Health Consultation

Evaluation of 1,4-Dioxane in Groundwater Wells

TUCSON INTERNATIONAL AIRPORT

TUCSON, PIMA COUNTY, ARIZONA

EPA FACILITY ID: AZD980737530

Prepared by the
Arizona Department of Health Services

SEPTEMBER 14, 2011

Prepared 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
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners 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 or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Summary

INTRODUCTION

In the *Tucson International Airport: Evaluation of 1,4-dioxane in groundwater wells*, the Arizona Department of Health Services' (ADHS') top priority is to ensure that the community and residents have the best information possible to safeguard their health.

This report was written in response to a request from the U.S. Environmental Protection Agency (EPA). Tucson International Airport Area is one of the National Priority List (NPL) sites due to elevated levels of volatile organic compounds (VOCs) including trichloroethylene (TCE) and perchloroethylene (PCE). After removing VOCs from the contaminated groundwater, the Tucson Airport Remediation Project (TARP) system provides drinking water to about 50,000 residents in north Tucson (or about 9% of the municipal water supply).

Since 2002, 1,4-dioxane has been detected in groundwater throughout the Tucson International Airport Area (TIAA) at levels above EPA Health Advisory for Drinking Water. Although, at the TIAA area, most of the residents obtain their water supply from the Tucson municipal water system, some residences in the area still use private wells for drinking purposes. This health consultation will evaluate the public health risks due to exposure to 1,4-dioxane alone in untreated groundwater at the TIAA.

Groundwater sampling results collected from 2006 to 2009 were used in this report to evaluate whether exposure to 1,4-dioxane alone in untreated groundwater could harm people's health. In an attempt to characterize the nature and degree of the contamination that would impact the health of residents, ADHS reviewed all the available data.

CONCLUSIONS

This report evaluated the potential health effects associated with the exposure to 1,4-dioxane alone in untreated groundwater. The potential health effects associated with the exposure to historical contaminants of concerns such as TCE has been discussed in previous reports and are available at ADHS (http://www.azdhs.gov/phs/oeh/atsdr_reports.htm) or ATSDR (http://www.atsdr.cdc.gov/HAC/PHA/HCPHA.asp?State=AZ).

ADHS concludes that the detected levels of 1,4-dioxane in groundwater wells in the TIAA project area are not expected to harm people's health. ADHS does not consider that there is a health threat to people who consume the water in former municipal supply, municipal supply, or private wells. However, this report cannot be used to evaluate the health effects due to exposure to multiple chemicals in untreated groundwater.

BASIS FOR DECISION

Residents may be exposed to 1,4-dioxane by ingestion, inhalation and skin contact. The detected concentrations of 1,4-dioxane was below the health screening values for acute and noncancerous adverse health effects. In addition, the estimated theoretical excess lifetime cancer risks are below or within the range of public health guidelines (10^{-6}~10^{-4}) for protection of

	human health as suggested by EPA. These cancer risks are considered to be very low, low or moderate based on the qualitative ranking of cancer risk estimates.
NEXT STEPS	To ensure the health and safety of residents, ADHS recommends the lead agencies continue to oversee the groundwater monitoring activities for 1,4-dioxane at the site. ADHS also recommends that the City of Tucson continue to treat TCE in water. Currently, the water supply from the affected area is only treated for trichloroethylene, not 1,4-dioxane, due to the capacity of the treatment facility. However, other water sources are used to reduce the concentration of 1,-4dioxane.
FOR MORE INFORMATION	If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3128 and ask for more information on the Tucson International Airport site.

Purpose

This report was written in response to a request from U.S. Environmental Protection Agency (EPA) to evaluate human health risks from exposure to 1,4-dioxane contaminated groundwater at Tucson International Airport Area (TIAA) Superfund site in Tucson, Arizona. TIAA is listed on the National Priority List (NPL) since 1983 due to elevated levels of volatile organic compounds (VOCs) such as trichloroethylene (TCE) and perchloroethylene (PCE). The Arizona Department of Health Services (ADHS) published several public health assessment reports (ADHS 1999 a, b; 2000 a, b) to address potential health risks associated with exposure to contaminated groundwater, soil and soil gas at TIAA. However, the compound 1,4-dioxane was not previously considered a chemical of concern because it had not been detected in the ground water samples. In 2002, 1,4-dioxane was discovered in wells in the TIAA area because of the use of an improved, more accurate analytical method (EPA Method 8270, modified). This method allowed 1,4-dioxane to be detected at 1~2 microgram per liter (µg/L) levels as opposed to the previous detection level of 100 µg/L. Since 2002, numerous parties have been monitoring groundwater for 1,4-dioxane. The monitoring results were used to determine if 1,4-dioxane alone in untreated groundwater could harm people's health.

Background and Statement of Issues

Site Description: The Tucson International Airport Area (TIAA) Superfund Site is located on the south side of Tucson, Arizona. The site is located approximately south of Ajo Way, north of Hughes Access Road, east of Interstate 19, and west of Alvernon way (see Appendix A). The site contains seven major project areas: Air Force Plant 44 (AFP44), Tucson Airport Remediation Project (TARP), the Airport Property, the Arizona Air National Guard Base, West Plume B, and Texas Instruments, Inc. The Tucson International Airport is located within the site. The site includes one main contaminated groundwater plume with smaller areas of groundwater contamination located east of the main plume. The area around the TIAA is of mixed commercial and residential usage. The area close to the airport tends to be more commercial than areas slightly further from the airport. The greatest concentrations of residences are west and north of the airport.

Site History: Between 1950 to 1970, industrial and defense related activities (electronics manufacturing, metal plating, aircraft maintenance, and weapons manufacturing) resulted in the release of hazardous substances into the soil and ground water. In 1981, groundwater was found contaminated with volatile organic compounds (VOCs), including trichloroethylene (TCE) and perchloroethylene (PCE), in the area (EPA 1988). A number of investigations were conducted to evaluate the nature and extent of contamination in the area. From these investigations, at least three separate areas of contamination, potentially from different sources, have been identified. The TIAA site was officially added to the National Priorities List (NPL) in 1983.

Approximately 20 facilities have operated at various times in the TIAA vicinity. These facilities may have contributed to the groundwater contamination. Known waste handling activities related to the TIAA site included: 1) surface discharge of waste liquids, containing several organic compounds, into soils, disposal ponds, and unlined landfills, and 2) burning of waste for use in fire training exercises.

In 2002, elevated levels of 1,4-dioxane were discovered in wells in the TIAA area. Based on the data collected so far, it appears that the majority of the 1,4-dioxane contamination originated at AFP 44. There may also be some smaller sources on the Airport Property. There are currently ongoing investigations to evaluate the presence of 1,4-dioxane on the Airport Property.

Public Health Concerns: The primary contaminants of concern (COCs) in the groundwater include VOCs such as TCE, dichloroethene (DCE), chloroform, and 1,4-dioxane. In 1987, a groundwater treatment facility at the AFP44 began operation to remove VOCs from groundwater. To address the elevated levels of 1,4-dioxane in groundwater, the AFP44 installed an advanced oxidation treatment system to replace the original one. The new system treats VOCs and 1,4-dioxane and began operating in 2009.

In 1994, an additional treatment facility at TARP began treating contaminated groundwater from the northern portion of the plume. VOCs are removed by air stripping technology and carbon filtration. The TARP system provides drinking water to about 50,000 residents in north Tucson (or about 9% of the municipal water supply) (EPA 2010). This area covers about 30,000 home and business outside of the south side. This area is bounded by 22nd Street on the south, Silverbell Road on the west, First Avenue on the east, and River Road on the north (see Appendix A) (ADS 2011).

Currently, Tucson Water is the main municipal water provider. It operates the TARP treatment plant to meet the Federal (Maximum Contaminant Levels, MCLs) and Arizona State regulations (Aquifer water Quality Standards, AWQSs). They are legally enforceable standards that apply to public water systems to protect public health by limiting the levels of contaminants in drinking water. A list of contaminants and their MCLs can be found at EPA's website: http://water.epa.gov/drink/contaminants/index.cfm (Last accessed: July 15, 2011).

1,4-dioxane was also discovered in the groundwater at TARP, but it cannot be removed by the current treatment system. The enforceable MCL or AWQS for 1,4-dioxane have not been developed. However, EPA has a Drinking Water Advisory value of 35 µg/L at one-in-a thousand (10^{-4}) cancer risk level (EPA 2011). The state drinking water guideline for 1,4-dioxane is 3 µg/L in California, 3 µg/L in Massachusetts, 5 µg/L in Florida, and 32 µg/L in Maine (HSDB 2011). Since 2002, 1,4-dioxane has been detected throughout the TIAA area at levels above the EPA Drinking Water Health Advisory. Tucson Water uses blending (i.e. dilution) with other water sources to reduce the 1,4-dioxane level to about 1 parts per billion (ppb) prior to sending the water into the distribution system. At the TIAA area, most of the residents obtain their water from the Tucson municipal water system. However, the city of Tucson south side residents do not receive drinking water from treated effluent coming from the TARP facility, and no supply wells within the Tucson International Airport Superfund Site are used for the delivery of drinking water to south side Tucson Water customers. Some private owned domestic wells in the area have been impacted, but have either been shut down or converted to irrigation wells. However, a few residences in the area still chose to use private wells for drinking purposes. Surface water is not a significant source of water supply in the area. This health consultation will only evaluate the public health risks due exposure to 1,4-dioxane in untreated groundwater at the TIAA area. Historical COCs such as TCE will not be discussed in this report since TIAA is still listed on the NPL. For more information on the historical COCs, please refer to the previous reports (ADHS 1999 a, b; 2000 a, b) or the EPA website: http://www.epa.gov/superfund/sites/npl/nar899.htm.

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

Since 2006, the U.S. Geological Survey (USGS) Arizona Science Center, in cooperation with the U.S. Air Force Center for Engineering and the Environment and the City of Tucson, has conducted an investigation to assess the extent of groundwater contamination by 1,4-dioxane in the area. A total of 210 samples were collected and analyzed for 1,4-dioxane from 56 selected monitoring wells, supply wells, former supply wells and one private well (Tillman 2009).

Samples collected from 2006 to 2007 were analyzed by the TestAmerica Laboratory. These samples were analyzed by EPA Method 5030B/8260B which has a reporting limit of 1.0 µg/L. Samples collected from 2008 to 2009 were analyzed by the Weck Laboratories. These samples were analyzed by EPA Method 8270M which has a reporting limit of 0.5 µg/L (Tillman 2009).

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, 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.

At the TIAA site, complete and potential exposure pathways may result from people using water from contaminated wells (i.e. private and municipal supply wells) either for irrigation or domestic purposes or both. In the mid-1990s, several wells were identified with high levels of TCE or PCE. Some of them were abandoned over the years. Although an accurate assessment of the well usage may not be available, there are three that are actively being used for drinking water purposes. Two of the drinking water wells are in the general vicinity of the TARP plum: PW-012 and PW-013. Each is a drinking water source for a mobile home park. The third drinking water well serves a private residence, but it is located in the general vicinity of West Cap and West Plum B, and 1,4-dioxane has not been detected in the area.

Typical domestic and municipal supply well exposures to chemicals include: ingestion from drinking and cooking, and skin contact and inhalation from bathing or showering. However, skin contact and inhalation 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 1995). 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.

For monitoring wells, ADHS determined that the exposure pathway is eliminated. The purpose of these wells is to monitor the groundwater conditions to provide geologic, hydrologic and chemical data on soil and water. Thus, residents are unlikely to have contact with water and its contaminants through inhalation, ingestion or dermal contact. Workers may contact chemicals through ingestion or skin contact. However, these exposure pathways are considered insignificant due to limited amount and frequency of exposures. It should be noted that workers performing routine monitoring in these wells would typically follow a health and safety plan (HASP) designed to minimize or eliminate potential contact and exposures.

Table 1 summarizes the pathways for this site. ADHS further evaluated the completed and potential exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration, and frequency to result in adverse health effects. Eliminated exposure pathways require no further evaluation.

Table 1. Exposure pathway evaluation

Well Type	Exposure Pathway Elements					Time Frame	Type of Exposure Pathway
	Source	Media	Point of Exposure	Route of Exposure	Estimated Exposed Population		
Municipal supply well, private well	Surface discharge, burning of waste	Groundwater	Residence tap	Ingestion, inhalation, dermal contact	Residents	Past	Potential
						Current	Completed
						Future	Potential

Well Type	Exposure Pathway Elements					Time Frame	Type of Exposure Pathway
	Source	Media	Point of Exposure	Route of Exposure	Estimated Exposed Population		
Former municipal supply well	Surface discharge, burning of waste	Groundwater	Residence tap	Ingestion, inhalation, dermal contact	Residents	Past	Potential
						Current	Eliminated
						Future	Potential
Monitoring well	Surface discharge, burning of waste	Groundwater	—	—	Workers	Past	Eliminated
						Current	Eliminated
						Future	Eliminated

Comparison to 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 suggest "harmless." These comparison values are quite conservative, because they include ample safety factors that account for 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 at 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.

Table 2 is a summary of the measured 1,4-dioxane concentrations in supply, former supply and private wells. Two of the private wells (PW-012 and PW-013) are used as drinking water wells for mobile parks. The PW-020 is a church well that may be used for other purposes besides drinking, watering plants/gardens. In the table, R-001A through R-009A are the plume remediation wells. The southern wellfield (R-001A thru R-005A) is in the upper aquifer and while the TCE and 1,4-dioxane concentrations are higher, the production rates (about 1000 gpm combined) are lower. The northern wellfield (R-006A thru R-009A) is the higher production (about 1000 gpm per well) and provides containment of the plume but with low COCs. Former supply wells are not used currently.

Some of the samples have concentrations below the laboratory method reporting limits. It is the lowest amount of an analyte in a sample that can be quantitatively determined with acceptable precision and accuracy. Therefore, when laboratories report that a chemical was below its reporting limit in a sample that does not mean that the chemical was not present. Rather, it means that chemical was not present at levels that can be reliably measured by the analytical method, and the actual concentration is somewhere between 0 and the reporting limit. ADHS took a commonly used approach by using one-half of the detection limits to represent the exposure concentration.

Table 2. Summary of measured 1,4-dioxane concentrations and their respective comparison values (CVs) in micrograms per liter (µg/L). The samples were collected from wells located at the Tucson Airport Remediation Project Area (TARP) during the summer of 2006 through 2009 (See Appendix A).

Well ID	Well Type[a]	Number of Samples	Range of detected concentration (µg/L)	Averaged concentration[b] (µg/L)	Health-based CVs[c] (µg/L)
B-085 A	S	1	< 0.5	0.25	1,000 (EMEG-ci) 3(CREG)
B-103 A	FS	5	< 0.5 — < 1	0.35	
C-064 A	FS	4	1.4 — 1.7	1.58	
C-064 B	FS	4	1.5 — 2.0	1.7	
C-066 A	FS	4	1.9 — 4.0	3.05	
C-077 A	FS	5	< 0.5 — < 1	0.51	
C-078 A	FS	5	0.52 — < 1	0.54	
C-081 A	FS	4	< 0.5 — < 1	0.38	
PK-010 A	FS	5	1.5 — 2.0	1.76	
PW-012	P	10	0	0	
PW-013	P	10	0 — 2.3	1.29	
PW-020	P	5	3.0 — 6.8	4.64	
R-001 A	S	5	6.2 — 7.8	6.98	
R-002 A	S	5	6.6 — 8.6	7.68	
R-003 A	S	2	7.5 — 9.3	8.40	
R-004 A	S	2	7.1 — 8.2	7.65	
R-005 A	S	2	6.7 — 7.4	7.05	
R-006 A	S	1	< 0.5	0.25	
R-007 A	S	1	1.5	1.50	
R-008 A	S	1	< 0.5	0.25	
R-009 A	S	1	0.58	0.58	
SS-001 A	S	1	< 0.5	0.25	
SS-017 A	S	1	< 0.5	0.25	
SS-021 A	S	4	< 0.5 — < 1	0.38	
SS-023B	S	4	< 0.5 — < 1	0.38	

[a.] Well type: S for supply well; FS for former supply well; P for private well [b.] Average groundwater concentrations are used for screening and dose assessment. When measured concentration below the reporting limit, one-half of the reporting limit was used to represent the concentration.

[c.] Health-based CVs: EMEG-ci: Environmental Media Evaluation Guide for children's chronic exposure, which is determined by the following equation: $\frac{Minimal\ Risk\ Level\ (\frac{\frac{mg}{kg}}{day})\ \times Body\ Weight\ (kg)}{Ingestion\ Rate\ (\frac{L}{day})} = \frac{0.1\ (\frac{\frac{mg}{kg}}{day})\times 10(kg)}{1(\frac{L}{day})} = 1000\ \frac{ug}{L}$;

CREG: Cancer Risk Evaluation Guide for 10^{-6} risk level, which is determined by the following equation:

$$\frac{Target\ Risk\ Level\ \times Body\ Weight\ (kg)}{Ingestion\ Rate\ \left(\frac{L}{day}\right) \times Cancer\ slope\ Factor\ (\frac{\frac{mg}{kg}}{day})^{-1}} = \frac{10^{-6}\ \times 70\ (kg)}{2\left(\frac{L}{day}\right) \times 0.011\ (\frac{\frac{mg}{kg}}{day})^{-1}} = 3\ \frac{ug}{L}$$

Public Health Implications: This section provides general toxicological information of 1,4-dioxane and site-specific exposure evaluation.

<u>General Toxicological Information of 1,4-dioxane</u>

1,4-Dioxane is a stable, clear liquid at ambient temperatures and dissolves almost completely in water. 1, 4-Dioxane is used as an additive to stabilize various compounds and as a solvent for chemical processing and manufacture of adhesives, cleaning and detergent preparations, cosmetics, deodorant fumigants, emulsions and polishing compositions, varnishes, and waxes. It has also been used as a laboratory reagent and is found in plastic, rubber, insecticides, and herbicides (ATSDR 2007).

People are exposed to 1,4-dioxane every day because of its widespread use in medicines, shampoo, cosmetics, detergents, and household items. In 2000, Food and Drug Administration (FDA) instituted a formal policy that cosmetic products should not contain 1,4-dioxane at concentrations greater than 10 parts per million (ppm). However, in products (e.g., children's shampoos and bubble baths) analyzed since 1994, the FDA observed between the years 1992 and 1997, the average concentration of 1,4-dioxane in cosmetic finished products was reported to fluctuate from 14 to 79 ppm (14,000 to 79,000 ppb). Current levels of 1,4-dioxane in consumer products are much lower (ATSDR 2007, FDA 2005).

1,4-dioxane is readily absorbed through the lungs and gastrointestinal system and poorly absorbed through the skin. At exposure to lower doses, 1,4-dioxane and its metabolites rapidly leave the body, with almost all of it eliminated within one day after exposure ceases. At exposure to higher doses, the metabolic process may become saturated resulting in 1,4-dioxane being excreted in exhaled air (ATSDR 2007).

1,4-dioxane has moderate to low acute toxicity. Exposure to high levels of 1,4-dioxane may irritate the eyes, nose, throat, and lungs in humans. ATSDR's toxicological profile summarizes that: Eye irritation was observed at 50 parts per million (ppm) during a 6-hour exposure. However, in another study, no eye or respiratory irritation have been observed among volunteers exposed to 1,4-dioxane at 20 ppm for 2 hours. In animal studies, liver and kidney degeneration and necrosis were observed frequently in acute oral and inhalation exposures (ATSDR 2007).

The available data shows that the liver and kidneys are the target organs for 1,4-dioxane toxicity. Epidemiologic studies of workers exposed to low levels of 1,4-dioxane have not shown adverse effects (Rowe and Wolf 1982). Dose-related liver and kidney damage have been observed in several species of animals (EPA 1995). Kociba et al. (1974) reported the most sensitive effects in the liver and kidney based on a "no-observed-adverse-effect-level (NOAEL[1])" of 9.6 mg/kg-day and a "lowest-observed-adverse-effect-level (LOAEL)" of 94 mg/kg-day.

The Department of Health and Human Services (DHHS) considers 1,4-dioxane as reasonably anticipated to be a human carcinogen on the basis of sufficient evidence of carcinogenicity in experimental animals (NTP 2005). The International Agency for Research on Cancer (IARC) classifies 1,4-dioxane as Group B2, possible human carcinogen (IARC 1987). EPA classifies 1,4-dioxane as "likely to be carcinogenic to humans", based on inadequate evidence in humans and sufficient data in animals (EPA, 1,4-dioxane, IRIS, 8/11/2010). Limited and inconclusive human data exist with respect to associations between chronic 1,4-dioxane exposure and incidence of cancer. Only two studies are available and these were limited by small sample size and small number of reported cancer cases (Buffler et al., 1978, Thiess et al. 1976). Results from animal drinking water studies showed increased hepatic tumors in rats and mice, and peritoneum (intestinal lining), mammary gland, and nasal tumors in rats (Kano et al. 2009, JBRC 1998, Yamazaki et al. 1994).

The reproductive toxicity of 1,4-dioxane has not been evaluated directly; the only study involving 1,4-dioxane was in combination with 1,1,1-trichloroethane. In this study, no effects on fertility were reported in OCR Swiss mice given 1,1,1-trichloroethane containing 3% 1,4-dioxane during a 2-generation drinking water study. When pregnant rats were dosed with 1,4-dioxane by gavage at doses that caused the mothers to lose weight, there were no significant differences between control and treated groups of offspring (Giavini et al.,1985).

<u>Site-specific Exposure Evaluation for 1,4-dioxane[2] in untreated groundwater</u>

- Chronic (Noncancer) Effect

  As shown in Table 2, none of the averaged concentrations exceeded the Environmental Media Evaluation Guide (EMEG) for children's chronic exposure. EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic health effects based on Agency for Toxic Substances and Disease Registry (ATSDR) evaluation. Therefore, detected levels of 1,4-dioxane in untreated groundwater are not expected to cause noncancerous health effects in the exposed population..

- Carcinogenic Effect

  Some wells contain 1,4-dioxane above the Cancer Risk Evaluation Guideline (CREG). ATSDR develops the CREG using EPA's slope factor, a target risk level (10^{-6}) and exposure assumptions. For site-specific exposures, ADHS used a mathematical model to estimate a theoretical opportunity of a person developing cancer from ingestion to 1,4-

[1] A NOAEL is an experimentally determined dose at which there was no statistically or biologically significant indication of the toxic effect of concern.

[2] Historical COCs such as TCE and DCE are not evaluated in this report. For more information on the potential health effects associated with exposure to historical COCs in untreated water please refer to the previous reports (ADHS 1999 a, b; 2000 a, b)

dioxane contaminated water since oral ingestion is the major route of exposure. Exposures from skin contact and inhalation are minimal as discussed previously, and were not included in the cancer risk estimation. The slope factor (0.1 per mg/kg/day) used in the cancer risk estimation is published at Integrated Risk Information System (IRIS) by EPA on 8/10/2010. All the estimated theoretical cancer risks fall between 0 and 1.15×10^{-5}. These risks are below or within the range of public health guideline (10^{-6}~10^{-4}) for protection of human health as suggested by the EPA (see Appendix B). These cancer risks due to 1,4-dioxane exposure are considered to be very low, low or moderate based on the qualitative ranking of cancer risk estimates (see Appendix C).

ATSDR 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 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 child 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 report evaluated the potential health effects associated with the exposure to 1,4-dioxane alone in untreated groundwater. The potential health effects associated with the exposure to historical contaminants of concerns such as TCE has been discussed in previous reports (ADHS 1999 a, b; 2000 a, b) and are available at ADHS (http://www.azdhs.gov/phs/oeh/atsdr_reports.htm) or ATSDR (http://www.atsdr.cdc.gov/HAC/PHA/HCPHA.asp?State=AZ).

The detected levels of 1,4-dioxane in groundwater wells are not expected to harm the health of people. The detected concentrations were below the EPA's health advisory of short-term exposures (1-day and 10-day exposures) for children. The detected concentrations of 1,4-dioxane were also below the health-based guidelines for noncancerous adverse health effects. In addition, the estimated theoretical excess lifetime cancer risks are below or within the range of public health guidelines (10^{-6}~10^{-4}) for protection of human health as suggested by EPA. These cancer risks are considered to be very low, low, or moderate based on the qualitative ranking of cancer risk estimates. Therefore, ADHS does not consider 1,4-dioxane alone will pose a health threat to people who consume the water in former municipal supply, municipal supply or private wells.

Limitation: This report did not evaluate the health effects due to exposure to multiple chemicals, such as dioxane, PCE and /or TCE, in untreated groundwater.

Recommendations

- The lead agency, United States Air Force, and EPA should continue to oversee groundwater monitoring activities for 1,4-dioxane at the Tucson Airport Remediation Project area.
- Currently, the water supply from the affected area is only treated for trichloroethylene, not 1,4-dioxane, due to the lack of a Maximum Contaminant Level (MCL) or Aquifer Water Quality Standard (AWQS). For the safety of the public, ADHS also recommends that the City of Tucson continue to treat TCE in water from the affected area.

Public Health Action Plan

- ADHS will continue to review and evaluate groundwater monitoring results from the site when data are acquired by EPA or other agencies overseeing the site.
- ADHS will attend public meetings, make presentations, and develop educational information on the public health implications of groundwater contaminants when requested by the community, United States Air Force (USAF) and EPA.

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Certification

This Health Consultation entitled *Tucson International Airport, Evaluation of 1,4-dioxane in groundwater wells, Pima 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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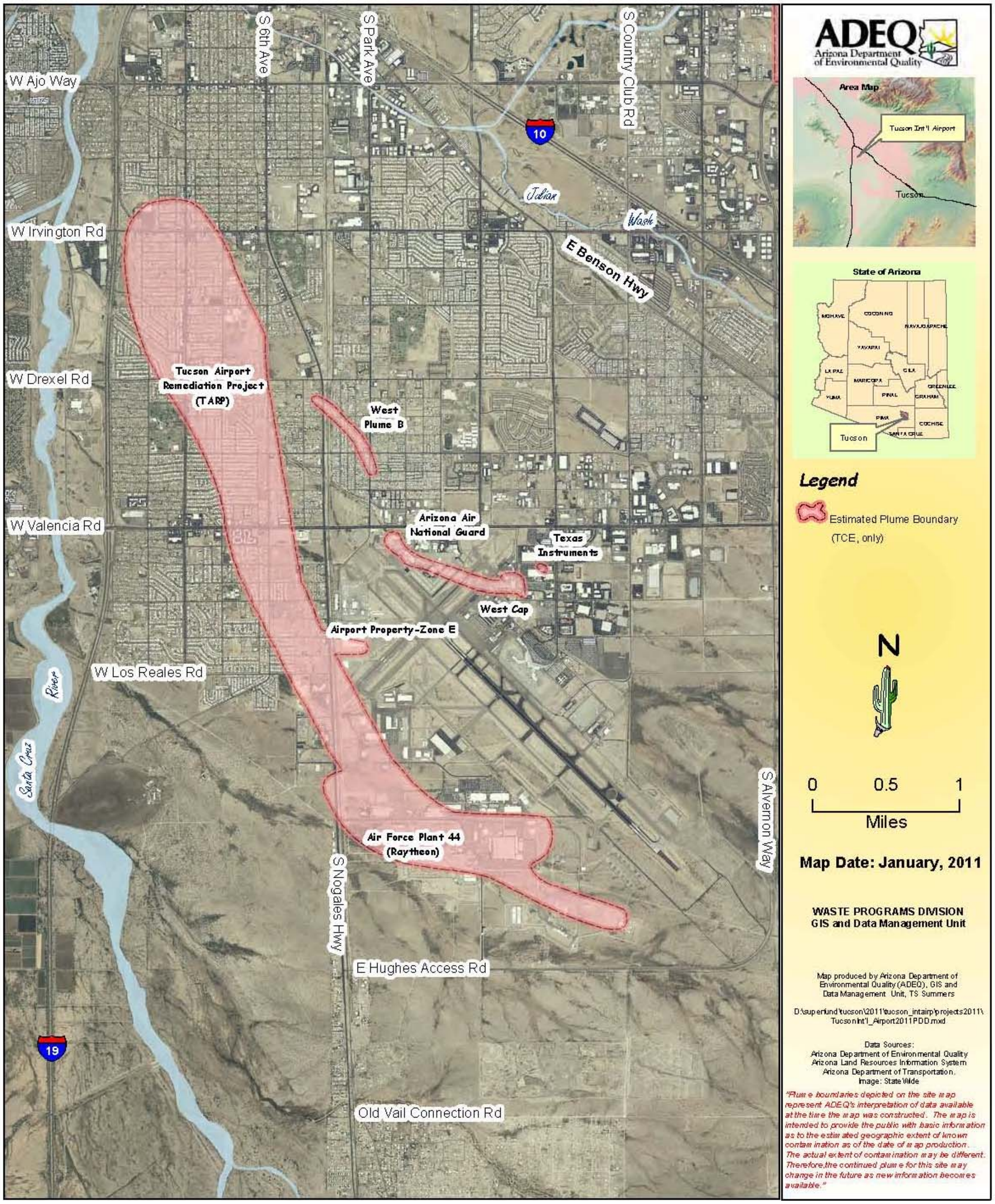
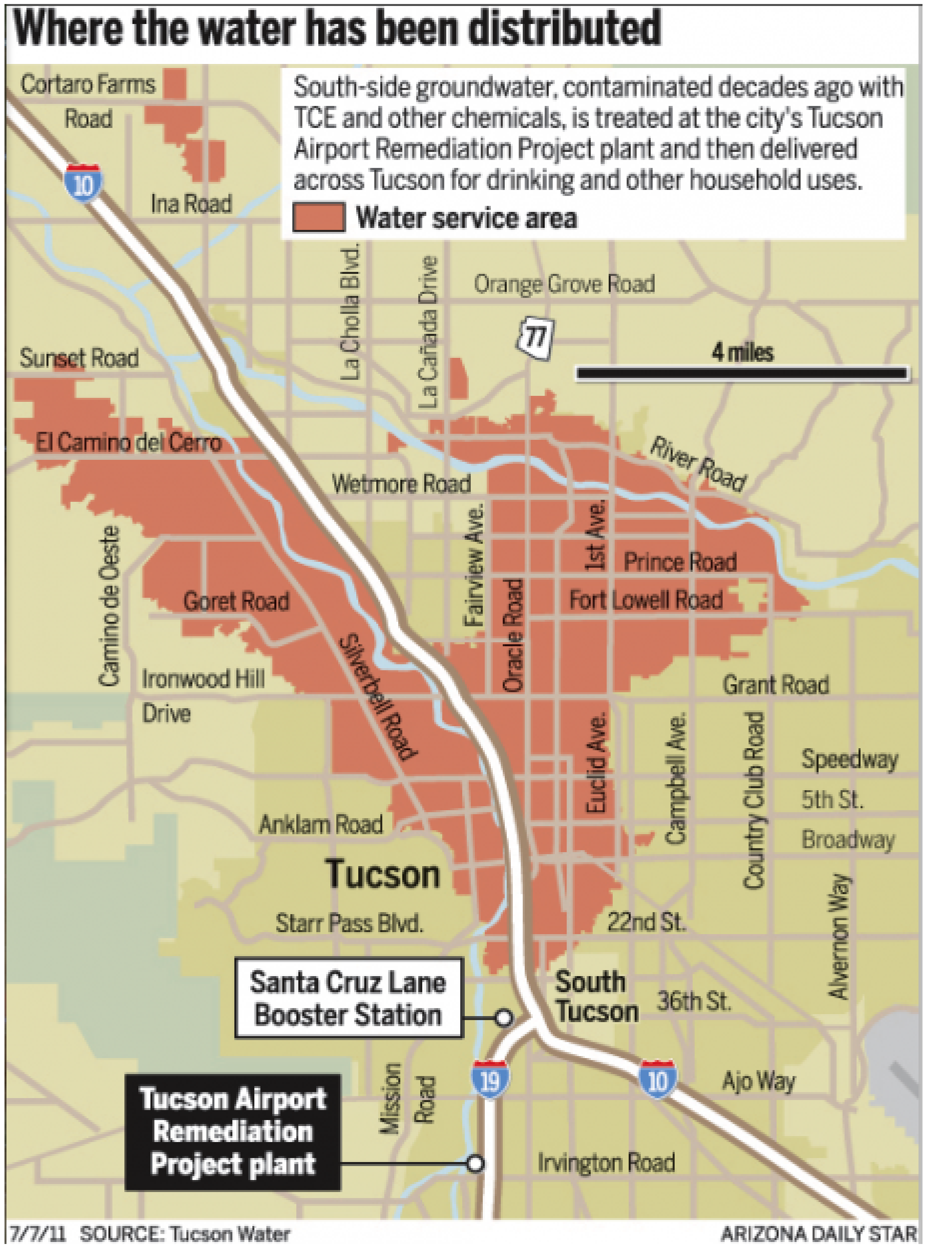
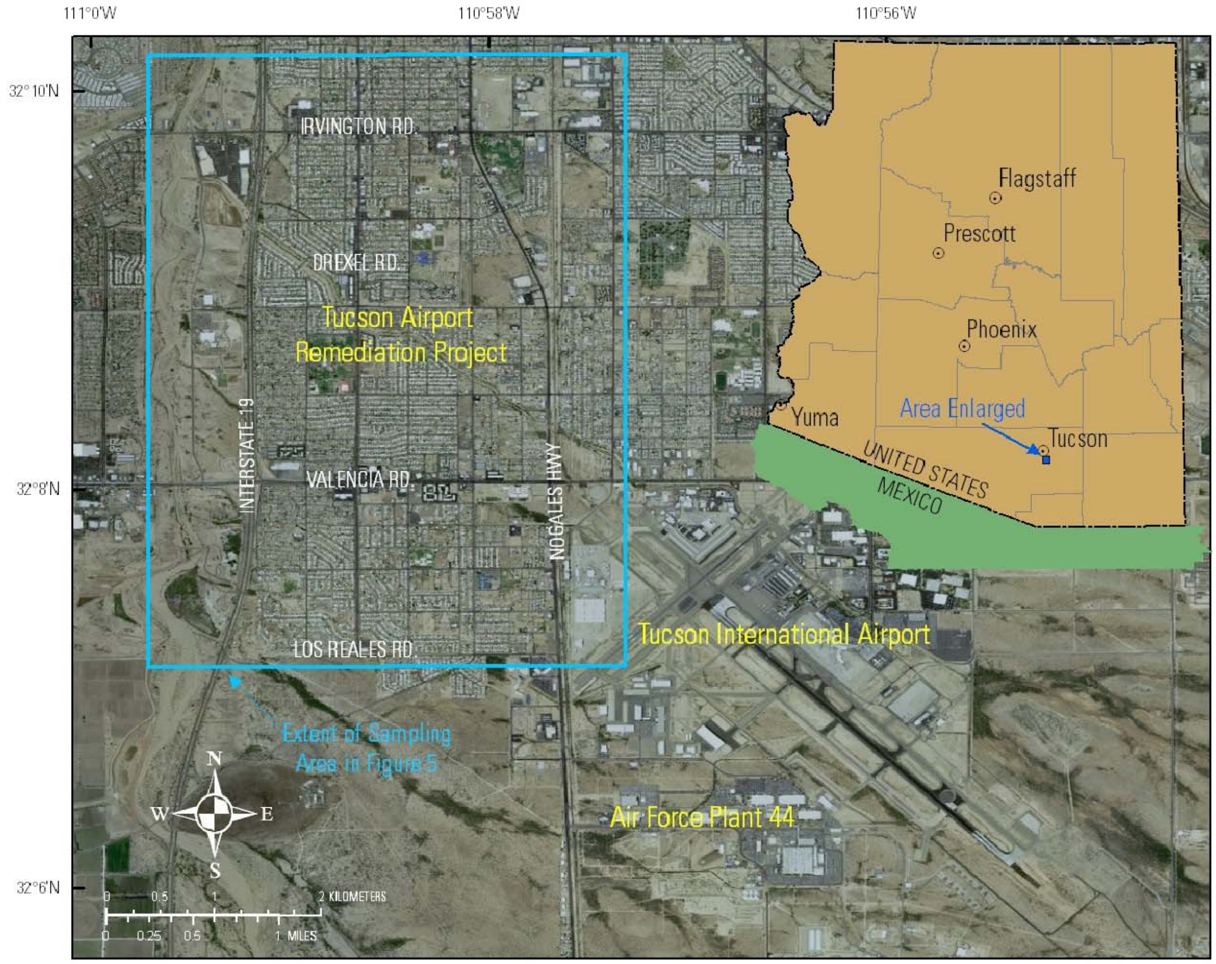
Appendix A



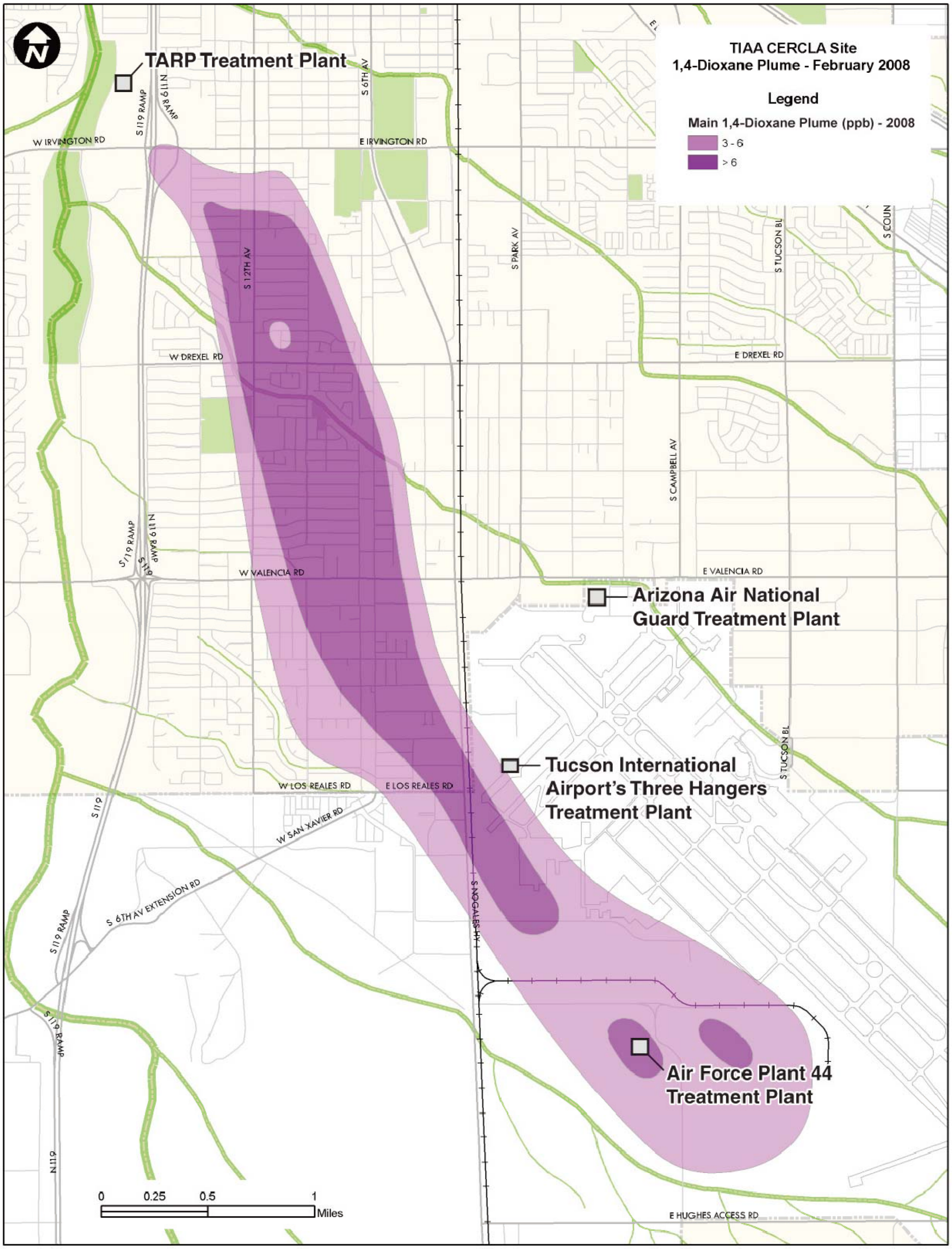
The location of the EPA National Priorities List Site: Tucson International Airport Area. The map is adapted from: http://www.azdeq.gov/environ/waste/sps/download/tucson/tiaamap.pdf



Map shows the area of water has been distributed after treated by the Tucson Airport Remediation Project. The map is adapted from Arizona Daily Star: http://azstarnet.com/news/science/environment/article_9a717419-f32e-547e-af31-10924cec2b26.html



Study area shows general locations of the Tucson Airport Remediation Project (TARP), Tucson International Airport and Air Force Plant 44. The figure is adapted from USGS Report (Tillman 2009).



1,4-Dioxane Plume Map. Adapted from EPA Factsheet: Tucson International Airport Area Superfund Site (EPA, Region 9, March 2010; http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/b488311d281d26d7882574260072fae1/059cb5fab6167d2d882576f50080233e/$FILE/TIAA%203_10%203mb.pdf)

Appendix B

Formula and assumptions used to calculate cancer risk from water ingestion:

$$\text{Chronic Daily Intake (mg/kg/day)} = \frac{C_w \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

$$\text{Cancer Risk} = \text{Chronic Daily Intake} \times \text{SF}$$

Variable			
C_w	Chemical concentration in water	mg/L	variable
IR	Ingestion rate	L/day	2
EF	Exposure frequency	days/year	350
ED	Exposure duration	years	35
BW	Body weight	kg	70
AT	Averaging time	days	25,550
SF	Slope Factor	$(\text{mg/kg/day})^{-1}$	0.1

Below is an example to show how the cancer risk was estimated for well B-085 A. The detected 1,4-dioxane concentration in well B-085 A is 0.25 µg/L (i.e. 0.00025 mg/L)

$$Chronic\ Daily\ Intake = \frac{0.00025\ \frac{mg}{L} \times 2\frac{L}{day} \times 350\frac{days}{year} \times 35\ years}{70\ kg \times 25{,}550\ days}$$

$$= 0.00000342\left(\frac{\frac{mg}{kg}}{day}\right) = 3.42 \times 10^{-6}\left(\frac{\frac{mg}{kg}}{day}\right)$$

$$Cancer\ Risk = 3.42 \times 10^{-6}\left(\frac{\frac{mg}{kg}}{day}\right) \times 0.1\left(\frac{\frac{mg}{kg}}{day}\right)^{-1} = 3.42 \times 10^{-7}$$

<u>Estimated Cancer Risks for Individual Wells</u>

Well ID	Well Type	Estimated Theoretical Cancer Risk
B-085 A	Supply	3.42×10^{-7}
B-103 A	Former Supply	4.79×10^{-7}
C-064 A	Former Supply	2.16×10^{-6}
C-064 B	Former Supply	2.33×10^{-6}
C-066 A	Former Supply	4.18×10^{-6}
C-077 A	Former Supply	6.99×10^{-7}
C-078 A	Former Supply	7.40×10^{-7}
C-081 A	Former Supply	5.21×10^{-7}
PK-010 A	Former Supply	2.41×10^{-6}
PW-012	Private	0
PW-013	Private	1.77×10^{-6}
PW-020	Private	6.36×10^{-6}
R-001 A	Supply	9.56×10^{-6}
R-002 A	Supply	1.05×10^{-5}
R-003 A	Supply	1.15×10^{-5}
R-004 A	Supply	1.05×10^{-5}
R-005 A	Supply	9.66×10^{-6}
R-006 A	Supply	3.42×10^{-7}
R-007 A	Supply	2.05×10^{-6}
R-008 A	Supply	3.42×10^{-7}
R-009 A	Supply	7.95×10^{-7}
SS-001 A	Supply	3.42×10^{-7}
SS-017 A	Supply	3.42×10^{-7}
SS-021 A	Supply	5.21×10^{-7}
SS-023B	Supply	5.21×10^{-7}

Appendix C

Qualitative Descriptors for Excess Lifetime Cancer Risk

Cancer Risk	Qualitative Descriptor
Equal to or less than one per million (Cancer Risk $\leq 10^{-6}$)	Very Low
Greater than one per million to less than one per ten thousand (10^{-6} < Cancer Risk $\leq 10^{-5}$)	Low
Greater than one per ten thousand to less than one per thousand (10^{-5} < Cancer Risk $\leq 10^{-4}$)	Moderate
Greater than one per thousand to less than one per ten (10^{-4} < Cancer Risk < 10^{-1})	High
Equal to or greater than one per ten (Cancer Risk $\geq 10^{-1}$)	Very High

An estimated increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is a plausible upper-bound estimate of the probability that a person may develop cancer sometime in his or her lifetime following exposure to that contaminant.

There is insufficient knowledge of cancer mechanisms to decide if there exists a level of exposure to a cancer-causing agent below which there is no risk of getting cancer, namely, a threshold level. Therefore, every exposure, no matter how low, to a cancer-causing compound is assumed to be associated with some increased risk. As the dose of a carcinogen decreases, the chance of developing cancer decreases, but each exposure is accompanied by some increased risk.

There is general consensus among the scientific and regulatory communities on what level of estimated excess cancer risk is acceptable. The EPA considers an acceptable cancer risk range from 10^{-6} to10^{-4}.