effects.

The US EPA develops the MCLs. MCLs are enforceable standards for public drinking water supplies that are protective of human health, over a lifetime. MCLs are not health-based threshold levels. Therefore, people ingesting chemicals at or slightly above MCLs will not experience any illness or other adverse health effects. Table 2 shows analytical results of the water samples. The identified chemicals of interest are antimony, arsenic, beryllium, cadmium, copper, lead, manganese, nickel, and zinc.

Table 2. Private well sampling results in micrograms per liter (µg/L) for Walker Area

Chemicals	Number of Samples	Ranges of detected concentration (mg/L)	Health-based CVs (mg/L)	Source of CV	Number of detections greater than CV	Is it a chemical of interest?
Aluminum	31	ND[a] − 4.7	20	RMEG-ci[b] ATSDR	0	No
Antimony	31	ND − 0.007	0.006	MCL[c] US EPA	1	**Yes**
Arsenic	31	ND − 0.48	0.01	MCL US EPA	3	**Yes**
Barium	31	ND − 0.14	2	MCL US EPA	0	No
Beryllium	31	ND − 0.0074	0.004	MCL US EPA	1	**Yes**
Cadmium	31	ND − 1	0.005	MCL US EPA	7	**Yes**
Chromium	31	ND − 0.023	0.1	MCL US EPA	0	No
Copper	31	ND − 1.9	1.3	MCL US EPA	1	**Yes**
Lead	31	ND − 1.6	0.015	MCL US EPA	11	**Yes**
Manganese	31	ND − 7.1	0.5	RMEG-ci ATSDR	8	**Yes**
Mercury	31	ND	0.002	MCL US EPA	0	No
Nickel	31	ND − 0.73	0.2	RMEG-ci ATSDR	1	**Yes**
Selenium	31	ND − 0.018	0.05	MCL US EPA	0	No
Silver	31	ND − 0.0023	0.05	RMEG-ci ATSDR	0	No
Thallium	31	ND	0.002	MCL US EPA	0	No
Zinc	31	ND − 100	3	EMEG-ci[c] ATSDR	4	**Yes**

[a] ND: non-detected (i.e., dissolved metal concentrations in groundwater samples were below the laboratory reporting limit)
[b] RMEG-ci: Reference Dose Media Evaluation Guides for children's intermediate exposure
[c] MCL: Maximum Contaminant Level
[d] EMEG-ci: Environmental Media Evaluation Guide for children's chronic exposure

Health Effects Evaluation

To further evaluate the selected chemicals of interest, ADHS estimated the chronic daily intakes (CDIs) based on the site-specific conditions (e.g. duration and frequency). The estimated CDIs were then compared to health guideline values. The health guideline values are estimates of the daily human exposure to a chemical that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure.

Chemicals of interest having CDIs below conservatively derived health guidelines likely pose no public health hazards. However, chemicals of interest having CDIs above the health guidelines do not mean that the chemicals of interest will cause adverse health effects, but rather there is a need for further toxicological evaluation by comparing the estimated CDI for residents to CDIs known to cause harmful effects.

Uptake chemicals through skin contact

As indicated in Table 1, residents can uptake chemicals through water ingestion and skin contact. ADHS determined that uptake of most metals through skin contact can be ignored because metals are not readily absorbed through the skin.

Exposure to metals through skin contact results in a much lower dose than the water ingestion pathway. For example, dermal exposure to arsenic is usually not of concern because only a small percentage will pass through skin and into the body (ATSDR 2000a). Direct skin contact with arsenic could cause some irritation or swelling, but skin contact is not likely to result in any serious internal effects.

Uptake of chemicals through water ingestion

The CDIs from water ingestion were estimated by following the Arizona Department of Health Services Deterministic Risk Assessment Guidance (ADHS 2003). For non-cancer health effects, the estimated CDIs were compared to the ATSDR's Minimal Risk Levels (MRLs) or the US EPA's Reference Dose (RfD). For cancer health effects, the estimated CDIs were used to calculate the excess lifetime cancer risk.

The MRLs or RfDs are derived based on the non-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) and an uncertainty factor. A NOAEL is the highest exposure level of a chemical at which adverse health effects were not observed. A LOAEL is the lowest exposure level of a chemical at which adverse health effects were observed.

An MRL contains uncertainty that is due to the lack of knowledge about the data on which it is based. To account for this uncertainty, "safety factors" are used to set MRLs below actual toxic effect levels (i.e. NOAEL or LOAEL). This approach provides an added measure of protection against the potential for adverse health effects to occur.

Table 3 shows the estimated CDIs for antimony, arsenic, beryllium, cadmium, copper, lead, manganese, nickel, and zinc for wells containing concentrations higher than the CVs. These values were used to evaluate the non-cancer health effects. The estimated CDIs for arsenic, cadmium, copper, manganese, nickel and zinc exceeded their health guideline values, which indicate that these chemicals require more careful examination (i.e. toxicological evaluation). Lead was retained for further evaluation since no health guideline value was available.

Table 3. Estimated chronic daily intake (CDI) in milligrams per kilogram per day (mg/kg/day) compared to the health guidelines

Chemical	Chemical concentration (well name) (mg/L)	Chronic daily intake (mg/kg/day)		Health guideline (mg/kg/day)	Source		Does the child CDI exceed the health guideline?	Does the adult CDI exceed the health guideline?
		Child	Adult					
Antimony	0.007 (W21/3)	0.0004	0.0002	0.0004	RfD[a]	USEPA	No	No
Arsenic	0.011 (W14/3)	0.0007	0.0003	0.0003	MRL[b]	ATSDR	**Yes**	No
	0.02 (W16/3)	0.0013	0.0006				**Yes**	**Yes**
	0.48 (W21/3)	0.0307	0.0132				**Yes**	**Yes**
Beryllium	0.0074 (W18/3)	0.0005	0.0002	0.002	MRL	ATSDR	No	No
Cadmium	0.006 (W02/3)	0.0004	0.0002	0.0002	MRL	ATSDR	**Yes**	No
	0.073 (W06/3)	0.0047	0.002				**Yes**	**Yes**
	0.014 (W07/3)	0.0009	0.0004				**Yes**	**Yes**
	0.025 (W11/3)	0.0016	0.0007				**Yes**	**Yes**
	0.45 (W18/3)	0.0288	0.0123				**Yes**	**Yes**
	0.0097 (W19/3)	0.0006	0.0003				**Yes**	**Yes**
	1 (W21/3)	0.0639	0.0274				**Yes**	**Yes**
Copper	1.9 (W18/3)	0.1215	0.0521	0.01	MRL	ATSDR	**Yes**	**Yes**
Lead	0.027 (W02/3)	0.0017	0.0007	NA[c]	NA	NA	NA	NA
	0.038 (W04/3)	0.0024	0.001				NA	NA
	0.028 (W05/3)	0.0018	0.0008				NA	NA
	0.12 (W06/3)	0.0077	0.0033				NA	NA
	0.039 (W12/3)	0.0025	0.0011				NA	NA

Chemical	Chemical concentration (well name) (mg/L)	Chronic daily intake (mg/kg/day)		Health guideline (mg/kg/day)	Source	Does the child CDI exceed the health guideline?	Does the adult CDI exceed the health guideline?
		Child	Adult				
Lead Cont.	0.23 (W16/3)	0.0147	0.0063			NA	NA
	0.75 (W17/3)	0.0479	0.0205			NA	NA
	1.2 (W18/3)	0.0767	0.0329			NA	NA
	1.6 (W21/3)	0.1023	0.0438			NA	NA
	0.016 (W01/4)	0.001	0.0004			NA	NA
	0.023 (W06/4)	0.0015	0.0006			NA	NA
Manganese	0.66 (W01/3)	0.04	0.02	0.05	RfD USEPA	No	No
	1.8 (W02/3)	0.12	0.05			**Yes**	No
	0.9 (W05/3)	0.06	0.02			**Yes**	No
	7.1 (W18/3)	0.45	0.19			**Yes**	**Yes**
	2.6 (W21/3)	0.17	0.07			**Yes**	**Yes**
	1.7 (W22/3)	0.11	0.05			**Yes**	No
	2.1 (W01/4)	0.13	0.06			**Yes**	**Yes**
	4.8 (W08/4)	0.31	0.13			**Yes**	**Yes**
Nickel	0.73 (W06/4)	0.05	0.02	0.02	RfD USEPA	**Yes**	No
Zinc	5.7 (W02/3)	0.36	0.16	0.3	MRL ATSDR	**Yes**	No
	28 (W17/3)	1.79	0.77			**Yes**	**Yes**
	13 (W18/3)	0.83	0.36			**Yes**	**Yes**
	100 (W21/3)	6.39	2.74			**Yes**	**Yes**

[a] RfD: reference dose; [b] MRL: minimal risk level; [c] NA: Not Available

Toxicological Evaluation

(1) *Arsenic*

Arsenic is a naturally occurring element widely distributed in the earth's crust. Arsenic can be released to water from the natural weathering of soil and rocks and can also leach from soil and minerals into groundwater. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Ingestion of arsenic can increase the risk for skin cancer and internal cancers: liver, lung, bladder, and kidney (ATSDR 2000a).

(A) Non-cancer Health Effects

Well W14/3, W16/3 and W21/3 were selected for further evaluation because the estimated child or adult CDI exceeded the MRL. The arsenic MRL was derived from the long-term arsenic NOAEL of 0.0008 mg/kg/day, obtained from human epidemiologic studies, and an uncertainty factor of three. The long-term LOAEL associated with these epidemiologic studies is 0.014 mg/kg/day, where exposure to arsenic above this level resulted in keratosis (patches of hardened skin), hyperpigmentation of the skin, and possible vascular complication. In addition, studies have shown no dermal or other effects to people exposed to arsenic in drinking water at chronic doses of 0.0004 to 0.01 mg/kg/day (ATSDR 2000a). The results in Table 3 indicate the following:

a) W14/3
   - Child CDI (0.0007 mg/kg/day) is below the NOAEL (0.0008 mg/kg/day)

b) W16/3
   - Child CDI (0.0013 mg/kg/day) is higher than the NOAEL, but it is much lower than the LOAEL (0.014 mg/kg/day)
   - Adult CDI (0.0006 mg/kg/day) is below the NOAEL

c) W21/3
   - Child CDI (0.0307 mg/kg/day) is above the LOAEL (0.014 mg/kg/day)
   - Adult CDI (0.0132 mg/kg/day) is higher than the NOAEL, and close to the LOAEL

(B) Cancer Health Effect

The excess lifetime cancer risks due to arsenic from water ingestion were estimated based on ADHS Deterministic Risk Assessment Guidance (ADHS 2003) and the cancer slope factor of arsenic developed by the US EPA. The estimated excess lifetime theoretical cancer risks are 0.00019 for W14/3, 0.00035 for W16/3, and 0.0085 for W21/3, over a lifetime. It means that there is a potential increase in excess lifetime cancer of 1.9 to 85 cases per 10,000 persons.

a) W14/3 & W16/3: The estimated excess lifetime cancer risks are slightly greater than the acceptable risk range of one-in-one-million to one-in-ten-thousand persons defined by the US EPA (1991). However, an April 1991 memo from Assistant Administrator Donald Clay in the Office of Solid Waste and Emergency Response (OSWER) states that in certain cases the Agency, "may consider risk estimates slightly greater than 10,000 to be protective." For example, the MCL for arsenic of 10 mg/L is associated with excess lifetime cancer risk of 0.00018 (i.e. 1.8 cases per 10,000 persons).

   In addition, the cancer slope factor of arsenic may be overestimated due to the uncertainty related to the model assumptions and differences in the health and nutrition between Taiwanese and American populations (ATSDR 2000a). As a result, the ability of arsenic to cause cancer is reduced. Thus, the estimated excess lifetime cancer risks (i.e. 0.00019 and 0.00035 for residents consuming water from W14/3 and W16/3, respectively, over lifetime) due to arsenic from water ingestion are considered to be within the low range.

b) W21/3: The estimated excess lifetime theoretical cancer risks are greater than the upper bound of the acceptable risk, one-in-ten-thousand persons, defined by the US EPA (1991).

After a review of available exposure and health effect data, ADHS determined that detected arsenic level in the well W21/3 poses a health hazard to adults and children.

(2) *Cadmium*

Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death. Taking in low levels of cadmium for a long time can lead to a build-up of cadmium in the kidneys. Eventually, it may cause kidney damage and fragile bones when the level is high enough (ATSDR 1999).

The US EPA has determined that cadmium is a probable human carcinogen by inhalation. However, studies of humans or animals that eat or drink cadmium have not found increases in cancer. Skin contact with cadmium is not known to affect the health of people or animals because virtually no cadmium can enter the body through the skin under normal circumstances (ATSDR 1999).

W06/3, W18/3, and W21/3 were selected for further evaluation because the estimated CDIs are higher than the MRL. Table 3 also indicates the following:

a) W06/3
   - Child CDI (0.0047 mg/kg/day) is above the NOAEL (0.0021 mg/kg/day)
   - Adult CDI (0.002 mg/kg/day) is below the NOAEL

b) W18/3
   - Child CDI (0.0288 mg/kg/day) is above the NOAEL

- Adult CDI (0.0123 mg/kg/day) is above the NOAEL

c) W21/3

- Child CDI (0.0288 mg/kg/day) is above the NOAEL
- Adult CDI (0.0123 mg/kg/day) is above the NOAEL

NOAEL is the highest exposure level at which adverse health effects were not observed in the experimental animals. The NOAEL is established by ATSDR based on the renal effects of cadmium exposure.

After a review of available exposure and health effect data, ADHS determined that 1) W06/3 pose a health hazard to children; and 2) W18/3 and W21/3 pose a health hazard to adults and children.

(3) *Copper*

Copper is essential for good health. However, exposure to higher doses can be harmful. Drinking water with high levels of copper may cause nausea, vomiting, stomach cramps, or diarrhea. Intentionally high intakes of copper can cause liver and kidney damage and even death (ATSDR 2004).

ADHS determined that W18/3 poses a health hazard to children because the estimated CDI (0.1215 mg/kg/day) exceeded the LOAEL (0.091 mg/kg/day). Copper in this well is not a health hazard to adults since the adult CDI (0.0521 mg/kg/day) is much lower than the LOAEL. The NOAEL and LOAEL are established by the ATSDR based on gastrointestinal effects using the data from Araya et al. (2003).

(4) *Lead*

People may be exposed to lead by breathing air, drinking water, eating foods, or swallowing dust or dirt that contain lead. Most of the lead that enters our body comes through swallowing. The amount lead gets into the body from the stomach depends on 1) when we ate the last meal; 2) how old we are; and 3) how well the lead particles we ate dissolved in the stomach juices. Experiments showed that, for adults who had just eaten, the amount of lead got into the blood from the stomach was only about 6% of the total amount taken in. In adults who had not eaten for a day, about 60-80% of the lead from the stomach got into their blood. In general, if adults and children swallow the same amount of lead, a bigger proportion of the amount swallowed will enter the blood in children than in adults. Children absorb about 50% of ingested lead (ATSDR 2005a).

The main target for lead toxicity is the nervous system, both in adults and children. Children are more sensitive to the health effects of lead than adults. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people. Lead exposure may also cause anemia. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead

may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production (ATSDR 2005a).

No health based guideline values for lead are available. However, environmental lead concentrations can be used to predict the blood lead levels in order to determine if any follow-up action is needed. For children, a blood lead level of 10 micrograms of lead per deciliter (µg/dL) is considered to be "the level of concern". For adults, a blood lead level of 25 µg/dL is considered to be "elevated".

ADHS estimated the blood lead levels for children and adults based on a regression analysis developed by ATSDR (ATSDR 2005a). Table 4 shows the estimated blood levels for children and adults due to lead in the water and other environmental media (i.e. air, food, soil, and dust), based on the levels suggested by ATSDR.

Table 4. Estimated blood lead levels in microgram per deciliter (µg/dL) for children and adults for selective wells based on ATSDR's framework

Well Name	Child		Adult	
	Estimated blood lead level (µg/dL)	Does it exceed 10 µg/dL?	Estimated blood lead level (µg/dL)	Does it exceed 25 µg/dL?
W02/3	9.16	No	2.71	No
W04/3	12.02	**Yes**	3.37	No
W05/3	9.42	No	2.77	No
W06/3	33.34	**Yes**	8.29	No
W12/3	12.28	**Yes**	3.43	No
W16/3	61.94	**Yes**	14.89	No
W17/3	197.14	**Yes**	46.09	**Yes**
W18/3	314.14	**Yes**	73.09	**Yes**
W21/3	418.14	**Yes**	97.09	**Yes**
W01/4	6.30	No	2.05	No
W06/4	8.12	No	2.47	No

Based on the estimated blood levels, ADHS determined that 1)W04/3, W06/3, W12/3, W16/3, W17/3, W18/3 and W21/3 pose a health hazard to children; and 2)W17/3, W18/3 and W21/3 pose a health hazard to adults.

(5) *Manganese*

Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. Manganese is present in many foods, including grains and cereals, and is found in high concentrations in many foods, such as tea. There is only limited evidence that ingesting excessive levels of manganese can result in adverse health effects in humans. Manganese ingestion may lead to neurological effects similar to those seen following inhalation exposure. Symptoms include weakness, abnormal gait, ataxia, muscle hypotonicity, and a fixed emotionless face. Based on the available literature, it is possible that other factors may contribute to the neurological effects (ATSDR 2000b).

US EPA estimated a NOAEL of 10 mg/day (0.14 mg/kg/day) for chronic human consumption of manganese in the diet. Most people consume about 2~5 mg/day (0.03~0.07 mg/kg/day) in their diet. In addition, Kondakis et al. (1989) shows possible adverse health effects associated with a lifetime consumption of drinking water containing 2 mg/L of manganese. Evidence exists that neonates absorb more manganese from the gastrointestinal tract, and excrete less of the absorbed manganese. Infant formula typically contains a much higher concentration of manganese than human or cows' milk. Powdered formula reconstituted with drinking water represents an additional source of intake. Thus, US EPA recommended that a modifying factor of 3 be applied when assessing risk from manganese in drinking water or soil. As a result, the NOAEL will be about 0.05 mg/kg/day

Table 3 indicates that

a) W02/3
   - Child CDI (0.12 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

b) W05/3
   - Child CDI (0.06 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

c) W18/3
   - Child CDI (0.45 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)
   - Adult CDI (0.19 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

d) W21/3
   - Child CDI (0.17 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)
   - Adult CDI (0.07 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

e) W22/3
   - Child CDI (0.11 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

f) W01/4
   - Child CDI (0.13 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)
   - Adult CDI (0.06 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

g) W08/4

- Child CDI (0.31 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)
- Adult CDI (0.13 mg/kg/day) is above the estimated NOAEL (0.05 mg/kg/day)

Based on the available information, ADHS determined that 1) W02/3, W05/3, W18/3, W21/3, W22/3, W01/4 and W08/4 pose a health hazard to children; and 2) W18/3, W21/3, W01/4 and W08/4 pose a public health hazard to adults.

(6) *Nickel*

Nickel is a naturally occurring element that may exist in various mineral forms. It is used in a wide variety of applications including metallurgical processes and electrical components, such as batteries (ATSDR 2005b). Some evidence suggests that nickel may be an essential trace element for mammals.

Decrease in body weight and organ weight were observed in experimental animals exposed to 8.6 mg/kg/day or higher. The NOAEL for nickel is identified to be 5 mg/kg/day by US EPA. Based on the information, ADHS determined that nickel is not a public health hazard. However, people sensitive to nickel may have allergic reaction such as skin rash when their skin comes in contact with nickel contaminated water. After an individual becomes sensitized to nickel, dermal contact with a small amount of nickel or oral exposure to fairly low doses of nickel can result in dermatitis. Approximately 10–20% of the general population is sensitized to nickel (ATSDR 2005b).

(7) *Zinc*

Zinc is an essential element in our diet. Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. The recommended dietary allowances (RDAs) for zinc for the year 2000 (IOM 2001) are 11 mg/day for adult males and 8 mg/day for adult females (not pregnant or lactating). Large doses taken by mouth even for a short time can cause stomach cramps, nausea, and vomiting. Taken longer, it can cause anemia and decrease the levels of your good cholesterol (ATSDR 2005c).

The ATSDR identified the NOAEL as 0.83 mg/kg/day. Based on the information, ADHS determined that 1) W17/3, W18/3 and W21/3 pose a health hazard to children; and 2) W21/3 poses a public health hazard to adults.

ATSDR Child Health Concern

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contaminants in environmental media. Children's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children ingest a larger amount of water relative to body weight, resulting in higher burden of pollutants. Furthermore, children often engage in vigorous outdoor activities, making them more sensitive to pollution than healthy adults. All health analyses in this report

take into consideration the unique vulnerability of children. Children will be adversely affected by the levels of metals found in private wells W02/3 (manganese), W04/3 (lead), W05/3 (manganese), W06/3 (cadmium and lead), W12/3 (lead), W16/3 (lead), W17/3 (lead and zinc), W18/3 (cadmium, copper, lead, manganese and zinc), W21/3 (arsenic, cadmium, lead, manganese and zinc), W22/3 (manganese), W01/4 (manganese), and W08/4 (manganese) at the residence.

Conclusions

The Arizona Department of Health Services has classified the private wells W02/3, W04/3, W05/3, W06/3, W12/3, W16/3, W17/3, W18/3, W21/3, W22/3, W01/4, and W08/4 as "Public Health Hazard". That is because one or more metal levels in the private wells are higher than the acceptable levels. Residents using the well water for drinking or cooking for a long time may experience adverse health effects.

If further information becomes available, ADHS will evaluate it and update conclusions as necessary.

Recommendations

- For groundwater wells containing one or metals above the safety level(s), a treatment system that effectively removes the metal(s) should be installed. Meanwhile, residents should use an alternative water source, such as bottled water, for drinking or cooking.
- All residents in the Walker area who use private well water for drinking or cooking should have their well water tested yearly for bacteria and nitrates, and at least once for primary metals, such as arsenic, copper, and lead, etc.

Public Health Action Plan

Public Health Action	Who Will Implement the Action	Time Frame for Implementation	Desired Outcome When Implemented	Public Health Impact
Notify residents of testing results and associated potential health effects	ADHS	May 2006	Raise residents' individual awareness about their well water quality	Reduction in exposure to heavy metals in private well water
Develop and mail "Well Water and Your Health" flyers	ADHS	1. May 2006 2. Upon request by community association	Raise residents' individual awareness about well water, health & treatment options	1. Increase frequency of well water testing by homeowners 2. Increase installation of filtration systems
Mail finalized health consultation to residents	ADHS	After the Health Consultation is finalized	Raise residents' individual awareness about the overall well water quality in their area	1. Reduction in exposure to heavy metals in drinking water 2. Increase frequency of well water testing by homeowners
Post flyer, health consultation, and arsenic brochure on ADHS and the Walker community's website	ADHS & Walker Community Website Manager	After the Health Consultation is finalized	Raise the community's awareness about well water quality, potential health effects, and methods of reduction of exposure	1. Reduction in exposure to potential contaminants in drinking water 2. Increase frequency of well water testing by all homeowners in the community
Organize a Public Meeting	ADHS & other interested agencies	After the Health Consultation is finalized	Provide an interactive environment to discuss the health consultation and residents' concerns	Assures residents' concerns will be heard and addressed. If needed, ADHS will organize additional meetings

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Certification

This Health Consultation entitled *Evaluation Of Primary Metals In Private Drinking Water Wells In The Walker Area, Prescott, Yavapai County, Arizona* was prepared by the Arizona Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner.

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The Division of Health Assessment and Consultation, Agency for Toxic Substance and Disease Registry, has reviewed this health consultation and concurs with its findings.

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Appendix A

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites in Walker, Prescott, or Humboldt

Area	Site	EPA ID	Site Status
Walker	Hassayampa / Lynx Creek Abandoned Mines	AZ5120090068	SI[1] Ongoing
	Blue John Mine	AZSFN0905574	Referred to Removal – Further Assessment Needed
	Sheldon Mine	AZ0000309245	HRS[2] Start Needed
Humboldt	Iron King Mine	AZ0000309013	HRS Start Needed
	Humboldt Smelter	AZN000906020	HRS Start Needed
Prescott	Senator Mine	AZ0000309211	HRS Start Needed
	Cash Mine	AZ0001038546	
	Holiday Girl Mine	AZ0001038785	
	Lion Adit	AZN000905896	Addressed as part of the Senator Mine
	McCleur Tailings	AZ0000309096	
	McKinley Mill	AZN000905897	
	Sundance Mine	AZ0001039379	
	Phelps Dodge Corp – Copper Basin Branch	AZ0000309179	NFRAP[3]
	Prescott National Forest	AZ1122307555	PA[4] Start Needed
	Sheldon Mine	AZ000309245	HRS Start Needed
	Southwest Forest Ind Wood Treatment Plant	AZD008398703	NFRAP

[1] SI: Site Inspection
[2] HRS: Hazardous Ranking System
[3] NFRAP: No Further Response Action Planned
[4] PA: Preliminary Assessment