Health Consultation

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
TOPOCK GROUNDWATER STUDY

Evaluation of Chromium in Groundwater Wells

GOLDEN SHORES AND TOPOCK
MOHAVE COUNTY, ARIZONA

SEPTEMBER 7, 2005

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

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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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Evaluation of Chromium in Groundwater Wells

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Prepared by:

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

From May 2005 to June 2005, the Arizona Department of Environmental Quality (ADEQ) conducted a study, Potable Well Sampling Task 4.0, to determine if the chromium and chromium VI plume due to the discharge of the Pacific Gas and Electronic (PG&E) Topock Compressor Station has migrated under the Colorado River and impacted water supplies in Arizona. The ADEQ investigated the total chromium and hexavalent chromium (chromium VI) concentrations in (1) public water supply wells, (2) combined industrial and domestic water supply wells, and (3) private domestic water supply wells at Topock and Golden Shores, Arizona. The communities of Topock and Golden Shores have expressed their concerns regarding the findings. Thus, the ADEQ requested the Arizona Department of Health Services to evaluate the potential health effects of exposure to well water contaminated with chromium.

Background and Statement of Issues

The Pacific Gas and Electric Company (PG&E) Topock Compressor Station, located southeast of Needles, San Bernardino County, California, is a natural gas compressor station for transmission of natural gas by pipeline. From 1951 to 1985, PG&E used chromiumVI as an anti-corrosion agent in the cooling towers to prevent corrosion of the cooling tower equipment. From 1951 to 1964, PG&E discharged about 6 million gallons per year of untreated wastewater containing chromium VI to Bat Cave Wash (CA, USA), which is normally a dry streambed that feeds into the Colorado River. Beginning in 1964, PG&E treated the wastewater to remove chromium VI. The treated wastewater was discharged into Bat Cave Wash until 1968, and subsequently into an on-site injection well between the years of 1970 to 1973. Over time, PG&E installed a series of lined evaporation ponds for wastewater disposal. In 1985, PG&E stopped using the chromium-based additive and switched to a phosphate-based solution. In 1996, PG&E entered into a Corrective Action Consent Agreement with the California Environmental Protection Agency, Department of Toxic Substances Control to investigate and clean up the chromium VI contamination at the Station (CalEPA 2004).

A plume of chromium VI has been identified in the groundwater at the compressor station, which is located 15 miles southeast of Needles, California. The plume has been detected in recently installed wells that are located less than 60 feet west of the Colorado River. To date, 70 monitoring wells, 4 extraction wells, and 2 injection wells have been installed at the site in California. Ground water extraction began in March 2004 as part of interim measures to contain the plum and protect the Colorado River. PG&E proposes to treat extracted groundwater and re-inject the treated water back into groundwater.

In February 2005, chromium VI was detected at a concentration of 354 parts per billion (ppb) in a newly installed well (Well MW-34-100) located 60 feet west of the Colorado River (CA, USA). Concentrations have since increased to 417 ppb. The Arizona Department of Environmental Quality (ADEQ) has expressed great concern about potential impacts of chromium VI on Arizona groundwater resources and Colorado River water uses since data from this well suggests that the eastern edge of the plume is undefined.

Discussion

Groundwater Sampling Data

From May 2005 to June 2005, GeoTrans Inc. (Phoenix, AZ) collected groundwater samples from the selected domestic, industrial and public water supply wells in the communities of Topock (one-half mile east-northeast across the Colorado River) and Golden Shores (eight miles north of the PG&E Topock Compressor Station), Arizona. Figure 1 shows the locations of the twenty wells sampled during the ADEQ Potable Well Sampling event.

Groundwater samples were analyzed for chromium VI and total chromium by EMAX Laboratories, Inc. (Torrance, CA) and TransWest GeoChem, Inc. (Phoenix, AZ), respectively. Chromium VI concentrations in groundwater samples were determined by EPA Method 218.6 and EPA SW (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods) 7196A and total chromium concentrations in groundwater samples were determined by EPA Method 200.7. The measured concentrations of chromium VI in groundwater samples ranged from 0.61 to 26.2 micrograms per liter (µg/L). The measured concentrations of total chromium in groundwater samples ranged from < 10 (laboratory reporting limit) to 28 µg/L. Table 1 and Figure 1 summarize the chromium analytical results for wells sampled during the May 2005 ADEQ Potable Well Sampling event.

The laboratory-reporting limit is the lowest reported concentration after corrections have been made for sample dilution and sample weight. The laboratory reporting limits ranged from 0.2 to 4 µg/L for EPA Method 218.6. The laboratory-reporting limit for both EPA Method SW 7196A and EPA Method 200.7 is 10 µg/L. All the method blanks, laboratory spikes, filed and laboratory duplicates met quality control objectives, which indicates the analytical concentrations of chromium VI and total chromium detected by the laboratories are of high quality and high certainty.

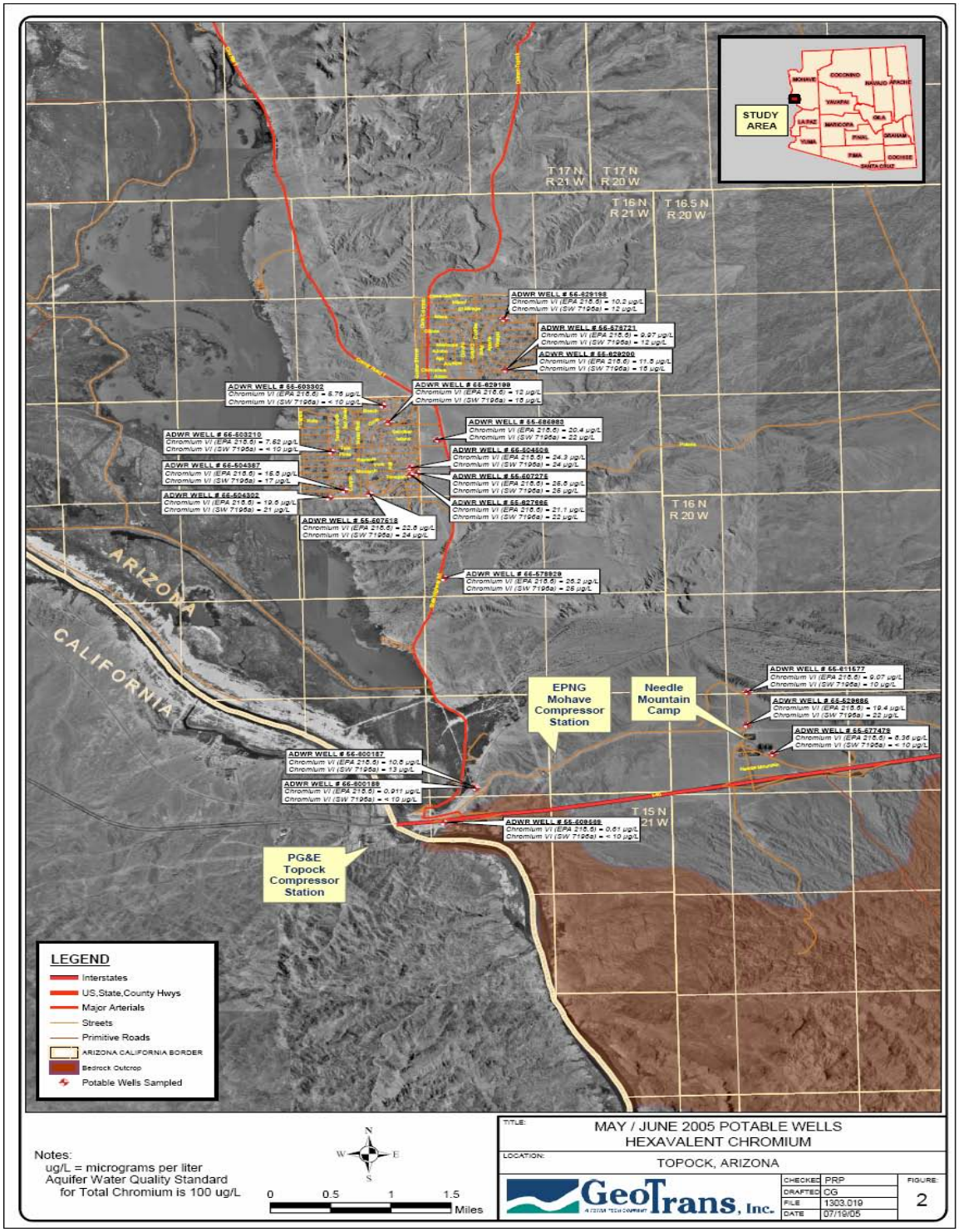

Figure 1. Arizona Department of Environmental Quality (ADEQ) Topock Groundwater Study Area

Figure 1[1] shows the wells that were selected for the 2005 potable well sampling as part of the ADEQ Topock groundwater study. µg /L: micrograms per liter; Arizona Aquifer Water Quality Standard for total chromium is 100 µg/L.

[1] This figure was prepared by GeoTrans Inc on behalf of the Arizona Department of Environmental Quality (ADEQ).

Table 1. Analytical results of chromium VI, total chromium and their duplicates in micrograms per liter (µg/L) for wells sampled during the May 2005 ADEQ Potable Well Sampling event

Well name	Well use	Measured concentration of chromium VI				Measured concentration of total chromium	
		EPA Method 218.6		EPA SW 7196A		EPA Method 200.7	
		Field sample	Duplicate	Field sample	Duplicate	Field sample	Duplicate
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Private well #1	Domestic	0.61		< 10[a]		< 10	
Private well #2	Domestic	25.8		25		28	
Private well #3	Domestic	24.3		24		27	
Private well #4	Domestic	21.1		22		25	
Private well #5	Domestic	5.76		< 10	< 10[b]	< 10	
Private well #6	Domestic	22.8		24		24	
Private well #7	Domestic	19.6	19.2[c]	21	17	19	20
Private well #8	Domestic	15.8		17		16	
Private well #9	Domestic	7.52	7.57	< 10	< 10	< 10	
Private well #10	Domestic, irrigation	26.2	26	25	33	26	25
EPNG Topock 1	Domestic, industrial	19.4		22		23	
EPNG Topock 2	Domestic, industrial	9.07		10	11	11	
GSWC 1	Municipal	12.0		18		13	
GSWC 2	Municipal	10.2		12		< 10	
GSWC 3	Municipal	11.8		18		14	
GSWC 4	Municipal	9.97	10	12		12	
ADOT 2 new well	Domestic, industrial	8.36	8.3	< 10		10	
Topock School	Irrigation	20.4		22		21	
CON Topock 2	Domestic, industrial, municipal	0.91	0.90	< 10	< 10	11	
CON Topock 3	Domestic, industrial, municipal	10.8		13		15	

[a] < 10 µg/L: laboratory-reporting limit
[b] Green text represents laboratory duplicate sample results for quality control
[c] Red text represents blind duplicate sample result for quality control

Exposure Pathway Evaluation

The Arizona Department of Health Services identified the exposure pathways to determine if and how residents might be exposed to chromium in groundwater. 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
- An exposed 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.

Current completed and future potential exposure pathways may result from people using the water from the contaminated wells (i.e., domestic, irrigation and municipal supply wells) either for irrigation or domestic purposes or both. Typical domestic and municipal supply well exposures to chromium include dermal exposures from bathing and showering, and ingestion exposures from drinking and using water for cooking. Inhalation while showering is not a relevant pathway because chromium is not volatile (i.e., chromium does not evaporate). It tends not to be soluble and are not likely available to people as aerosols while showering.

For irrigation wells, only limited dermal and ingestion exposures could occur to anyone who comes in contact with the contaminated water. This would include exposures to adults while they are watering the lawn or gardens, children playing at grounds that are irrigated with contaminated well water, or anyone who eats vegetables or fruits that are irrigated with contaminated water and which accumulate the contaminants.

For industrial wells, the Arizona Department of Health Services determined that the exposure pathway is eliminated. The groundwater primarily is used in cooling towers. As a result, the exposure points and exposure routes cannot be identified. That is people are unlikely to have contact with chromium through inhalation, ingestion or dermal contact.

Toxicological Evaluation

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is present in the environment in several different forms. The most common forms are metal chromium (chromium 0), trivalent chromium (chromium III), and chromium VI. Chromium III occurs naturally in the environment and

is an essential nutrient. Chromium VI and metal chromium are generally produced by industrial processes (ATSDR 2000).

The body absorbs chromium VI more readily than it absorbs chromium III. However, once absorbed by the body, chromium VI is rapidly changed to chromium III. The effects of chromium exposure on the human body vary according to the exposure route (i.e., inhalation, ingestion, or skin contact) and form of chromium. Inhalation exposure to chromium VI can result in marked damage to the nasal mucosa, perforation of the nasal septum and damage to the lower respiratory tract. However, breathing in chromium III does not cause irritation to the nose or mouth in most people (ATSDR 2000). The United States Environmental Protection Agency (U.S. EPA) has classified chromium VI as a known human carcinogen through inhalation. Chromium VI is not classified as a human carcinogen through ingestion or by dermal contact (U.S. EPA 2005a). Chromium III is not classified as a human carcinogen through inhalation, ingestion or dermal contact (U.S. EPA 2005b).

The Arizona Department of Health Services assesses a site by evaluating the level of exposure in potential or completed pathways to determine if residents are being exposed to chromium at levels of public health concern. An exposure pathway defines how a chemical may enter a person's body that may cause adverse health effects. The evaluation includes use of comparison values, which are screening tools used with environmental data relevant to the exposure pathways. Comparison values are concentrations of chemicals that can reasonably and conservatively be regarded as harmless to public health based on the available scientific data.

If public exposure concentrations related to a site are below the appropriate comparison value, then the exposures are not of public health concern and no further analysis of the pathway is conducted. However, while concentrations below the comparison value are not expected to lead to any observable adverse health effect, it should not be inferred that a concentration greater than the comparison value 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 comparison values should not be used to predict the occurrence of adverse health effects.

The Arizona Department of Health Services used average concentrations of chromium VI to evaluate the potential health effects because they are most representative of the concentration that would be contacted at a site. If the detected chromium concentration is indicated as non-detect (i.e., < 10 µg/L) in the laboratory report, the concentration of chromium VI was assumed to be 10 µg/L. This assumption is the most conservative for risk assessment, because it will tend to bias data on the high side. This approach indicates that there is a high degree of confidence that chromium is present, but at a level that is at or just below the laboratory-reporting limit.

In addition, the average concentrations of chromium VI were determined based on the analytical results of both EPA Method 218.6 and EPA Method SW 7196A. For example, for Private Well # 10, averaging the EPA Method 218.6 and EPA Method SW 7196A values in Table 1 (i.e., 26.2 and 25 µg/L) results in an average concentration of 25.6

µg/L. In addition, the results of the duplicate samples were not used to obtain the average concentrations of chromium VI in groundwater samples because duplicate samples are used to verify the analytical results and check the overall precision of laboratory methods.

The average chromium VI concentrations were compared to the Reference Dose Media Evaluation Guides (RMEGs) for chromium VI in water. The Agency for Toxic Substances and Disease Registry (ATSDR) develops RMEGs using the U.S. EPA's reference dose and default exposure assumptions, which account for variations in intake rates between adults and children. RMEGs represent concentrations of substances in water, soil, or air to which humans may be exposed without experiencing adverse health effects, over a lifetime. Table 2 indicates that the average chromium VI concentrations in groundwater sampled at various locations are lower than the ATSDR's RMEG for chromium VI.

As indicated in Table 2, the average concentration of chromium for field samples did not exceed the ATSDR's CV for children and adults. However, the measured duplicate concentration of chromium VI for private well #10 (33 µg/L, Table 1) exceeded the ATSDR's child CV for chromium VI (30 µg/L). The Arizona Department of Health Services recognizes the unique vulnerabilities and sensitivities of children. Thus, the Arizona Department of Health Services conducted further risk analysis based on the maximum detected concentration (i.e., 33 µg/L) in the duplicate sample for private well #10. The following equation was used to estimate intake from ingestion of water for children:

$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

where, *CDI* = chronic daily intake (mg/kg/day)
CW = chemical concentration in groundwater (mg/L, 1 mg/L = 1000 µg/L)
IR = ingestion rate of water (L/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged, days)

The values used to estimate the chronic daily intake of chromium VI from ingestion of water for children was based on the values for children listed in the Arizona Department of Health Services Deterministic Risk Assessment Guidance (ADHS 2003). A water ingestion rate of 1 L/day, exposure frequency of 350 days/year, exposure duration of 6 years, body weight of 15 kg, and averaging time of 2,190 days were used to obtain the chronic daily intake of 0.0021 mg/kg/day.

Table 2. Measured chromium VI concentrations in micrograms per liter (µg/L) compared to ATSDR's Reference Dose Media Evaluation Guide (RMEG).

Well name	Sampling date	Well use	Average concentration of chromium VI	Does the detected concentration value exceed the ATSDR RMEG for chromium VI?	
Standard				**Child 30 µg/L**	**Adult 100 µg/L**
Private well #1	05/24/05	Domestic	5.3	No	No
Private well #2	05/26/05	Domestic	25.4	No	No
Private well #3	05/26/05	Domestic	24.2	No	No
Private well #4	05/26/05	Domestic	21.6	No	No
Private well #5	05/26/05	Domestic	7.9	No	No
Private well #6	05/31/05	Domestic	23.4	No	No
Private well #7	06/01/05	Domestic	20.3	No	No
Private well #8	06/01/05	Domestic	16.4	No	No
Private well #9	06/01/05	Domestic	8.8	No	No
Private well #10	05/31/05	Domestic, irrigation	25.6	No	No
EPNG Topock 1	05/25/05	Domestic, industrial	20.7	No	No
EPNG Topock 2	05/25/05	Domestic, industrial	9.5	No	No
GSWC 1	06/02/05	Municipal	15.0	No	No
GSWC 2	06/02/05	Municipal	11.1	No	No
GSWC 3	06/02/05	Municipal	14.9	No	No
GSWC 4	06/02/05	Municipal	11.0	No	No
ADOT 2 (new well)	05/25/05	Domestic, industrial	9.2	No	No
Topock School	06/01/05	Irrigation	21.2	No	No
CON Topock 2	05/24/05	Domestic, industrial, municipal	5.5	No	No
CON Topock 3	05/24/05	Domestic, industrial, municipal	11.9	No	No

The Arizona Department of Health Services used the hazard quotient (HQ) to estimate the potential for children suffering from an adverse health effect due to ingestion of water. The HQ is the ratio of an exposure level over a specific time (i.e., *CDI*) to the chemical specific Reference Dose (*RfD*), which is derived by the U.S. EPA and is not expected to produce toxic effects over the period of concern.

The HQ for ingestion of water for children was calculated as follows:

$$\mathrm{HQ} = \frac{CDI}{RfD}$$

where, *CDI* is the chronic daily intake (i.e., 0.0021 mg/kg/day) and *RfD* is the oral reference dose for chromium VI (i.e., 0.003 mg/kg/day) (U.S. EPA 2005a).

If the HQ exceeds 1, there is a chance that the exposed individual may experience adverse health effects and there is a need for in-depth analysis. Using the above equation and values, the estimated HQ was equal to 0.7, which is less than 1 and is not a public health concern.

The concentrations of total chromium in groundwater samples were compared to the Arizona Aquifer Water Quality Standards (AAWQSs) and the U.S. EPA' s Maximum Contamination Levels (MCLs) for total chromium. The AAWQSs are enforceable standards developed to protect groundwater sources for drinking water use (AAC §R18-11-406). In Arizona, all aquifers are identified as drinking water source aquifers unless specifically exempt (ARS §49-224). The AAWQSs and MCLs are enforceable standards for public drinking water supplies that are protective of human health. Table 3 indicates that the total chromium concentrations in groundwater sampled at various locations are lower than the AAWQS and the MCL.

Table 3. Measured total chromium concentrations in micrograms per liter (µg/L) compared to Arizona Aquifer Water Quality Standard (AAWQS) and the U.S. EPA Maximum Contamination Level (MCL) for total chromium.

Well name	Well use	Detected concentration of total chromium		Does the detected concentration value exceed AAWQS for total chromium?	Does the detected concentration value exceed the U.S. EPA MCL for total chromium?
Standard		**µg/L**		**100 µg/L**	**100 µg/L**
Sampling year		**1996**	**2005**		
Private well #1	Domestic	NS[a]	< 10	No	No
Private well #2	Domestic	24	28	No	No
Private well #3	Domestic	NS	27	No	No
Private well #4	Domestic	NS	25	No	No
Private well #5	Domestic	NS	< 10	No	No
Private well #6	Domestic	20	24	No	No
Private well #7	Domestic	15	19	No	No
Private well #8	Domestic	NS	16	No	No
Private well #9	Domestic	ND[b]	< 10	No	No
Private well #10	Domestic, irrigation	NS	26	No	No
EPNG Topock 1	Domestic, industrial	NS	23	No	No
EPNG Topock 2	Domestic, industrial	NS	11	No	No
GSWC 1	Municipal	ND	13	No	No
GSWC 2	Municipal	12	< 10	No	No
GSWC 3	Municipal	NS	14	No	No
GSWC 4	Municipal	NS	12	No	No
ADOT 2 (new well)	Domestic, industrial	NS	10	No	No
Topock School	Irrigation	NS	21	No	No
CON Topock 2	Domestic, industrial, municipal	NS	11	No	No
CON Topock 3	Domestic, industrial, municipal	NS	15	No	No

[a] NS: not sampled
[b] ND: not detected; laboratory reporting limit: < 10 µg/L

ATSDR Child Health Initiative

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 not be adversely affected by the levels of chromium found in groundwater wells at Topock and Golden Shores, AZ.

Conclusions

The Arizona Department of Health Services has classified the study sites as "No Apparent Public Health Hazard." This classification is based upon the following conclusions:

- Low levels of total chromium and chromium VI are present in the groundwater wells.
- Exposures to total chromium and chromium VI are not at levels that are likely to cause adverse health effects, even to children and sensitive populations.
- The sites do not pose a public health hazard because exposure concentrations are low.

If further information becomes available, the Arizona Department of Health Services will evaluate it and update conclusions as necessary.

Recommendations

The Arizona Department of Health Services does not have any recommendation at this time.

Public Health Action Plan

The Arizona Department of Health Services staff will attend community meetings to communicate the results of this consultation. The Arizona Department of Health Services will gather community concerns and answer any additional questions that community members have.

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Certification

The Arizona Department of Environmental Quality Topock Groundwater Study Health Consultation 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.

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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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