Health Consultation

Re-evaluation of Past Exposures to VOC Contaminants in Drinking Water

FORMER WURTSMITH AIR FORCE BASE

OSCODA, IOSCO COUNTY, MICHIGAN

EPA FACILITY ID: MI5570024278

November 17, 2020

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Community Health and Hazard Assessment
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 the
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SUMMARY

INTRODUCTION This report was written in response to a request to ATSDR by a group of concerned citizens and veterans to re-evaluate past exposures to volatile organic compounds (VOCs) in drinking water at the former Wurtsmith Air Force Base (WAFB) in Oscoda, Michigan, and to update our health-based conclusions to reflect the latest science. ATSDR evaluated these exposures in the past [ATSDR 2001]. This document updates the previous evaluation to reflect important changes in science and exposure evaluation approaches for VOCs that have occurred since the publication of the 2001 document.

ATSDR re-evaluated our previous health-based conclusions for past exposures to VOCs in drinking water from on-base and off-base water supply wells. We used sampling data from the 2001 report for the re-evaluation. Other exposure pathways and/or contaminants have already been addressed [MDCH 2012; 2015a; 2015b; 2017] or will be addressed in future evaluations, as needed.

Most of the past exposures occurred before 1980. Today, the majority of on-base and off-base facilities, residences, and camps receive their drinking water from the Huron Shores Regional Utility Authority, a source that is not located near WAFB and that meets all federal and state drinking water quality standards. A few wells that are still in service are being monitored by local authorities.

ATSDR reached three conclusions about past exposures at the former Wurtsmith AFB site.

CONCLUSION 1 *Some children and adults who used trichloroethylene (TCE) contaminated water for household (e.g., drinking, showering, bathing) or potable purposes (drinking only) in the past may be at risk for harmful non-cancer health effects.*

The results for each well are summarized in Tables 13D - 25D in Appendix D.

BASIS FOR CONCLUSION Critical adverse non-cancer effects associated with TCE include developmental effects (heart malformations), immunological effects, and developmental immunotoxicity. ATSDR evaluated various groups of children and adults (see Table A) who were exposed to TCE via drinking water in the past. Based on estimated doses, some children and adults

who were exposed to TCE may be at increased risk for harmful immunological effects.

Additionally, if a pregnant woman was exposed to TCE during pregnancy, her baby may be at increased risk for fetal heart malformations. The baby may be at risk for cardiac heart defects even if the pregnant woman was exposed for a fairly short period of time (i.e., under three weeks) and if the exposure occurred when the fetal heart was developing (during the first trimester). The concern exists for developmental effects if a woman was exposed even for a fairly short period of time during the three-week window of critical fetal heart development in the first trimester of pregnancy. Therefore, even short-term exposures during pregnancy may be a concern for cardiac effects.

CONCLUSION 2 *Some people who were exposed to TCE via drinking wells in the past may be at an increased risk for cancer*.

The results for each well are summarized in Tables 13D - 25D in Appendix D.

BASIS FOR CONCLUSION ATSDR estimated increased cancer risk from potential past exposures for individuals who were exposed to TCE in their water via the ingestion, inhalation, and dermal routes of exposure. We assumed that off-base (residential) children and adults were exposed for 21 years (from birth to >21 years of age) and 33 years, respectively; on-base military adults and children were exposed for 5 years; and that on-base employees were exposed for 25 years. Using the maximum amount of TCE in each well, we concluded that some children and adults may have an elevated cancer risk. Without comprehensive historical data or accurate knowledge about the source(s) of the contamination, ATSDR recognizes that there is some uncertainty in estimating cancer risk at this site.

CONCLUSION 3 *On-base employees who were exposed to benzene in drinking water in Building 5008 for many years may be at increased risk for harmful non-cancer (hematological) and cancer health effects.*

BASIS FOR CONCLUSION Benzene causes problems in the blood (hematologic). People who are exposed to benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. Long-term exposure to benzene can cause cancer of the blood-forming organs. This condition is called leukemia. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid

leukemia (AML). In estimating the excess cancer risk, we assumed that on-base employees were exposed for 25 years. Without comprehensive historical data or accurate knowledge about the source(s) of the contamination, ATSDR recognizes that there is some uncertainty in estimating cancer risk from exposure to benzene at this site.

NEXT STEPS

From our review of available information, ATSDR recommends the following:

- ATSDR supports the ongoing activities by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to ensure that the community around WAFB is provided safe drinking water.

- ATSDR recommends ongoing monitoring of potable wells by EGLE in areas that are known to be, or that could be, affected by contamination from the site.

- ATSDR recommends continued investigative actions to define the nature and extent of contamination on and surrounding the WAFB.

For more information, call ATSDR at 1-800-CDC-INFO and ask for information on the Wurtsmith Air Force Base Site.

PURPOSE

This document evaluates past volatile organic compound (VOC) contamination at the former Wurtsmith Air Force Base (WAFB) in Oscoda, Michigan, with a focus on past VOC exposures via on-base and off-base water supply wells to military members and their families, employees, visitors and nearby residents. ATSDR evaluated this exposure pathway in the past [ATSDR 2001]. ATSDR was asked by a group of concerned citizens and veterans to re-evaluate the past VOC exposures and to draw new health-based conclusions that reflect the latest science. This document updates the previous document to reflect important changes in science and exposure evaluation approaches for VOCs that have occurred since the publication of the 2001 document. Where necessary, the current document references relevant information from the 2001 document.

ATSDR is publishing this document to update our past evaluation of the public health hazards of VOCs in drinking water at the WAFB, in light of new science. As the science has developed for some of the major contaminants at this site, and our exposure assessment methods have improved, we are updating our previous evaluation using the best new science available.

Trichloroethylene (TCE), and, to a lesser extent, benzene, are the contaminants of concern in drinking water at this site. Therefore, this document reflects the latest scientific developments regarding health effects for the chemicals TCE and benzene, as well as ATSDR's updated guidance for assessing exposures. Although other VOCs were detected in drinking water, and other pathways were evaluated in the past, the other VOCs and pathways are not part of this re-evaluation for the following reasons:

- other exposure pathways and/or contaminants have already been addressed or will be addressed in future evaluations, as needed;
- no new science or methods are available to update our previous evaluation/conclusions;
- the detected contaminants were not considered to be site-related (e.g., some are common drinking water disinfection byproducts such as chloroform, bromoform, and dichlorobromomethane; or are common laboratory contaminants such as methylene chloride); or
- the exposure pathway resulted in very limited or no known exposures.

Again, this document will evaluate only past TCE and benzene exposures in drinking water; other exposure pathways and/or contaminants have already been addressed or will be addressed in future evaluations, as needed.

Please refer to ATSDR's original 2001 Public Health Assessment (PHA) for Wurtsmith Air Force Base for more detailed information about this site. The document is currently available at https://www.atsdr.cdc.gov/HAC/pha/WurtsmithAFB/Wurtsmith2001_PHA.pdf. This current document contains only relevant portions excerpted from the original document.

BACKGROUND

Site Description and History

Wurtsmith Air Force Base (WAFB) is in Oscoda (Iosco County), Michigan, approximately 170 miles north of Detroit (Figure 1). The 5,221-acre site is located less than one mile from Lake Huron. It is bounded by Van Etten Lake (to the north and east), the Oscoda and Au Sable communities (to the east and south), the Huron National Forest (to the south) and the Alpena State Forest (to the west). A variety of hazardous substances (e.g., fuels, solvents, and pesticides) have been handled, stored, and disposed at WAFB. Some of these materials were released to the environment, resulting in soil, groundwater, sediment, and surface water contamination at a number of locations. Contaminants from some of these areas have migrated beyond the base's boundaries. Congress approved the closure of the base in October 1991, and closing ceremonies were held on June 30, 1993 [Air Force 1995].

Contaminants were first discovered at WAFB in October 1977, when an on-base resident complained that the base's drinking water supply contained peculiar tastes and odors. In response to this complaint, a tap water sample was collected from an on-base housing unit and TCE was detected. This discovery prompted several environmental investigations and it soon became evident that a groundwater plume had formed under the base and impacted on-base water supply wells. In the years to follow, WAFB discovered that several other environmental media (i.e., surface water, sediment, and soil) had been impacted by VOC and semi-volatile organic compounds (SVOC) contaminants as well. A total of 58 areas with potential contamination were evaluated at WAFB under the Installation Restoration Program (IRP). At some of these areas, contamination was significant enough to warrant immediate cleanup activities. The site was proposed for the U.S. Environmental Protection Agency's (EPA's) National Priorities List in January 1994 [AFBCA 2000f].

Past exposures to VOCs in on-base and off-base water supplies occurred before 1980. Several of USAF's main water supply wells were taken off line when contaminants were detected in the tap water of on-base housing areas in 1977. Today, the majority of on-base and off-base facilities, residences, and camps receive their drinking water from the Huron Shores Regional Utility Authority, a source that is not located near WAFB and that meets all federal and state drinking water quality standards. A few wells are still in service and are being monitored by local authorities.

Figure 1. Wurtsmith Air Force Base Site Map

ATSDR's 2001 Public Health Assessment

In 2001, ATSDR completed a Public Health Assessment (PHA) for the WAFB. The PHA identified two pathways by which on-base residents and the surrounding community might have come into contact with contaminants originating from WAFB: (1) exposures to drinking water from on-base and off-base water supply wells and (2) exposures to on-base and off-base surface water bodies. ATSDR evaluated these potential exposure pathways and addressed community health concerns in the PHA. ATSDR reached several health-based conclusions regarding the public health implications of past, present and future exposures to VOCs, semivolatile organic compounds (sVOCs), and metals at the site.

ATSDR's primary conclusions in 2001 were as follows:

- *Past exposures to groundwater may have posed an increased risk of developing adverse health effects.* Several on-base and off-base water supply wells were used in the past to service residential areas, facility buildings, and recreational areas. Contaminants were detected in some of these wells and in samples collected from building faucets. Although TCE concentrations in on-base water supply wells and one off-base well were high enough to warrant concern, it is unknown whether the concentrations persisted at high enough levels for long enough durations to actually pose a public health hazard.
- *Current and potential future exposures to groundwater are not expected to pose a public health hazard.* The majority of on-base and off-base areas receive their drinking water supplies from the Huron Shores Regional Utility Authority, a source that is not located near WAFB, and which meets all federal and state safe drinking water standards. A few wells are still in service, but exposure to the water that they provide is not expected to pose current or future health hazards because the wells do not contain high contaminant concentrations, they are only rarely used, and/or exposure durations are expected to be short. Institutional controls are in place to prevent new wells from being installed in contaminated areas in the future.
- *ATSDR concluded that past, present, and future exposures to surface water and sediment are not expected to pose a public health hazard.* Contaminants from WAFB have been released to Van Etten Lake, the Au Sable River, Duell Lake, and a wetland area located in the southern portion of the base. Although these surface water bodies have been and continue to be used for recreational activities, contaminant concentrations are low and/or exposure is too infrequent to result in health hazards.

The Re-evaluation Process

In this report, we re-evaluated past exposures to drinking water from on-base and off-base water supply wells to determine if our conclusions should be updated. Specifically, we updated our exposure assessment and health effects evaluation to reflect current scientific understanding and guidance. We used sampling data that was already available to us in the 2001 PHA.

Below is a summary of the updates made and the historical information that did not change.

Here's what we changed:

- *Exposure assessment*. The exposure assessment is the process of identifying human exposure pathways and estimating the amount of human exposure under each exposure scenario. An important part of the exposure assessment is estimating how much of a contaminant a person may be exposed to. To do this, ATSDR calculates exposure doses. In cases where site-specific information is not available, ATSDR will apply conservative exposure assumptions to estimate exposure doses. ATSDR scientists have studied and reviewed new environmental science data to better define exposures and to fill critical data gaps. Examples include advancements in the assessment of dermal (skin) absorption and inhalation exposures while showering. We updated the approaches used to calculate exposure doses at WAFB to reflect the best available science. The updated parameters allow ATSDR to better define the contribution of each contaminant/pathway to the degree of hazard posed by a contaminant at a site.
- *Health effects evaluation*. The health effects evaluation is conducted to determine whether contact with contamination may result in harmful health effects. ATSDR uses scientific information, which can include the results of medical, toxicologic, and epidemiologic studies and data collected in disease registries, to determine what health effects may result from exposures. Since the publication of the PHA in 2001, several important scientific developments for the chemicals TCE and benzene have occurred that have allowed ATSDR to better determine whether the exposures are likely to result in harmful health effects, including potential impacts to vulnerable populations (e.g., children, women of childbearing age, fetuses). Specifically, we updated the toxicological information for TCE, which indicates health effects at lower doses and from shorter-term exposures than previously understood. Also, we updated our chronic Minimal Risk Level (MRL) for benzene in 2007.

Here's what we left the same:

- *Environmental sampling data*. ATSDR used sampling data that was previously collected from drinking water wells; no other sampling data were used or collected to redefine our understanding of the nature and extent of contamination.
- *Completed exposure pathway*. ATSDR evaluated the drinking water pathway as a past completed pathway. [A completed exposure pathway exists when there is direct evidence or, in the judgment of the health assessment team, a strong likelihood that people have in the past or are presently coming in contact with site-related contaminants. All five of the following elements of the exposure pathway must be present: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population.]
- *Well usage information*. ATSDR used available well history information to determine usage patterns for the water supply wells at the site. Previous assumptions regarding

the purpose (e.g., potable, industrial), time in service, and status (e.g., mixed, abandoned, closed) of on-base and off-base water supply wells were not changed.

DISCUSSION

Evaluating the Drinking Water Pathway

The drinking water pathway is a past completed exposure pathway and is the focus of this evaluation.

Groundwater underlying WAFB has been impacted by site activities. A groundwater aquifer lies below the base and extends beyond the base's boundaries. Several groundwater plumes have been identified, some of which have migrated beyond the base's boundaries. On-base and off-base drinking water wells have been impacted by the groundwater plumes beneath WAFB. For a number of years, the aquifer served as a drinking water source for WAFB and several nearby off-base properties.[1]

In 2001, ATSDR summarized information about the groundwater conditions and evaluated available well usage information and sampling data. ATSDR separated the wells into three categories based on the areas that they serviced:

- USAF's main water supply wells – supplied water to on-base housing units and several base buildings; used for both potable (drinking and other household uses) and nonpotable (industrial activities) purposes

- USAF's area-specific wells – supplied water to one particular area or building

- Off-base wells – supplied water to off-base private properties that are situated between WAFB and Van Etten Lake, including residential properties, campgrounds, and recreational buildings

For the re-evaluation, ATSDR used the 2001 well usage information to determine the potentially exposed population(s) and exposure route(s) for each well. The following groups of people have been identified for further evaluation:

- O*n-base military members and their families* (including children) who used the water from the water supply wells for household purposes, including drinking, cooking, showering, and laundering.

[1] According to the 2001 report, nearly all of the areas now receive their drinking water from municipal sources. ATSDR did not confirm nor check the status of this information as part of this re-evaluation.

- O*n-base employees* who may have ingested contaminated water while at work, but likely did not shower or bathe in it.
- O*ff-base residents* who live in nearby properties, who may have used water from a contaminated supply well for household purposes such as drinking, cooking, showering and laundering.
- *Visitors or short-term guests* who visited a campground, cottage, or recreational area and used the water for potable purposes, including drinking and showering. Their exposures would be short-term (conservatively assumed to be 4 weeks) and not recurring.

Table A below summarizes ATSDR's exposure assumptions for each group of people evaluated.

Table A. Assumed Exposure Times and Exposure Routes for each Potentially Exposed Group – Wurtsmith AFB

Potentially Exposed Population	Assumed Maximum Exposure Time	Reasoning	Exposure Routes
On-Base Military Members and Families	5 years	Time-on-station for Air Force members likely varied. The time stationed at the WAFB would have depended on the Airman's job and other military-related factors. ATSDR assumed that the time-on-station for Air Force members (and their families) was 5 years. The actual time spent at WAFB by any Airman could have been more or fewer than 5 years.	Ingestion Inhalation Dermal
On-Base Workers/Civilian Personnel	25 years	ATSDR assumes an individual works 25 years at the same location unless site-specific conditions warrant another exposure duration. The 25 years represent the 95th percentile estimate of tenure with current employer from the Bureau of Labor Statistics (ATSDR 2014b). The workers would have been exposed via water ingestion only, since it is unlikely that they would have showered or had other household uses while at work.	Ingestion
Off-Base Resident	33 years	ATSDR assumed that off-base residents could be exposed for a total of 33 years, which represents the 95th percentile residential occupancy period. The estimate is plausible if exposures began before the discovery of the initial contamination (1977) and continued for some time after the base closure in 1993.	Ingestion Inhalation Dermal
Occasional Visitor/Vacationer/Short-term Guest	4 weeks (28 days)	ATSDR assumed that wells that are designated for use at non-permanent housing or non-housing facilities would only be used occasionally and for short periods of time, perhaps up to 4 weeks by a visitor or vacationer.	Ingestion Inhalation Dermal

Notes:

The potential exposed populations were categorized based on the previously published well usage history or by the type of building serviced by the well. For example, Well AF4 is described as one of USAF's main water supply wells, providing potable water to on-base residents and employees. ATSDR assigned Well AF4 as a well that could have potentially been used by on-base military members and their families, as well as on-base workers/civilian personnel. Well AF22 is described as servicing the Burkhart Lodge, a visitation center for pilots. ATSDR assigned this well as one for temporary/intermittent use by visitors/vacationers. We were unable to accurately identify the use pattern and potentially exposed population for some wells. In those instances, we made conservative assumptions. If additional information becomes available, we will update our exposure assumptions, as needed.

People may have been exposed to contaminants in the drinking water in the following ways:

- **Ingestion:** drinking contaminated water;

- **Inhalation:** breathing in TCE and benzene that volatized to the air from the contaminated water;

- **Dermal Absorption:** VOCs can be absorbed through the skin when bathing and showering. The amount of exposure can increase as your contact time with water increases, for example, if you typically take long baths or showers.

Environmental Contamination

Environmental sampling data are critical inputs to the public health evaluation process. Environmental data indicate the levels of chemicals found in the environment. In this re-assessment, ATSDR used past drinking water data collected on or near the WAFB for our evaluation. **ATSDR did not collect additional new data or evaluate current use patterns/concentrations and exposures**.

ATSDR defines a comparison value (CV) as a concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening tool during the public health assessment process. Substances found in amounts greater than their CVs do not necessarily pose a risk to health. Rather, these substances are selected for further evaluation in the public health assessment process to determine whether harmful health effects are likely.

If contaminant concentrations are above these environmental screening values (or CVs), ATSDR assigns exposure parameters (for example, duration and frequency; see below), and analyzes the toxicology of the contaminant and epidemiology studies for possible health effects. During this part of the evaluation process, ATSDR estimates site-specific exposure doses and compares them to health guideline values and calculates cancer risk estimates to further evaluate the potential for harmful health effects from exposures.

Exposure Parameters

Selecting exposure parameters is an important part of deriving quantitative estimates of exposure, or exposure doses. An exposure dose (usually expressed as milligrams of chemical per kilogram of body weight per day, or “mg/kg/day”) is an estimate of how much of a substance a person may contact based on their actions and habits.

Estimating an exposure dose requires identifying how much, how often, and how long a person or population may come in contact with a concentration of a substance in a specific medium.

To estimate exposure doses at this site, ATSDR used the following exposure assumptions (See Appendix A for a detailed discussion on exposure assumptions and dose calculations):

- ATSDR used average body weights, inhalation rates, breathing rates, surface area, and shower times for calculating exposure doses. ATSDR used above-average (i.e., high-end, 95th percentile) water intake rates to be especially health protective.
- ATSDR assumed the bioavailability of TCE and benzene was 100% - that is, all of the contaminant that a person ingested is assumed to enter the bloodstream.
- ATSDR assumed that people were exposed to the maximum detected contaminant concentration for the entirety of their exposure duration (up to 33 years for off-base residents).
- ATSDR used an exposure factor of 1 for military members, visitors and residents, to represent being exposed daily. We used an exposure factor of 0.71 for workers, to represent being exposed 5 days per week (5/7).

The exposure factor (EF) term is an important parameter in the dose equation and is used to adjust the dose to account for either continuous or intermittent exposure. The EF is an expression of how often (frequency) and how long (duration) a person may be exposed to a substance. The exposure factor is calculated by multiplying the frequency of exposure (F) by the exposure duration (ED) and dividing by the averaging time (AT), as in the following equation:

$$EF = \frac{(F \times ED)}{AT}$$

Uncertainty and Data Limitations

ATSDR made every attempt to accurately assess the potential impact each contaminant had on people's health, but there are limitations to the data and uncertainty in the assumptions used in this assessment. When limitations or uncertainty existed, ATSDR chose to be more conservative in an effort to be protective of people's health. Therefore, actual exposures may have been different from those described in this document. The major uncertainties and limitations are:

- ATSDR selected the highest exposure point (maximum concentration) detected in each well to calculate exposure doses. This assumption is conservative because it assumes that people were exposed to the maximum detected concentration over the entire duration of exposure. The actual exposure levels likely fluctuated over time, which means that the levels could have been higher or lower than the maximum detected concentration. We also know that water from some individual wells was mixed with other well water before being distributed for use. However, ATSDR considered the maximum contaminant concentration detected in each individual well to represent the level that would have been detected in the faucet. We understand that this is a conservative assumption.
- The contaminant dose a person receives depends on the concentration of chemical in the water at a given time. However, sometimes we have limited sampling data to evaluate the chemical concentrations in a well over time. This limitation makes it difficult to accurately estimate the contaminant levels people might have been exposed to in the past. The concentration of chemical in a well at any given time depends on the proximity to the source of the contamination, the migration of the groundwater plume, and many other environmental factors. Therefore, it is likely that the contaminant levels in each well varied over time. We do not account for that variability in our estimates.
- The exact duration of exposure for each potentially exposed population is unknown. The contamination was first detected in 1977; however, the wells could have contaminated for many years before the initial discovery in 1977. The base opened in 1923 and served in various capacities throughout its history.[2] Some of the base operations are the potential source(s) of the contamination. Therefore, the timeframe in which the hazardous substances were released into the environment and reached wells is unknown. ATSDR used conservative assumptions to assign a maximum exposure time for Airmen (and their families), base employees, off-base residents, and visitors. We are willing to re-assess any of these assumptions if site-specific information is made available to us.

HEALTH EFFECTS EVALUATION

This section of the re-assessment evaluates the health effects that could possibly result from exposures to TCE and benzene in wells on or near the WAFB. For a public health hazard to exist, people must contact contamination at levels high enough and for long enough to affect their health.

[2] During different points in its history, the WAFB base served as (1) an airfield-housing, maintaining, and refueling several types of planes; (2) a training facility-offering training in overseas fighting, gunnery and combat zone fighting, and fire survival; and (3) a weapons storage area-maintaining, processing, testing, and housing a wide variety of weapons. Throughout much of the 1960s, 70s, and 80s, WAFB was on Ground Alert (i.e., continuous alert for foreign attacks), but it was placed on a base closure list following the end of the Cold War.

To evaluate resident's exposure to TCE and benzene in drinking water, ATSDR calculated exposure doses and estimated non-cancer and cancer risks. Calculated exposure doses are then compared to the available health guidelines to determine whether the potential exists for adverse non-cancer health effects. In the event that calculated exposure doses exceed established health guidelines (e.g., ATSDR's Minimal Risk Levels [MRLs] or EPA's Reference Doses [RfD]), an in-depth toxicological evaluation is performed to determine the likelihood of harmful health effects. ATSDR also may compare the estimated doses directly to human and animal studies, which are reported in ATSDR's chemical-specific Toxicological Profiles and other sources.

Estimating Non-Cancer Health Effects

ATSDR calculated exposure doses for the past completed drinking water pathway at this site. Often, ingestion exposure is the most significant source of exposure to hazardous substances in drinking water. However, in the case of VOC contamination, combined inhalation and dermal exposures can make a significant contribution to the total exposure dose. Studies have shown that exposure to VOCs from routes other than ingestion might be as large as the exposure from ingestion alone. Showering is considered a major contributor to overall exposure because VOCs evaporate quickly from hot water into the air, and showering is typically done in a small, enclosed space where VOC concentrations might build up. The inhalation dose due to volatization during a shower may be equal to the ingestion dose, and 50% to 90% of VOCs in water may volatize during showering, laundering, and other activities [Moya *et. al*. 1999; Giardino and Andelman 1996]. In addition to breathing in the VOCs from the air, people can absorb the chemical through their skin. Therefore, ATSDR included inhalation and dermal contact doses, as well as the ingestion dose, to estimate total exposures to TCE and benzene.

ATSDR used the inhalation model developed by Andelman and dermal exposure methods documented by EPA to estimate exposures from inhalation and dermal exposure, respectively. The Andelman method is used to estimate the exposure that would occur due to volatilization of TCE during the showering process and the subsequent inhalation of TCE-contaminated air. The model includes time spent in the enclosed bathroom after showering [Andelman 1990]. The EPA dermal exposure calculation is used to estimate skin intake of VOCs during the showering process. ATSDR evaluated exposures using a shower time of 15 minutes. ATSDR combined the drinking (oral), inhalation, and dermal exposures to derive a total exposure dose.

(See Appendix A for a detailed explanation, with examples, of how to derive a total exposure dose.)

Tables 9C – 12C in Appendix C present the combined oral, inhalation and dermal exposure doses for children and adults, including pregnant women. (It should be noted that ATSDR did not estimate inhalation and dermal exposures from showering for children less than 1 year of age because these very young children are more likely to

take baths than showers.) ATSDR paid special attention to the exposure doses for young children and pregnant women because the scientific data indicate that the developing heart and nervous system in fetuses and young children may be especially sensitive to the toxic effects of TCE [ATSDR 2014a].

Hazard quotients (HQs) were calculated to compare estimated exposure doses to health guidelines (ATSDR's MRL of 0.0005 mg/kg/day for TCE and benzene), which are levels adverse health effects are not expected. If an HQ is less than 1, the estimated exposure dose is below the health guideline and adverse non-cancer health effects are not expected. If the HQ is greater than 1, ATSDR compared the effect levels in key studies to the estimated exposure doses (from ingestion, inhalation, and dermal exposure) for children and adults to evaluate the potential for harmful non-cancer health effects.

Non-Cancer Health Effects – TCE

Harmful non-cancer effects associated with oral TCE exposure include decreased body weight, liver and kidney effects, and neurological, immunological, reproductive, and developmental effects. Previous epidemiological studies of women living in areas where the drinking water was contaminated with TCE, as well as other VOCs, have suggested an increased risk of several types of birth defects [ATSDR 2014a]. Studies in Arizona and New Jersey suggested an association between TCE contamination in public drinking water wells and cardiac defects, and the New Jersey study also found an increased risk of oral clefts and neural tube defects [Bove *et. al*., 1995, Goldberg *et. al*, 1990]. Studies of women exposed to TCE-contaminated drinking water have shown some evidence of increased risks of low or very low birth weight, term low birth weight, and small for gestational age. In laboratory animals, exposure to high levels of TCE has damaged the central nervous system, immune system, liver and kidneys, and adversely affected reproduction and development of offspring [ATSDR 2014a].

ATSDR adopted EPA's RfD of 0.0005 mg/kg/day as its chronic oral MRL in January 2013 [ATSDR 2013]. The most sensitive observed adverse effects, which were used as the primary basis for the RfD, were based on the critical effects of heart malformations (rats), adult immunological effects (mice), and developmental immunotoxicity (mice), all from oral studies. The RfD is further supported by studies showing adverse effects in the kidney (an oral study for the effect of toxic nephropathy [rats]) and route-to-route extrapolated results from an oral study for the effect of increased kidney weights (rats).

Three principal toxicological studies used in developing the RfD are detailed below:

- Johnson showed increased rates of heart defects in newborn rats born to mothers who were exposed to TCE in drinking water during gestation [Johnson *et al*., 2003]. EPA applied Physiologically Based Pharmacokinetics (PBPK)

models of TCE metabolism in rats and humans to the study results to obtain a 99th percentile human equivalent dose (HED_{99})[3] of 0.0051 mg/kg/day. At 0.0051 mg/kg/day ingested TCE, a 1% response rate is expected for fetal heart malformations in humans [EPA 2011; Johnson *et. al*. 2003].

- A study in female adult mice showed immune system effects (decreased thymus weight) after exposure to TCE in a thirty-week drinking water study [EPA 2011; Keil *et. al*. 2009]. EPA converted the study findings to obtain a HED_{99} of 0.048 mg/kg/day.

- A study of mice exposed during gestation and following birth to TCE in drinking water showed problems with immune system development [EPA 2011; Peden-Adams *et. al*. 2006]. EPA used the lowest study effect level of 0.37 mg/kg/day as a point of departure.

Based on estimated doses, some babies born to mothers who were exposed to TCE during pregnancy may be at increased risk for heart defects. (See Tables 13D – 25D in Appendix D.) One of the studies supporting the RfD is based on the critical effect of fetal heart malformations in rats. Some of the estimated doses for pregnant women approach or exceed the HED_{99} of 0.005 mg/kg/day for cardiac birth defects. Therefore, babies born to mothers who were exposed to TCE during pregnancy may be at increased risk for heart malformations. Some TCE-associated adverse health effects have been documented after short-term exposures. For example, fetal cardiac malformations have been shown to occur in rats at a level that would be equivalent to human ingesting a dose of 0.005 mg/kg/day. Thus, the concern exists for developmental effects if a woman was exposed even for a fairly short period of time during the three-week window of critical fetal heart development in the first trimester of pregnancy. Therefore, even short-term exposure during pregnancy may be a concern for cardiac effects.

Based on estimated doses, some children and adults exposed to TCE in private wells may be at increased risk for harmful immunological effects. (See Tables 13D – 25D in Appendix D.) In addition to heart defects, EPA based the RfD on immune system toxicity. Harmful effects related to the immune system have been associated with TCE exposure in both human and animal studies [EPA 2011]. A relationship between systemic autoimmune diseases, such as scleroderma, and occupational exposure to TCE has been reported in several recent studies [EPA 2011]. Immunotoxicity has also been reported in experimental studies of TCE in animals. Numerous studies have demonstrated accelerated autoimmune responses in autoimmune-prone mice, including changes in cytokine levels similar to those reported in human studies, with more severe effects, including autoimmune hepatitis, inflammatory skin lesions, and alopecia, manifesting at longer exposure periods [EPA 2011]. Developmental immunotoxicity in

[3] The HED_{99} can be interpreted as the applied dose in humans for which there is 99% likelihood that a randomly selected individual will have an internal dose less than or equal to the internal dose derived in the animal study.

the form of hypersensitivity responses have been reported in TCE-treated guinea pigs and mice via drinking water pre- and postnatally [EPA 2011]. Evidence of localized immunosuppression has also been reported in mice and rats [EPA 2011]. Overall, the human and animal studies of TCE and immune-related effects provide strong evidence for a role of TCE in autoimmune disease and in a specific type of generalized hypersensitivity syndrome, while there are less data pertaining to immunosuppressive effects [EPA 2011].

The key animal studies upon which the RfD is based derived an HED_{99} of 0.048 mg/kg/day for decreased thymus weight, an indication of immune toxicity, and a lowest observed adverse effect level (LOAEL) of 0.37 mg/kg/day for developmental immunotoxicity. When comparing our estimated doses to these key animal studies, some of our doses approach or exceed the observed effect levels in these animal studies, increasing the likelihood of adverse health effects. ATSDR used the Andelman model to estimate inhalation exposures while showering and in the enclosed bathroom after the shower, but the model does not account for VOC exposures that occur in the rest of the house throughout the day.

Non-Cancer Health Effects – Benzene

Benzene can cause problems in the blood (hematologic). People who breathe benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. A decrease in red blood cells can lead to anemia. Reduction in other components in the blood can cause excessive bleeding. Blood production may return to normal after exposure to benzene stops. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection and perhaps lowering the body's defense against cancer [ATSDR 2007].

Based on estimated doses, on-base employees who were exposed to benzene in drinking water in Building 5008 may be at increased risk for harmful hematological effects. (See Table 10C in Appendix C). ATSDR's chronic oral MRL of 0.0005 mg/kg/day for benzene is based on a hematological endpoint (decreased B cell count). The MRL is based on route-to-route extrapolation of the results of benchmark dose (BMD) analysis of a hematological endpoint assessed in benzene-exposed workers. Benzene-inducted B cell count was selected as the critical effect for benchmark dose modeling because it represented the highest magnitude of effect [ATSDR 2007].

Benzene is toxic by all routes of administration. Hematotoxicity and immunotoxicity have been consistently reported to be the most sensitive indicators of noncancer toxicity in both humans and experimental animals. The bone marrow is the target organ for the expression of benzene hematotoxicity and immunotoxicity [EPA 2003]. Exposure to benzene may be harmful to the reproductive organs and breathing benzene may cause

harmful effects on the developing fetus. These effects include low birth weight, delayed bone formation, and bone marrow damage [ATSDR 2007].

Estimating Cancer Health Effects

Cancer Health Effects – TCE

Various agencies have determined that TCE is a human carcinogen, including the Agency for Research on Cancer (IARC) IARC, the National Toxicology Program at the National Institutes of Environmental Health Sciences (NTP), and EPA. The carcinogenicity of TCE has been evaluated in numerous epidemiological studies and experimental animal studies. TCE exposures can cause cancer, with increased susceptibility for early-life exposures. The occupational studies of relatively high TCE exposures have shown increased risks for several types of cancer. The most consistent evidence has been for kidney, liver, and esophageal cancers and non-Hodgkin's lymphoma [ATSDR 2014a]. Additional evidence from occupational studies points to possible relationships between TCE exposure and increased risk of Hodgkin's disease, cervical cancer, multiple myeloma, bladder cancer, female breast cancer, and prostate cancer [Krishnadasan *et al*., 2007; Sung *et al.*, 2007; Siegel Scott and Chiu, 2006; Zhao *et al*., 2005; Hansen *et al*., 2001; Wartenberg *et al*., 2000; ATSDR 2014a]. Many of these additional studies have strong limitations including unknown exposure levels and small sample sizes. In addition, many of these studies were unable to adequately separate the effects of TCE from other solvents present in the workplace.

The National Toxicology Program (NTP) classifies TCE as reasonably anticipated to be a human carcinogen based on limited evidence of carcinogenicity from studies in humans, sufficient evidence of carcinogenicity from studies in experimental animals, and information from studies on mechanisms of carcinogenesis [NTP 2011]. The human studies were epidemiological studies that showed increased rates of liver cancer and non-Hodgkin's lymphoma, primarily in workers who were exposed to TCE on the job. The animal studies showed increased numbers of liver, kidney, testicular, and lung tumors by two different routes of exposure. EPA characterizes TCE as "carcinogenic to humans" by all routes of exposure [EPA 2011d]. This conclusion is based on human epidemiology studies showing associations between human exposure to TCE and kidney cancer, non-Hodgkin's lymphoma, and liver cancer.

In 2011, EPA published an oral cancer slope factor for TCE of 0.046 $(mg/kg/day)^{-1}$ and an inhalation unit risk of 4.1×10^{-6} $(\mu g/m^3)^{-1}$ reflecting total incidence of kidney, non-Hodgkin's lymphoma, and liver cancers [EPA 2011d]. For a given age group, the estimated increased risk of developing cancer resulting from exposure to the contaminants was calculated by multiplying the site-specific estimated exposure dose, by an appropriate cancer slope factor or inhalation unit risk (EPA values can be found at http://www.epa.gov/iris), the appropriate ADAF, and the fraction of a 78-year lifetime

under consideration. Using the above factors, ATSDR calculated the lifetime excess cancer risk from exposure to TCE in well water. (See Appendix B for detailed explanation of TCE cancer risk and example calculations.) The excess cancer risk is the number of increased cases of cancer in a population over a lifetime above background that may result from exposure to a particular contaminant under the assumed exposure conditions. For example, an estimated cancer risk of 1E-06 represents a possible one excess cancer case in a population of one million. Because of the uncertainties and conservatism inherent in deriving the cancer slope factors, the excess cancer risk is only an estimate of risk; the true risk is unknown.

Based on the calculated increased cancer risks from long-term exposures, some children and adults, on- and off-base, exposed to TCE in drinking water in the past could be at increased risk for cancer health effects. (See Tables 13D – 25D in Appendix D.) [Note: Cancer risks were not calculated for visitors and short-term guests because their exposure duration was considered to be too short.] The cancer risks are expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer.[4] Therefore, when we talk about the additional or excess cancer risk, we mean the risk above and beyond what is considered background. Typically, health guideline comparison values developed for carcinogens are based on one excess cancer case per 1,000,000 individuals (expressed exponentially as 1E-06 or 10^{-6}). ATSDR considers estimated cancer risks of less than one additional cancer case among one million persons exposed (1E-06) as insignificant or no increased risk.

Cancer Health Effects – Benzene

Benzene is a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies [EPA 2003]. Epidemiological studies and case reports provide clear evidence of a causal relationship between occupational exposure to benzene and benzene-containing solvents and the occurrence of acute nonlymphocytic leukemia (ANLL), particularly the myeloid cell type (acute myelogenous leukemia, AML) Some of the studies also provide suggestive evidence of associations between benzene exposure and non-Hodgkin's lymphoma (NHL) and multiple myeloma. The epidemiological studies are generally limited by confounding chemical exposures and methodological problems, including inadequate or lack of exposure monitoring and low statistical power (due to small numbers of cases), but a consistent excess risk of leukemia across studies indicates that benzene is the causal factor [ATSDR 2007].

Long-term exposure to benzene can cause cancer of the blood-forming organs. This condition is called leukemia. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML). The Department of Health and Human Services has determined that benzene is a known

[4] For perspective, the lifetime risk of being diagnosed with cancer in the United States is 42 per 100 individuals for males, and 38 per 100 for females (ACS 2017).

carcinogen (can cause cancer). Both the International Agency for Cancer Research and the EPA have determined that benzene is carcinogenic to humans [ATSDR 2007].

ATSDR estimated cancer risks from exposure to benzene at the WAFB site. The following equation is used to calculate excess cancer risk for benzene:

$$\text{Cancer risk} = \frac{\text{Exposure Dose x EPA's Cancer Slope Factor (CSF) x Years of Exposure}}{\text{78 years (lifetime)}}$$

The CSF is the cancer risk (proportion affected) per unit dose and is used to compare the relative potency of different chemical substances. The CSF is expressed in mg/kg/day. The CSF for benzene is 0.055 $(mg/kg/day)^{-1}$.

Based on the calculated increased cancer risks, on-base employees exposed to benzene in drinking water from Building 5008 could be at increased risk for cancer health effects. The calculated excess cancer risk was 7E-04 (or stated another way, one might expect 7 extra cases of cancer if 10,000 people are exposed), indicating an elevated cancer risk. The cancer risks are expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. Typically, health guideline comparison values developed for carcinogens are based on one excess cancer case per 1,000,000 individuals (expressed exponentially as 1E-06 or 10^{-6}). ATSDR considers estimated cancer risks of less than one additional cancer case among one million persons exposed (1E-06) as insignificant or no increased risk.

CHILD HEALTH CONSIDERATIONS

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Consumption of water and body weight are factors that make the dose higher. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing and medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health. The exposures at this site occurred many years ago. People who may have been exposed as children need to understand their potential risks now that they are adults. TCE exposures are a particular concern during the development of the fetus [Johnson *et al* 2003, EPA 2011]. Exposures during the critical fetal heart developmental period in the first trimester are of special concern. Collectively, the scientific data indicate that the developing heart and nervous system of fetuses and young children may be sensitive to the toxic effects of TCE. Our toxicity discussion above addresses these exposure concerns.

CONCLUSIONS

ATSDR was asked by a group of concerned citizens and veterans to re-evaluate past exposures at the WAFB and to draw new health-based conclusions that reflect the latest science. As part of this re-evaluation, ATSDR examined drinking water data for on- and off-base drinking water wells. We evaluated only past TCE and benzene exposures in drinking water; other exposure pathways and/or contaminants have already been addressed or will be addressed in future evaluations, as needed.

ATSDR reached the following three conclusions:

- *Some children and adults who used TCE-contaminated water for household purposes (e.g., drinking, showering, bathing, etc.) in the past may be at risk for harmful non-cancer health effects associated with TCE exposure.* The results for each well are summarized in Tables 13D-25D in Appendix D.

Critical adverse non-cancer effects associated with TCE are the critical effects of heart malformations, immunological effects, and developmental immunotoxicity. ATSDR evaluated various groups of children and adults who were exposed to TCE via drinking water in the past. Based on estimated doses, some children and adults who were exposed to TCE may be at increased risk for harmful immunological effects.

Additionally, if a pregnant woman was exposed to TCE during pregnancy, her baby may be at increased risk for fetal heart malformations. The baby may be at risk for cardiac heart defects even if the pregnant woman was exposed for a fairly short period of time (i.e., under three weeks) and if the exposure occurred when the fetal heart was developing (during the first trimester). The concern exists for developmental effects if a woman was exposed even for a fairly short period of time during the three-week window of critical fetal heart development in the first trimester of pregnancy. Therefore, even short-term exposures during pregnancy may be a concern for cardiac effects.

- *Some people who were exposed to TCE via drinking wells in the past may be at an increased risk for cancer*. The results for each well are summarized in Tables 13D-25D in Appendix D.

ATSDR estimated increased cancer risk from past exposures for individuals who were exposed to TCE in their water via the ingestion, inhalation, and dermal routes of exposure. We assumed that off-base (residential) children and adults were exposed for 21 years (from birth to >21 years of age) and 33 years, respectively; on-base military adults and children were exposed for 5 years; and that on-base employees were exposed for 25 years. Using the maximum amount of TCE in their well water, we estimated an elevated cancer risk for some children and adults. However, ATSDR

assumed many years of exposure to the maximum concentrations of TCE and benzene in estimating the cancer risks, so the actual cancer risks could be much lower. Without historical data or knowledge about the source of the contamination, ATSDR recognizes that there is some uncertainty in estimating cancer risk at this site.

- *On-base employees who were exposed to benzene in drinking water in Building 5008 for many years may be at increased risk for harmful non-cancer (hematological) and cancer health effects.*

Benzene causes problems in the blood (hematologic). People who are exposed to benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. Long-term exposure to benzene can cause cancer of the blood-forming organs. This condition is called leukemia. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML). In estimating the excess cancer risk, we assumed that on-base employees were exposed for 25 years. ATSDR assumed many years of exposure to the maximum concentrations of benzene in estimating the cancer risks, so the actual cancer risks could be much lower. Without historical data or knowledge about the source(s) of the contamination, ATSDR recognizes that there is some uncertainty in estimating cancer risk from exposure to benzene at this site.

RECOMMENDATIONS

- ATSDR supports ongoing activities by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to ensure that the community around WAFB is provided safe drinking water.

- ATSDR recommends ongoing monitoring of potable wells by EGLE in areas that are known to be, or that could be, affected by contamination from the site.

- ATSDR recommends continued investigative actions to define the nature and extent of contamination on and surrounding the WAFB.

PUBLIC HEALTH ACTION PLAN

A Public Health Action Plan ensures that this health assessment not only identifies public health hazards but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The Public Health Action Plan includes public health actions that have been taken and those that are recommended:

- ATSDR will coordinate with other involved partners to notify concerned citizens and veterans about the findings in this report.

- ATSDR will coordinate with EGLE to develop a sampling plan to analyze VOCs in private wells in the vicinity of WAFB that are still in use but are in need of sampling or re-sampling to determine current VOC levels.

- ATSDR will update our exposure assessment should additional information become available that conflicts with our current exposure assumptions.

- ATSDR will provide support for public meetings to discuss the findings of this health consultation upon request. ATSDR will make presentations, develop handouts, conduct health education activities, and provide assistance, as necessary, to concerned citizens and veterans.

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APPENDIX A:

EXPOSURE ASSUMPTIONS AND DOSE CALCULATIONS

ATSDR's Exposure Assumptions and Exposure Dose Equations

To estimate past exposure to TCE, ATSDR used mathematical models and default exposure assumptions to estimate exposure doses. An exposure dose (usually expressed as milligrams of chemical per kilogram of body weight per day, or "mg/kg/day") is an estimate of how much of a substance a person may contact based on their actions and habits. Estimating an exposure dose requires identifying how much, how often, and how long a person or population may come in contact with a concentration of a substance in a specific medium.

To estimate exposure doses at this site, ATSDR used default exposure assumptions about body weight and other body characteristics of children and adults exposed, how they may have been exposed, and how often they may have been exposed. The following section details the exposure assumptions and calculation of exposure doses for the drinking water, inhalation, and dermal contact pathways evaluated in this document.

Ingestion of contaminated water is one of the most significant exposure pathways at this site. ATSDR used the following equation and assumptions to estimate exposure to TCE from the ingestion of contaminated well water:

Water Ingestion Exposure Dose Equation:

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

D = exposure dose in milligrams per kilogram per day, mg/kg/day

C = chemical concentration in milligrams per liter, ($\frac{mg}{L}$)

IR = ingestion rate in liters per day, ($\frac{L}{day}$)

BW = body weight in kilograms, kg

Table 1A. Assumptions for Ingestion of Contaminated Water

Age Group	Body Weight (kg)	Ingestion of Water in Liters Per Day High-end Water Intake Rate (L/day)
Birth to <1 year	7.8	1.113
1 to <2 years	11.4	0.893
2 to <6 years	17.4	0.977
6 to <11 years	31.8	1.404
11 to <16 years	56.8	1.976
16 to <21 years	71.6	2.444
21+ years	80	3.1
Pregnant Women (16 to 45 yrs)	73	2.589

Notes:
[ATSDR 2014b]. Agency for Toxic Substances and Disease Registry. 2014. Exposure Dose Guidance for Water Ingestion. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. November 2014.
High-end water intake rate represents the water intake for a person who consumes more than the average amount of water per day (the 95^{th} percentile values).

EXAMPLE OF INGESTION CALCULATION:

Use the equation and values in Table 1A to calculate the amount of VOC ingested from drinking contaminated drinking water.

Example using: Adult (21+ years old) using High-End Water Intake, 45 ppb TCE

Ingestion Exposure Dose

High-End Water Intake

$$\frac{0.045\,\frac{mg}{L}\,x\,3.1\,\frac{L}{day}}{80\ kg} = 1.7E-03\ mg\ /kg/day$$

Drinking water wells on and near the WAFB were contaminated with TCE and benzene. The contaminated water was used for household purposes, including showering. VOCs such as TCE and benzene can escape, or volatilize, from water used in the home. Breathing in (inhaling) the vapors in air that occurs when using contaminated water for showering can be a significant source of exposure. Because inhalation and skin absorption of VOCs during showering can be significant, ATSDR evaluated those exposures separately. To evaluate inhalation and dermal exposures, ATSDR computed the 24-hour VOC concentration and then compared that value with available health guidelines. There are several steps, discussed below, in estimating the equivalent 24-hour air concentration.

Note: We recognize that very young children (<1 year) are likely to take more baths than showers, therefore, we did not estimate showering exposures for this age group. ATSDR used several equations and exposure assumptions to estimate how much VOC contamination a person would inhale while showering.

Table 2A. Exposure Assumptions for Inhalation of VOCs while Showering

Age Group	Average Shower time (minutes)	Average Bathroom Stay after Shower (minutes)	Average Short-term Breathing Rates While Showering (m^3/min)	Average Long-term Breathing Rates (m^3/day)
1 to <2 years	15	5	0.012	8.0
2 to <6 years	15	5	0.011	9.8
6 to <11 years	15	5	0.011	12.0
11 to <16 years	15	5	0.013	15.2
16 to <21 years	15	5	0.012	16.3
21+ years	15	5	0.012	15.2
Pregnant Women (16 to 45 yrs)	15	5	0.016	22

Notes:

Average shower time and bathroom stay after shower derived using professional judgment with input from Table 16-32: Time spent (minutes) Showering and in Shower Room Immediately After Showering, EPA Exposure Factors Handbook (2011).

Table 6-2: Recommended Short-Term Exposure Values for Inhalation (males and females combined), Light Intensity, EPA Exposure Factors Handbook (2011).

Average represents the mean (50^{th} percentile) value.

EXAMPLE OF INHALATION CALCULATION(S):

Use the equations below and values in Table 2A to calculate the amount of VOC inhaled while showering.

Example using: Adult (21+ years old) Showering for 15 Minutes, 45 ppb TCE

Estimating the inhalation exposure dose is a 2-step process:

1) Calculate the VOC concentration in the bathroom
2) Calculate the amount of VOC inhaled

ATSDR used a model developed by Andelman [Andelman 1990] to estimate the VOC concentration occurring in the bathroom as a result of showering. The equation is as follows:

Equation for Concentration of TCE in Air:

$$C_a = \frac{k \; x \; F_w \;\; x \; T_s \; x \; C_w \; x \; CF}{V_a}$$

C_a = air concentration in bathroom/shower, in milligrams per cubic meter, $\frac{mg}{m^3}$

k = volatile mass transfer coefficient, unitless (default is 0.6)

F_w = flow rate of water through shower, in liters per min, L/min (default is 8 $\frac{L}{min}$)

T_s = time in shower, in minutes (varies with age, See Table 2A)

C_w = VOC concentration in water, in milligrams per liter, $\frac{mg}{L}$

CF = conversion factor (1,000 $\frac{L}{m^3}$)

V_a = bathroom air volume, in liters, L (default is 10,000 L)

<u>Step 1. Calculate the concentration of VOC in the bathroom</u>

Concentration VOC in Air

$$\frac{0.6 \; x \; 8 \; \frac{L}{min} \; x \; 15 \, \text{min} \; x \; 0.045 \; \frac{mg}{L} \; x \; 1000 \; \frac{L}{m^3}}{10{,}000L} = 0.324 \; \frac{mg}{m^3}$$

The VOC concentration in air will be breathed in during the shower and during any time stayed in the bathroom after the shower. Next is to calculate how much of the contaminant in the air

will be inhaled by the average person, using the following equation and the average short-term breathing rates found in Table 2A.

Step 2. Calculate the amount of VOC inhaled

Equation for Intake of VOC in Air:

$$Intake_{inhalation}\ (\mu g) = \text{peak concentration } (\frac{\mu g}{m^3}) \times IR_{st}\ \frac{m^3}{min} \times (T_s + T_b)(min)$$

Peak conc = concentration calculated in Step 1, in $\frac{\mu g}{m^3}$

IR_{st} = short-term inhalation rate ($\frac{m^3}{min}$)

T_s = time in shower, in minutes (See Table 2A)

T_b = time in bathroom after shower, in minutes (See Table 2A)

VOC Intake Due to Inhalation

$$324\ \frac{\mu g}{m^3} \times 0.012\ \frac{m^3}{min} \times (15 + 5)\ min = 77.8\ \mu g\ TCE$$

Dermal (skin contact) absorption of contaminants in water occurs while showering or bathing. ATSDR used the equation and exposure assumptions in Table 3A to estimate how much dermal exposure to VOCs would occur while showering.

ATSDR estimated skin intake using the general methods of EPA's Risk Assessment Guidance for Superfund, Part E [EPA 2004].

Dermal Absorption Equation:

$$\mathbf{2\ x\ FA\ x\ K_p\ x\ C_w\ x\ \frac{1L}{1000\ cm^3}\ x\ SA\ x\ \sqrt{\frac{6\ x\ \tau(hr) x\ T_s}{60\ \frac{min}{hr}\ x\ \pi}}}$$

$Intake_{skin}$ = absorbed dose (µg)
FA = fraction absorbed water (assumed to be 1)
K_p = dermal permeability coefficient (0.012 cm/hr, TCE, 0.015 cm/hr, benzene)
C_w = chemical concentration in water (µg/L)
SA = total skin surface area in cm^2 (See Table 3A)
τ_{event} = lag time per event (0.58 hr)
T_s = time in shower (See Table 2A)
π = pi, 3.14

Table 3A. Estimates for Dermal Absorption of VOCs while Showering

Age Group	Total Body Surface Area in cm^2 (Average surface area)
1 to <2 years	5,300
2 to <6 years	7,225
6 to <11 years	10,800
11 to <16 years	15,900
16 to <21 years	18,400
21+ years	19,810
Pregnant Women (16 to 45 yrs)	18,610

Source:
Agency for Toxic Substances and Disease Registry. 2015. Exposure Dose Guidance for Dermal Exposures to Soil and Sediment. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. October 2015.

EXAMPLE OF DERMAL ABSORPTION CALCULATION

Example using: Adult (21+ years old) Showering for 15 Minutes, 45 ppb TCE

TCE Intake Due to Skin Absorption

$$2\ x\ 1\ x\ 0.012\ \frac{cm}{hr}\ x\ 45\ \frac{\mu g}{L}\ x\ \frac{1L}{1000\ cm^3}\ x\ 19{,}780\ cm^2\ x\ \sqrt{\frac{6\ x\ 0.58\ (hr) x\ 15\ min}{60\ \frac{min}{hr}\ x\ 3.14}}$$

= 11.2 µg TCE

To estimate the total (inhalation + dermal) intake of VOCs from showering, ATSDR summed the inhalation and skin intakes and converted to a 24-hour equivalent air concentration.

EXAMPLE OF CONVERTING TO 24-HOUR EQUIVALENT AIR CONCENTRATION

Exposures that occur through skin contact need to be converted to a 24-hour equivalent air concentration to compare to inhalation guidelines.

Example using: Adult (21+ years old) with an average breathing rate of ($15.2\ \frac{m^3}{day}$)

To convert to a 24-hour air concentration, the total intake is divided by the daily average long-term breathing rate for an adult using the following equation:

$$24\ hour\ Equivalent\ Concentration = \frac{Intake\ (\mu g)}{Inhalation\ Rate\ (\frac{m^3}{day})}$$

$$24\ hour\ Equivalent\ Concentration = \frac{(77.8 + 11.2)(\mu g)}{15.2\ (\frac{m^3}{day})} = \ 5.9\ \frac{\mu g}{m^3}$$

APPENDIX B:

EVALUATING TCE CANCER RISKS

EVALUATING TCE CANCER HEALTH EFFECTS

In 2011, EPA published an oral cancer slope factor for TCE of 0.046 $(mg/kg/day)^{-1}$ and an inhalation unit risk of 4.1×10^{-6} $(\mu g/m^3)^{-1}$ reflecting total incidence of kidney, non-Hodgkin's lymphoma, and liver cancers [EPA 2011d]. EPA used a PBPK model-based route-to-route extrapolation of the inhalation unit risk estimate for kidney cancer, with a factor of 5 applied to include non-Hodgkin's lymphoma and liver cancer risks, to obtain an oral slope factor for combined cancer risk of 0.046 $(mg/kg/day)^{-1}$, or 4.6×10^{-2} $(mg/kg/day^{-1})$. The combined cancer slope factor can be split into individual component slope factors as follows:

- For kidney cancer: 9.33×10^{-3} $(mg/kg/day)^{-1}$
- For non-Hodgkin's lymphoma: 2.16×10^{-2} $(mg/kg/day)^{-1}$
- For liver cancer: 1.55×10^{-2} $(mg/kg/day)^{-1}$

The methods used to calculate cancer slope factors rely upon several assumptions. The method assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. The methods also assume that no safe level exists for exposure. Little experimental evidence exists to confirm or refute those two assumptions. Lastly, most methods compute the upper 95^{th} percent confidence limit for the risk. The actual cancer risk can be lower, perhaps by several orders of magnitude.

If a substance causes cancer by a mutagenic mode of action, there is a greater risk for exposures that occur in early life. For these substances, age-dependent adjustment factors (ADAFs) are applied to the risks estimated as follows: An ADAF of 10 is applied for exposures taking place from birth up to 2 years old, and an ADAF of 3 is applied for exposures taking place from age 2 up to age 16. No adjustment is applied for exposures at age 16 or above. The EPA has concluded that TCE is carcinogenic by a mutagenic mode of action for induction of kidney tumors. As a result, increased early-life susceptibility is assumed for kidney cancer, and age-dependent adjustment factors (ADAFs) are used for the kidney cancer component of the total cancer risk when estimating age-specific cancer risks.

The lifetime excess cancer risk indicates the cancer potential of contaminants. To calculate the lifetime excess cancer risk, ATSDR multiplied the component oral cancer slope factor by the daily exposure dose (oral, inhalation, and dermal), the appropriate ADAF, and the fraction corresponding to the fraction of a 78-year lifetime under consideration.

EXAMPLE OF CANCER RISK CALCULATIONS:

Table 4B. Calculation of Excess Cancer Risk for CHILDREN of Military Members Exposed to TCE in *ON-BASE* wells Via Ingestion, Inhalation, and Dermal Contact – 5 years – 45 ppb TCE

Age Group	Estimated Total Exposure Dose (mg/kg/day)	Duration (years)	Fraction of Lifetime	Unadjusted Kidney Lifetime Cancer Slope Factor $(mg/kg/day)^{-1}$	ADAF*	Adjusted Kidney Cancer Risk	NHL** and Liver Lifetime Cancer Slope Factor $(mg/kd/day)^{-1}$	NHL** and Liver Cancer Risk	Total Cancer Risk: Adjusted Kidney and Unadjusted NHL** and Liver
Birth to <1 year	6.42E-03	1	1/78	9.3E-03	10	7.7E-06	3.7E-02	3.0E-06	1.1E-05
1 to <2 years	1.06E-02	1	1/78	9.3E-03	10	1.3E-05	3.7E-02	5.0E-06	1.8E-05
2 to <6 years	6.88E-03	3	3/78	9.3E-03	3	9.8E-06	3.7E-02	1.3E-05	1.7E-05
6 to <11 years	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11 to <16 years	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16 to <21 years	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total years exposed	**5**						**Total Cancer Risk**	**4.5E-05**

Notes:

Birth to <1 year total exposure dose does not include shower exposures (inhalation and dermal contact) because very young children are assumed to take baths instead of showers. The ingestion dose was used as the total exposure dose, which might underestimate total exposures to this age group.

ADAF* = age-dependent adjustment factor

NHL** = non-Hodgkin's lymphoma

N/A = not applicable

EXAMPLE OF CANCER RISK CALCULATIONS:

Table 5B. Calculation of Excess Cancer Risk for MILITARY MEMBERS AND ADULT FAMILY MEMBERS Exposed to TCE in *ON-BASE* wells Via Ingestion, Inhalation, and Dermal Contact – 5 years – 45 ppb TCE

Age Group	Estimated Total Exposure Dose (mg/kg/day)	Duration (years)	Fraction of Lifetime	Unadjusted Kidney Lifetime Cancer Slope Factor $(mg/kg/day)^{-1}$	ADAF*	Adjusted Kidney Cancer Risk	NHL** and Liver Lifetime Cancer Slope Factor $(mg/kd/day)^{-1}$	NHL** and Liver Cancer Risk	Total Cancer Risk: Adjusted Kidney and Unadjusted NHL** and Liver
Adult 21+ years	2.85E-03	5	5/78	9.3E-03	1	1.7E-06	3.7E-02	6.7E-06	8.4E-06
	Total years exposed	**5**						**Total Cancer Risk**	**8.4E-06**

Notes:

ADAF* = age-dependent adjustment factor

NHL** = non-Hodgkin's lymphoma

EXAMPLE OF CANCER RISK CALCULATIONS:

Table 6B. Calculation of Excess Cancer Risk for ADULT WORKERS Exposed to TCE via *ON-BASE* wells

Water Ingestion Only – 25 years – 45 ppb TCE

Age Group	Estimated Total Exposure Dose (mg/kg/day)	Duration (years)	Fraction of Lifetime	Unadjusted Kidney Lifetime Cancer Slope Factor $(mg/kg/day)^{-1}$	ADAF*	Adjusted Kidney Cancer Risk	NHL** and Liver Lifetime Cancer Slope Factor $(mg/kd/day)^{-1}$	NHL** and Liver Cancer Risk	Total Cancer Risk: Adjusted Kidney and Unadjusted NHL** and Liver
Adult 21+ years	1.2E-03	25	25/78	9.3E-03	1	1.2E-06	3.7E-02	4.9E-06	1.8E-05
	Total years exposed	**25**						**Total Cancer Risk**	**1.8E-05**

Notes:

ADAF* = age-dependent adjustment factor

NHL** = non-Hodgkin's lymphoma

EXAMPLE OF CANCER RISK CALCULATION:

Table 7B. Calculation of Excess Cancer Risk for CHILD RESIDENTS Exposed to TCE in *OFF-BASE* wells Via Ingestion, Inhalation, and Dermal Contact – 33 years – 45 ppb TCE

Age Group	Estimated Total Exposure Dose (mg/kg/day)	Duration (years)	Fraction of Lifetime	Unadjusted Kidney Lifetime Cancer Slope Factor $(mg/kg/day)^{-1}$	ADAF*	Adjusted Kidney Cancer Risk	NHL **and Liver Lifetime Cancer Slope Factor $(mg/kd/day)^{-1}$	NHL** and Liver Cancer Risk	Total Cancer Risk: Adjusted Kidney and Unadjusted NHL** and Liver
Birth to <1 year	6.42E-03	1	1/78	9.3E-03	10	7.7E-06	3.7E-02	3.0E-06	1.1E-05
1 to <2 years	1.06E-02	1	1/78	9.3E-03	10	1.3E-05	3.7E-02	5.0E-06	1.8E-05
2 to <6 years	6.88E-03	4	4/78	9.3E-03	3	9.8E-06	3.7E-02	1.3E-05	2.3E-05
6 to <11 years	4.42E-03	5	5/78	9.3E-03	3	7.9E-06	3.7E-02	1.0E-05	1.8E-05
11 to <16 years	3.21E-03	5	5/78	9.3E-03	3	5.7E-06	3.7E-02	7.5E-06	1.3E-05
16 to <21 years	2.77E-03	5	4/78	9.3E-03	1	1.7E-06	3.7E-02	6.5E-06	8.2E-06
	Total years exposed	**21**						**Total Cancer Risk**	**9.1E-05**

Notes:

Birth to <1 year total exposure dose does not include shower exposures (inhalation and dermal contact) because very young children are assumed to take baths instead of showers. The ingestion dose was used as the total exposure dose, which might underestimate total exposures to this age group.

ADAF* = age-dependent adjustment factor

NHL** = non-Hodgkin's lymphoma

EXAMPLE OF CANCER RISK CALCULATION:

Table 8B: Calculation of Excess Cancer Risk for ADULT RESIDENTS Exposed to TCE in *OFF-BASE* wells Via Ingestion, Inhalation, and Dermal Contact – 33 years – 45 ppb TCE

Age Group	Estimated Total Exposure Dose (mg/kg/day)	Duration (years)	Fraction of Lifetime	Unadjusted Kidney Lifetime Cancer Slope Factor $(mg/kg/day)^{-1}$	ADAF*	Adjusted Kidney Cancer Risk	NHL **and Liver Lifetime Cancer Slope Factor $(mg/kd/day)^{-1}$	NHL** and Liver Cancer Risk	Total Cancer Risk: Adjusted Kidney and Unadjusted NHL** and Liver
Adult 21+ years	2.85E-03	33	33/78	9.3E-03	1	1.1E-05	3.7E-02	4.4E-05	5.6E-05
	Total years exposed	**33**						**Total Cancer Risk**	**5.6E-05**

Notes:

ADAF* = age-dependent adjustment factor

NHL** = non-Hodgkin's lymphoma

APPENDIX C:

ESTIMATED EXPOSURE DOSES AND CANCER RISK

Table 9C. Summary of Estimated Exposure Doses and Cancer Risks for MILITARY MEMBERS AND FAMILIES Exposed via *ON-BASE* wells via Ingestion, Inhalation, and Dermal Contact – 5 years

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
AF1*	TCE	895.0	Birth to 1 year	1.3E-01	255	Children	9.0E-04
			1 to <2 years	2.1E-01	422		
			2 to <6 years	1.4E-01	274		
			6 to <11 years	8.8E-02	176		
			11 to <16 years	6.4E-02	128	Adults	1.7E-04
			16 to <21 years	5.5E-02	110		
			21+ years	5.7E-02	113		
			Pregnant Women (16 to 45 yrs)	6.3E-02	126		
AF2*	TCE	1739.0	Birth to 1 year	2.5E-01	496	Children	1.8E-03
			1 to <2 years	4.1E-01	820		
			2 to <6 years	2.7E-01	532		
			6 to <11 years	1.7E-01	342		
			11 to <16 years	1.2E-01	248	Adults	3.2E-04
			16 to <21 years	1.1E-01	214		
			21+ years	1.1E-01	220		
			Pregnant Women (16 to 45 yrs)	1.2E-01	244		
	Benzene	37.0	Birth to 1 year	5.3E-03	11	Children	2.2E-05
			1 to <2 years	8.8E-03	18		
			2 to <6 years	5.7E-03	11		
			6 to <11 years	3.7E-03	7		
			11 to <16 years	2.7E-03	5	Adults	8.4E-06
			16 to <21 years	2.3E-03	5		
			21+ years	2.4E-03	5		
			Pregnant Women (16 to 45 yrs)	2.6E-03	5		
AF3*	TCE	5173.0	Birth to 1 year	7.4E-01	1476	Children	5.2E-03
			1 to <2 years	1.2E+00	2439		
			2 to <6 years	7.9E-01	1581		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			6 to <11 years	5.1E-01	1017		
			11 to <16 years	3.7E-01	737	Adults	9.7E-04
			16 to <21 years	3.2E-01	636		
			21+ years	3.3E-01	656		
			Pregnant Women (16 to 45 yrs)	3.6E-01	727		
AF4*	TCE	14.0	Birth to 1 year	2.0E-03	4	Children	1.4E-05
			1 to <2 years	3.3E-03	7		
			2 to <6 years	2.1E-03	4		
			6 to <11 years	1.4E-03	3		
			11 to <16 years	1.0E-03	2	Adults	2.6E-06
			16 to <21 years	8.6E-04	2		
			21+ years	8.9E-04	2		
			Pregnant Women (16 to 45 yrs)	9.8E-04	2		
	Benzene	4.1	Birth to 1 year	5.9E-04	1	Children	2.4E-06
			1 to <2 years	9.7E-04	2		
			2 to <6 years	6.3E-04	1		
			6 to <11 years	4.1E-04	1		
			11 to <16 years	3.0E-04	1	Adults	9.3E-07
			16 to <21 years	2.6E-04	1		
			21+ years	2.6E-04	1		
			Pregnant Women (16 to 45 yrs)	2.9E-04	1		
AF5*	TCE	1174.0	Birth to 1 year	1.7E-01	335	Children	1.2E-03
			1 to <2 years	2.8E-01	554		
			2 to <6 years	1.8E-01	359		
			6 to <11 years	1.2E-01	231		
			11 to <16 years	8.4E-02	167	Adults	2.2E-04
			16 to <21 years	7.2E-02	144		
			21+ years	7.4E-02	149		
			Pregnant Women (16 to 45 yrs)	8.3E-02	165		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
	Benzene	7.8	Birth to 1 year	1.1E-03	2	Children	4.6E-06
			1 to <2 years	1.9E-03	4		
			2 to <6 years	1.2E-03	2		
			6 to <11 years	7.7E-04	2		
			11 to <16 years	5.6E-04	1	Adults	1.8E-06
			16 to <21 years	4.9E-04	1		
			21+ years	5.0E-04	1		
			Pregnant Women (16 to 45 yrs)	5.5E-04	1		
AF18*	TCE	91.5	Birth to 1 year	1.3E-02	26	Children	9.2E-05
			1 to <2 years	2.2E-02	43		
			2 to <6 years	1.4E-02	28		
			6 to <11 years	9.0E-03	18		
			11 to <16 years	6.5E-03	13	Adults	1.7E-05
			16 to <21 years	5.6E-03	11		
			21+ years	5.8E-03	12		
			Pregnant Women (16 to 45 yrs)	6.4E-03	13		
AF19*	TCE	65.9	Birth to 1 year	9.4E-03	19	Children	6.6E-05
			1 to <2 years	1.6E-02	31		
			2 to <6 years	1.0E-02	20		
			6 to <11 years	6.5E-03	13		
			11 to <16 years	4.7E-03	9	Adults	1.2E-05
			16 to <21 years	4.1E-03	8		
			21+ years	4.2E-03	8		
			Pregnant Women (16 to 45 yrs)	4.6E-03	9		
8306 Hawaii	TCE	148.9	Birth to 1 year	2.1E-02	42	Children	1.5E-04
			1 to <2 years	3.5E-02	70		
			2 to <6 years	2.3E-02	46		
			6 to <11 years	1.5E-02	29		
			11 to <16 years	1.1E-02	21	Adults	2.8E-05

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			16 to <21 years	9.2E-03	18		
			21+ years	9.4E-03	19		
			Pregnant Women (16 to 45 yrs)	1.0E-02	21		
Unlisted Housing	TCE	1,100	Birth to 1 year	1.6E-01	314	Children	1.1E-03
			1 to <2 years	2.6E-01	519		
			2 to <6 years	1.7E-01	336		
			6 to <11 years	1.1E-01	216		
			11 to <16 years	7.8E-02	157	Adults	2.1E-04
			16 to <21 years	6.8E-02	135		
			21+ years	7.0E-02	139		
			Pregnant Women (16 to 45 yrs)	7.7E-02	155		
8000 Area	TCE	32.2	Birth to 1 year	4.6E-03	9	Children	3.2E-05
			1 to <2 years	7.6E-03	15		
			2 to <6 years	4.9E-03	10		
			6 to <11 years	3.2E-03	6		
			11 to <16 years	2.3E-03	5	Adults	6.0E-06
			16 to <21 years	2.0E-03	4		
			21+ years	2.0E-03	4		
			Pregnant Women (16 to 45 yrs)	2.3E-03	5		
Building 8509D	TCE	75	Birth to 1 year	1.1E-02	21	Children	7.6E-05
			1 to <2 years	1.8E-02	35		
			2 to <6 years	1.1E-02	23		
			6 to <11 years	7.4E-03	15		
			11 to <16 years	5.3E-03	11	Adults	1.4E-05
			16 to <21 years	4.6E-03	9		
			21+ years	4.8E-03	10		
			Pregnant Women (16 to 45 yrs)	5.3E-03	11		
1612 A & B California	TCE	73.2	Birth to 1 year	1.0E-02	21	Children	7.4E-05
			1 to <2 years	1.7E-02	35		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			2 to <6 years	1.1E-02	22		
			6 to <11 years	7.2E-03	14		
			11 to <16 years	5.2E-03	10	Adults	1.4E-05
			16 to <21 years	4.5E-03	9		
			21+ years	4.6E-03	9		
			Pregnant Women (16 to 45 yrs)	5.2E-03	10		
10500 Idaho	TCE	6.8	Birth to 1 year	9.7E-04	1.9	Children	6.9E-06
			1 to <2 years	1.6E-03	3.2		
			2 to <6 years	1.0E-03	2.1		
			6 to <11 years	6.7E-04	1.3		
			11 to <16 years	4.8E-04	1.0	Adults	1.3E-06
			16 to <21 years	4.2E-04	0.8		
			21+ years	4.3E-04	0.9		
			Pregnant Women (16 to 45 yrs)	4.8E-04	1.0		
Barracks 502	TCE	71	Birth to 1 year	1.0E-02	20	Children	7.2E-05
			1 to <2 years	1.7E-02	33		
			2 to <6 years	1.1E-02	22		
			6 to <11 years	7.0E-03	14		
			11 to <16 years	5.1E-03	10	Adults	1.3E-05
			16 to <21 years	4.4E-03	9		
			21+ years	4.5E-03	9		
			Pregnant Women (16 to 45 yrs)	5.0E-03	10		
8808 E N Vermont	TCE	9.8	Birth to 1 year	1.4E-03	2.8	Children	9.9E-06
			1 to <2 years	2.3E-03	4.6		
			2 to <6 years	1.5E-03	3.0		
			6 to <11 years	9.6E-04	1.9		
			11 to <16 years	7.0E-04	1.4	Adults	1.8E-06
			16 to <21 years	6.0E-04	1.2		
			21+ years	6.2E-04	1.2		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			Pregnant Women (16 to 45 yrs)	6.9E-04	1.4		
Building 9750 D	TCE	27.3	Birth to 1 year	3.9E-03	8	Children	2.8E-05
			1 to <2 years	6.4E-03	13		
			2 to <6 years	4.2E-03	8		
			6 to <11 years	2.7E-03	5		
			11 to <16 years	1.9E-03	4	Adults	5.1E-06
			16 to <21 years	1.7E-03	3		
			21+ years	1.7E-03	3		
			Pregnant Women (16 to 45 yrs)	1.9E-03	4		
10037 8th Street	TCE	26.6	Birth to 1 year	3.8E-03	8	Children	2.7E-05
			1 to <2 years	6.3E-03	13		
			2 to <6 years	4.1E-03	8		
			6 to <11 years	2.6E-03	5		
			11 to <16 years	1.9E-03	4	Adults	5.0E-06
			16 to <21 years	1.6E-03	3		
			21+ years	1.7E-03	3		
			Pregnant Women (16 to 45 yrs)	1.9E-03	4		
10039 8th Street	TCE	57	Birth to 1 year	8.1E-03	16	Children	5.8E-05
			1 to <2 years	1.3E-02	27		
			2 to <6 years	8.7E-03	17		
			6 to <11 years	5.6E-03	11		
			11 to <16 years	4.1E-03	8	Adults	1.1E-05
			16 to <21 years	3.5E-03	7		
			21+ years	3.6E-03	7		
			Pregnant Women (16 to 45 yrs)	4.0E-03	8		
10000 Area; 10205 TN	TCE	48.7	Birth to 1 year	6.9E-03	14	Children	4.9E-05
			1 to <2 years	1.1E-02	23		
			2 to <6 years	7.4E-03	15		
			6 to <11 years	4.8E-03	10		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			11 to <16 years	3.5E-03	7	Adults	9.1E-06
			16 to <21 years	3.0E-03	6		
			21+ years	3.1E-03	6		
			Pregnant Women (16 to 45 yrs)	3.4E-03	7		
Barracks 225	TCE	5.1	Birth to 1 year	7.3E-04	1.5	Children	5.1E-06
			1 to <2 years	1.2E-03	2.4		
			2 to <6 years	7.8E-04	1.6		
			6 to <11 years	5.0E-04	1.0		
			11 to <16 years	3.6E-04	0.7	Adults	9.5E-07
			16 to <21 years	3.1E-04	0.6		
			21+ years	3.2E-04	0.6		
			Pregnant Women (16 to 45 yrs)	3.6E-04	0.7		
9750A & B 8th Street	TCE	72	Birth to 1 year	1.0E-02	21	Children	7.3E-05
			1 to <2 years	1.7E-02	34		
			2 to <6 years	1.1E-02	22		
			6 to <11 years	7.1E-03	14		
			11 to <16 years	5.1E-03	10	Adults	1.3E-05
			16 to <21 years	4.4E-03	9		
			21+ years	4.6E-03	9		
			Pregnant Women (16 to 45 yrs)	5.1E-03	10		
	Benzene	15.2	Birth to 1 year	2.2E-03	4	Children	9.0E-06
			1 to <2 years	3.6E-03	7		
			2 to <6 years	2.3E-03	5		
			6 to <11 years	1.5E-03	3		
			11 to <16 years	1.1E-03	2	Adults	3.4E-06
			16 to <21 years	9.5E-04	2		
			21+ years	9.8E-04	2		
			Pregnant Women (16 to 45 yrs)	1.1E-03	2		
10059 8th Street	Benzene	8.2	Birth to 1 year	1.2E-03	2.3	Children	4.8E-06

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			1 to <2 years	1.9E-03	3.9		
			2 to <6 years	1.3E-03	2.5		
			6 to <11 years	8.1E-04	1.6		
			11 to <16 years	5.8E-04	1.2	Adults	1.8E-06
			16 to <21 years	5.0E-04	1.0		
			21+ years	5.2E-04	1.0		
			Pregnant Women (16 to 45 yrs)	5.8E-04	1.2		
8822A 3rd Street	TCE	2.3	Birth to 1 year	3.3E-04	0.7	Children	2.3E-06
			1 to <2 years	5.4E-04	1.1		
			2 to <6 years	3.5E-04	0.7		
			6 to <11 years	2.3E-04	0.5		
			11 to <16 years	1.6E-04	0.3	Adults	4.3E-07
			16 to <21 years	1.4E-04	0.3		
			21+ years	1.5E-04	0.3		
			Pregnant Women (16 to 45 yrs)	1.6E-04	0.3		
10311 7th Street	TCE	13	Birth to 1 year	1.9E-03	4	Children	1.3E-05
			1 to <2 years	3.1E-03	6		
			2 to <6 years	2.0E-03	4		
			6 to <11 years	1.3E-03	2.6		
			11 to <16 years	9.3E-04	1.9	Adults	2.4E-06
			16 to <21 years	8.0E-04	1.6		
			21+ years	8.2E-04	1.6		
			Pregnant Women (16 to 45 yrs)	9.1E-04	1.8		
	Benzene	11	Birth to 1 year	1.6E-03	3.1	Children	6.5E-05
			1 to <2 years	2.6E-03	5.2		
			2 to <6 years	1.7E-03	3.4		
			6 to <11 years	1.1E-03	2.2		
			11 to <16 years	7.9E-04	1.6	Adults	2.5E-06
			16 to <21 years	6.9E-04	1.4		

Supply Well* ID or Tap Water Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			21+ years	7.1E-04	1.4		
			Pregnant Women (16 to 45 yrs)	7.7E-04	1.5		
Child Care Center	Benzene	24.4	Birth to 1 year	2.5E-03	5.0	Children	4.8E-06
			1 to <2 years	1.4E-03	2.7		
			2 to <6 years	9.8E-04	2.0		
			6 to <11 years	7.7E-04	1.5		
			11 to <16 years	6.1E-04	1.2		
			16 to <21 years	5.9E-04	1.2		

Table 10C. Summary of Estimated Exposure Doses and Cancer Risks for EMPLOYEES Exposed via *ON-BASE* wells

Via Water Ingestion Only – 25 years

Supply Well* ID Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
AF1*	TCE	895.0	21+ years	2.5E-02	49	Adults	2.9E-04
AF2*	TCE	1739.0	21+ years	4.8E-02	96	Adults	7.1E-04
	Benzene	37.0	21+ years	1.0E-03	2	Adults	1.8E-05
AF3*	TCE	5173.0	21+ years	1.4E-01	286	Adults	1.7E-03
AF4*	TCE	14.0	21+ years	3.9E-04	0.77	Adults	4.6E-06
	Benzene	4.1	21+ years	1.1E-04	0.23	Adults	2.0E-06
AF5*	TCE	1174.0	21+ years	3.2E-02	65	Adults	3.8E-04
	Benzene	7.8	21+ years	2.2E-04	0	Adults	3.8E-06
AF18*	TCE	91.5	21+ years	2.5E-03	5	Adults	3.0E-05
AF19*	TCE	65.9	21+ years	1.8E-03	3.6	Adults	2.15E-05
Hospital	TCE	17.0	21+ years	4.7E-04	0.9	Adults	6.9E-06
	Benzene	38.6	21+ years	1.1E-03	2.1	Adults	1.9E-05
NCO Club	TCE	75	21+ years	8.4E-04	1.7	Adults	2.4E-06
Officer's Club	TCE	27	21+ years	3.0E-04	0.6	Adults	8.8E-07
	Benzene	30	21+ years	3.4E-04	0.7	Adults	1.2E-06
Building 5008	TCE	11.1	21+ years	3.1E-04	0.6	Adults	4.5E-06
	Benzene	1510	21+ years	4.1E-02	82.9	Adults	7.3E-04
Building 5065	Benzene	2.3	21+ years	6.3E-05	0.1	Adults	1.1E-06
Building 1700	Benzene	27.1	21+ years	7.4E-04	1.5	Adults	1.3E-05
Child care center	Benzene	24.4	21+ years	6.7E-04	1.3	Adults	1.2E-05
Aircraft Alert Area	TCE	25	21+ years	6.9E-04	1.4	Adults	1.2E-05
AF14	TCE	12.7	21+ years	3.5E-04	0.7	Adults	5.2E-06
AF15	TCE	296	21+ years	8.2E-03	16.3	Adults	1.2E-04

Table 11C. Summary of Estimated Exposure Doses and Cancer Risks for SHORT-TERM VISITORS/GUESTS Exposed via *ON-BASE* & OFF-BASE wells Ingestion, Inhalation and Dermal Contact – 4 WEEKS

Supply Well* ID Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day
AF7	TCE	17.6	Birth to 1 year	2.5E-03	5
			1 to <2 years	4.1E-03	8
			2 to <6 years	2.7E-03	5
			6 to <11 years	1.7E-03	3
			11 to <16 years	1.3E-03	3
			16 to <21 years	1.1E-03	2
			21+ years	1.1E-03	2
			Pregnant Women (16 to 45 yrs)	1.2E-03	2
AF8	TCE	27.0	Birth to 1 year	3.9E-03	8
			1 to <2 years	6.4E-03	13
			2 to <6 years	4.1E-03	8
			6 to <11 years	2.7E-03	5
			11 to <16 years	1.9E-03	4
			16 to <21 years	1.7E-03	3
			21+ years	1.7E-03	3
			Pregnant Women (16 to 45 yrs)	1.9E-03	4
AF22	TCE	30.4	Birth to 1 year	4.3E-03	9
			1 to <2 years	7.2E-03	14
			2 to <6 years	4.6E-03	9
			6 to <11 years	3.0E-03	6
			11 to <16 years	2.2E-03	4
			16 to <21 years	1.9E-03	4
			21+ years	1.9E-03	4
			Pregnant Women (16 to 45 yrs)	2.1E-03	4
AF23	TCE	14.7	Birth to 1 year	2.1E-03	4
			1 to <2 years	3.5E-03	7
			2 to <6 years	2.2E-03	4

Supply Well* ID Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day
			6 to <11 years	1.4E-03	3
			11 to <16 years	1.0E-03	2
			16 to <21 years	9.0E-04	2
			21+ years	9.3E-04	2
			Pregnant Women (16 to 45 yrs)	1.0E-03	2

Table 12C. Summary of Estimated Exposure Doses and Cancer Risks for RESIDENTS Exposed via *OFF-BASE* wells

Ingestion, Inhalation and Dermal Contact – 33 years

LAST TWO DIGITS OF ADDRESSES ARE NOT SHOWN FOR PRIVACY REASONS

Well Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
59** West Shore Drive	TCE	25.0	Birth to 1 year	3.57E-03	7	Children	5.0E-05
			1 to <2 years	5.89E-03	12		
			2 to <6 years	3.82E-03	8		
			6 to <11 years	2.46E-03	5		
			11 to <16 years	1.78E-03	4	Adults	3.1E-05
			16 to <21 years	1.54E-03	3		
			21+ years	1.58E-03	3		
			Pregnant Women (16 to 45 yrs)	1.76E-03	4		
60** West Shore Drive	TCE	3.4	Birth to 1 year	4.85E-04	1	Children	6.9E-06
			1 to <2 years	8.02E-04	2		
			2 to <6 years	5.20E-04	1		
			6 to <11 years	3.34E-04	1		
			11 to <16 years	2.42E-04	0	Adults	4.2E-06
			16 to <21 years	2.09E-04	0		
			21+ years	2.15E-04	0		
			Pregnant Women (16 to 45 yrs)	2.39E-04	0		
57** F-41 County Road	TCE	4.0	Birth to 1 year	5.71E-04	1	Children	8.1E-06
			1 to <2 years	9.43E-04	2		
			2 to <6 years	6.11E-04	1		
			6 to <11 years	3.93E-04	1		
			11 to <16 years	2.85E-04	1	Adults	4.9E-06
			16 to <21 years	2.46E-04	0		
			21+ years	2.53E-04	1		
			Pregnant Women (16 to 45 yrs)	2.82E-04	1		

Well Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
60** F-41 County Road	TCE	45.0	Birth to 1 year	6.42E-03	13	Children	9.1E-05
			1 to <2 years	1.06E-02	21		
			2 to <6 years	6.88E-03	14		
			6 to <11 years	4.42E-03	9		
			11 to <16 years	3.21E-03	6	Adults	5.6E-05
			16 to <21 years	2.77E-03	6		
			21+ years	2.85E-03	6		
			Pregnant Women (16 to 45 yrs)	3.17E-03	6		
61** F-41 County Road	TCE	13.0	Birth to 1 year	1.86E-03	4	Children	2.6E-05
			1 to <2 years	3.07E-03	6		
			2 to <6 years	1.99E-03	4		
			6 to <11 years	1.28E-03	3		
			11 to <16 years	9.27E-04	2	Adults	1.6E-05
			16 to <21 years	8.00E-04	2		
			21+ years	8.24E-04	2		
			Pregnant Women (16 to 45 yrs)	9.15E-04	2		
61** F-41 County Road	TCE	15.0	Birth to 1 year	2.14E-03	4	Children	3.0E-05
			1 to <2 years	3.54E-03	7		
			2 to <6 years	2.29E-03	5		
			6 to <11 years	1.47E-03	3		
			11 to <16 years	1.07E-03	2	Adults	1.9E-05
			16 to <21 years	9.23E-04	2		
			21+ years	9.51E-04	2		
			Pregnant Women (16 to 45 yrs)	1.06E-03	2		
63** West Shore Drive	Benzene	3	Birth to 1 year	4.3E-04	1	Children	4.3E-06
			1 to <2 years	7.1E-04	1		

Well Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			2 to <6 years	4.6E-04	1		
			6 to <11 years	3.0E-04	1		
			11 to <16 years	2.2E-04	0	Adults	4.5E-06
			16 to <21 years	1.9E-04	0		
			21+ years	1.9E-04	0		
			Pregnant Women (16 to 45 yrs)	2.1E-04	0		
65** West Shore Drive	TCE	1281	Birth to 1 year	1.8E-01	366	Children	2.6E-03
			1 to <2 years	3.0E-01	604		
			2 to <6 years	2.0E-01	391		
			6 to <11 years	1.3E-01	252		
			11 to <16 years	9.1E-02	183	Adults	1.6E-03
			16 to <21 years	7.9E-02	158		
			21+ years	8.1E-02	162		
			Pregnant Women (16 to 45 yrs)	9.0E-02	180		
Knights of Columbus	TCE	36	Birth to 1 year	5.1E-03	10	Children	N/A
			1 to <2 years	8.5E-03	17		
			2 to <6 years	5.5E-03	11		
			6 to <11 years	3.5E-03	7		
			11 to <16 years	2.6E-03	5	Adults	N/A
			16 to <21 years	2.2E-03	4		
			21+ years	2.3E-03	5		
			Pregnant Women (16 to 45 yrs)	2.5E-03	5		
57** F-41 County Road	TCE	4	Birth to 1 year	5.7E-04	1	Children	8.1E-06
			1 to <2 years	9.4E-04	2		
			2 to <6 years	6.1E-04	1		
			6 to <11 years	3.9E-04	1		

Well Sample Location	Chemical	Maximum Chemical Concentration (ppb)	Age Group	Estimated Exposure Doses (mg/kg/day)	HQ Exposure Dose/ATSDR MRL of 0.0005 mg/kg/day	Cancer Risk Age Groups	Estimated Cancer Risk
			11 to <16 years	2.9E-04	1	Adults	4.9E-06
			16 to <21 years	2.5E-04	0		
			21+ years	2.5E-04	1		
			Pregnant Women (16 to 45 yrs)	2.8E-04	1		
Van Etten State Park	TCE	3.4 ppb	Birth to 1 year	4.9E-04	1	Children	N/A
			1 to <2 years	8.0E-04	2		
			2 to <6 years	5.2E-04	1		
			6 to <11 years	3.3E-04	1		
			11 to <16 years	2.4E-04	0	Adults	N/A
			16 to <21 years	2.1E-04	0		
			21+ years	2.2E-04	0		
			Pregnant Women (16 to 45 yrs)	2.4E-04	0		

APPENDIX D:

UPDATED PUBLIC HEALTH CONCLUSIONS FOR INDIVIDUAL WELLS

Table 13D. Updated Public Health Conclusions: TCE and Benzene

For On-base MILITARY MEMBERS AND ADULT FAMILY MEMBERS who may have been Exposed to Water from USAF's Main Water Supply

While Living in On-base Housing for 5 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
AF1: Site representatives estimate that AF1 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF1 was being used as a potable source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in November 1977, TCE was detected at 895 ppb (AFBCA 1993).	Immunological effects Fetal Heart Defect (Pregnant Women)	1.7E-04 (Elevated)	TCE (895 ppb) Increased risk for harmful non-cancer and cancer health effects for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF2: AF2 was constructed in 1959 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (Ayres 1990). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, starting in 1977 and ending some time before 1983. Site representatives could not provide an exact date for AF2's return to service, so ATSDR assumed that it came back on line around January 1978. Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high	ATSDR searched site files to obtain data that was collected while AF2 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 37 ppb. (About 45 samples were analyzed for benzene between December 1979 and March 1993. The contaminant was detected nine times; seven of the detections, all of which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*Chloroform*. Detections ranged from nondetect to 6.7 ppb. (About 14 samples were analyzed for chloroform between March 1982 and March 1993. The	Immunological effects Fetal Heart Defect (Pregnant Women)	3.2E-04 (Elevated)	TCE (1,739 ppb) Increased risk for harmful non-cancer and cancer health effect for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy. Benzene (37 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
enough to require the use of AF2 (AFBCA 1999b).	contaminant was detected in more than half of the samples, but it only exceeded ATSDR's CV once, during a June 1986 sampling event.) •*Dichlorobromomethane.* Concentrations ranged from nondetect to 2.3 ppb. (About 13 samples were analyzed for this contaminant between March 1982 and March 1993. The contaminant was only detected above trace levels three times; two of the detections, recorded in May 1983 and June 1986, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,739 ppb. (More than 175 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected in the majority of samples, but only exceeded ATSDR's CVs 18 times. Only four of the samples contained TCE at concentrations greater than 20 ppb. These were detected in late 1977 [concentrations of about 130 ppb were detected] and February 1979 [concentrations of 1,666 and 1,739 were detected].)			
AF3: Site representatives estimate that AF3 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in	ATSDR searched site files to obtain data that were collected while AF3 was being used as a potable water source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in	Immunological effects Fetal Heart Defect (Pregnant Women)	9.7E-04 (Elevated)	TCE (5,173 ppb) Increased risk for harmful non-cancer and cancer health effect for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	November 1977, TCE was detected t 5,173 ppb (AFBCA 1993).			
AF4: AF4 was constructed in 1942 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]) Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF4 (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF4 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Five contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 4.1 ppb. (More than 170 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels once, during an April 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was only detected once, during a February 1993 sampling event. •*Chloroform*. Detections ranged from nondetect to 6.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected four times, but it only exceeded ATSDR's drinking water CVs once, during a February 1993 sampling event.)	No Harmful Health Effects Expected	3.5E-06 (Low)	TCE (14 ppb) No harmful health effects expected. Benzene (4.1 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected twice, but it only exceeded ATSDR's CVs once, during a February 1993 sampling event.) •*TCE*. Concentrations ranged from nondetect to 14 ppb. (About 300 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was only detected above trace levels in 31 samples, and it only exceeded ATSDR's CVs on three occasions (i.e., during sampling events in December 1978, December 1979, and August 1980).			
AF5: AF5 was constructed in 1942 and served as one USAF's main water supply wells for many years, providing water to on-base employees and residents (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]). Between 1984 and June 1993, the well was still used but only on a supplemental basis when the supply from other wells could not meet base demands	ATSDR searched site files to obtain data that was collected while AF5 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Seven contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 7.8 ppb. (About 160 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels on two occasions; it only exceeded ATSDR's CVs once,	Immunological effects Fetal Heart Defect (Pregnant Women)	2.2E-04 (Elevated)	TCE (1,174 ppb) Increased risk for harmful non-cancer and cancer health effects for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy. Benzene (7.8 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF5 (AFBCA 1999b).	during a June 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.7 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Chloroform*. Detections ranged from nondetect to 9.3 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.0 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*1-2-Dichloroethene* . Detections ranged from nondetect to 207 ppb. (About 165 samples were analyzed for this contaminant between December 1979 and June 1993. The contaminant was detected about 20 times, but it only exceeded ATSDR's CVs once, during a December 1985 sampling event.) •*1,1,2,2-Tetrachloroethane* . Concentrations ranged from			

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	nondetect to 4.3 ppb. (About 12 samples were analyzed for this contaminant between March 1982 and June 1993. The contaminant was detected four times. All of the detections, which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,174 ppb. (More than 250 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was detected many times, but only exceeded ATSDR's drinking water CVs on four occasions. (The contaminant exceeded CVs three times in December 1979 [concentrations registered at 6.0 ppb on December 3, 1979; at 6.2 ppb on December 17, 1979; and at 1,174 ppb on December 31, 1979] and once in February 1981 [concentration registered at 6.0 ppb].)			
AF18: AF18 served as one of USAF's main water supply wells until March 1978 when it was removed from service. The well was never brought back on line (AFBCA 1999b, 1999c; USGS 1983).	ATSDR searched site files to obtain data that was collected through March 1978. TCE was the only contaminant analyzed during that time. It was sampled 13 times between November 1977 and March 1978. It was detected above ATSDR's drinking water CVs in all of the sampling events; concentrations ranged from 48.2 ppb to 91.5 ppb (AFBCA 1993).	Immunological effects Fetal Heart Defect (Pregnant Women)	1.7E-05 (Low)	TCE (91.5 ppb) Increased risk for harmful non-cancer effect for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF19: AF19 was constructed in 1965 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees	ATSDR searched site files to obtain data that was collected while AF19 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ	Immunological effects Fetal Heart Defect (Pregnant Women)	1.2E-05 (Low)	TCE (65.9 ppb) Increased risk for harmful non-cancer health effect for adults. Increased risk for a heart birth defect for babies if the mother

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). AF19 operated in this capacity until August 1978, when it was temporarily removed from service (AFBCA 1999c; USGS 1983). In later years, the well was brought back on line to provide water on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). (Site documents do not indicate exactly when AF19 was brought back on line. ATSDR assumed that it was only off line for a couple of months and started being used again in January 1979.) After the base closed in June 1993, demand was not high enough to require the use of AF19 (AFBCA 1999b).	1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 1.0 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 6.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was detected four times, but it only exceeded ATSDR's CV once, during a September 1989 sampling event.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*TCE*. Concentrations ranged from nondetect to 65.9 ppb. (About 200 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected above ATSDR's drinking water CVs 19 times, but			was exposed to TCE during the first trimester of pregnancy.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	only five of these detections, all of which were recorded between 1977 and August 1978, were above 20 ppb. No detections were recorded above ATSDR's CVs after January 1986.)			
AF30, AF31, and AF32: AF30, AF31, and AF32 were constructed in 1984 and served as USAF's main water supply wells (AFCEE 1996a). Use of AF30 was discontinued in 1992, but the other two wells were used as potable water sources until the base was hooked up to municipal supply in 1997.	Samples were collected between 1984 and 1997 (AFBCA 1993; Air Force 1990; MDEQ 1999b). The wells were analyzed for volatile organics, pesticides, and metals. Contaminants were rarely detected and when they were present they were typically below ATSDR's drinking water CVs. Only three contaminants exceeded CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.6 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was only detected once, during a September 1994 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 29.4 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected five times; two of the detections, recorded in September 1985 and September 1994, exceeded ATSDR's CVs.)	N/A	N/A	Neither TCE nor benzene was detected above comparison values in these wells. Therefore, no harmful health effects expected from these chemicals. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.9 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected three times. The detections, which were recorded in September 1985, August 1987, and September 1994, exceeded ATSDR's CVs.)			

Table 14D. Updated Public Health Conclusions: TCE and Benzene

For CHILDREN of ON-BASE MILITARY MEMBERS who may have been Exposed to Water from USAF's Main Water Supply

While Living in On-base Housing for 5 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
AF1: Site representatives estimate that AF1 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF1 was being used as a potable source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in November 1977, TCE was detected at 895 ppb (AFBCA 1993).	Immunological effects	9.0E-04 (Elevated)	TCE (895 ppb) Increased risk for harmful non-cancer and cancer health effects for children.
AF2: AF2 was constructed in 1959 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (Ayres 1990). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, starting in 1977 and ending some time before 1983. Site representatives could not provide an exact date for AF2's return to service, so ATSDR assumed that it came back on line around January 1978. Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high	ATSDR searched site files to obtain data that was collected while AF2 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 37 ppb. (About 45 samples were analyzed for benzene between December 1979 and March 1993. The contaminant was detected nine times; seven of the detections, all of which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*Chloroform*. Detections ranged from nondetect to 6.7 ppb. (About 14 samples were analyzed for chloroform between March 1982 and March 1993. The	Immunological effects Hematological effects	1.8E-03 (Elevated)	TCE (1,739 ppb) Increased risk for harmful non-cancer and cancer health effect for children. Benzene (37 ppb) Increased risk of reduced white blood cells and platelet counts

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
enough to require the use of AF2 (AFBCA 1999b).	contaminant was detected in more than half of the samples, but it only exceeded ATSDR's CV once, during a June 1986 sampling event.) •*Dichlorobromomethane.* Concentrations ranged from nondetect to 2.3 ppb. (About 13 samples were analyzed for this contaminant between March 1982 and March 1993. The contaminant was only detected above trace levels three times; two of the detections, recorded in May 1983 and June 1986, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,739 ppb. (More than 175 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected in the majority of samples, but only exceeded ATSDR's CVs 18 times. Only four of the samples contained TCE at concentrations greater than 20 ppb. These were detected in late 1977 [concentrations of about 130 ppb were detected] and February 1979 [concentrations of 1,666 and 1,739 were detected].)			
AF3: Site representatives estimate that AF3 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in	ATSDR searched site files to obtain data that were collected while AF3 was being used as a potable water source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in	Immunological effects	5.2E-03 (Elevated)	TCE (5,173 ppb) Increased risk for harmful non-cancer and cancer health effect for children.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	November 1977, TCE was detected t 5,173 ppb (AFBCA 1993).			
AF4: AF4 was constructed in 1942 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]) Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF4 (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF4 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Five contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 4.1 ppb. (More than 170 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels once, during an April 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was only detected once, during a February 1993 sampling event. •*Chloroform*. Detections ranged from nondetect to 6.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected four times, but it only exceeded ATSDR's drinking water CVs once, during a February 1993 sampling event.)	No Harmful Health Effects Expected	1.6E-05 (Low)	TCE (14 ppb) No harmful health effects expected. Benzene (4.1 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected twice, but it only exceeded ATSDR's CVs once, during a February 1993 sampling event.) •*TCE*. Concentrations ranged from nondetect to 14 ppb. (About 300 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was only detected above trace levels in 31 samples, and it only exceeded ATSDR's CVs on three occasions (i.e., during sampling events in December 1978, December 1979, and August 1980).			
AF5: AF5 was constructed in 1942 and served as one USAF's main water supply wells for many years, providing water to on-base employees and residents (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]). Between 1984 and June 1993, the well was still used but only on a supplemental basis when the supply from other wells could not meet base demands	ATSDR searched site files to obtain data that was collected while AF5 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Seven contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 7.8 ppb. (About 160 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels on two occasions; it only exceeded ATSDR's CVs once,	Immunological effects	1.2E-03 (Elevated)	TCE (1,174 ppb) Increased risk for harmful non-cancer and cancer health effects for children. Benzene (7.8 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF5 (AFBCA 1999b).	during a June 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.7 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Chloroform*. Detections ranged from nondetect to 9.3 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.0 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*1-2-Dichloroethene* . Detections ranged from nondetect to 207 ppb. (About 165 samples were analyzed for this contaminant between December 1979 and June 1993. The contaminant was detected about 20 times, but it only exceeded ATSDR's CVs once, during a December 1985 sampling event.) •*1,1,2,2-Tetrachloroethane* . Concentrations ranged from			

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	nondetect to 4.3 ppb. (About 12 samples were analyzed for this contaminant between March 1982 and June 1993. The contaminant was detected four times. All of the detections, which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,174 ppb. (More than 250 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was detected many times, but only exceeded ATSDR's drinking water CVs on four occasions. (The contaminant exceeded CVs three times in December 1979 [concentrations registered at 6.0 ppb on December 3, 1979; at 6.2 ppb on December 17, 1979; and at 1,174 ppb on December 31, 1979] and once in February 1981 [concentration registered at 6.0 ppb].)			
AF18: AF18 served as one of USAF's main water supply wells until March 1978 when it was removed from service. The well was never brought back on line (AFBCA 1999b, 1999c; USGS 1983).	ATSDR searched site files to obtain data that was collected through March 1978. TCE was the only contaminant analyzed during that time. It was sampled 13 times between November 1977 and March 1978. It was detected above ATSDR's drinking water CVs in all of the sampling events; concentrations ranged from 48.2 ppb to 91.5 ppb (AFBCA 1993).	Immunological effects	9.2E-05 (Low)	TCE (91.5 ppb) Increased risk for harmful non-cancer effect for children.
AF19: AF19 was constructed in 1965 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees	ATSDR searched site files to obtain data that was collected while AF19 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ	Immunological effects	6.6E-05 (Low)	TCE (65.9 ppb) Increased risk for harmful non-cancer health effect for children.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). AF19 operated in this capacity until August 1978, when it was temporarily removed from service (AFBCA 1999c; USGS 1983). In later years, the well was brought back on line to provide water on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). (Site documents do not indicate exactly when AF19 was brought back on line. ATSDR assumed that it was only off line for a couple of months and started being used again in January 1979.) After the base closed in June 1993, demand was not high enough to require the use of AF19 (AFBCA 1999b).	1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 1.0 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 6.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was detected four times, but it only exceeded ATSDR's CV once, during a September 1989 sampling event.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*TCE*. Concentrations ranged from nondetect to 65.9 ppb. (About 200 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected above ATSDR's drinking water CVs 19 times, but			

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	only five of these detections, all of which were recorded between 1977 and August 1978, were above 20 ppb. No detections were recorded above ATSDR's CVs after January 1986.)			
AF30, AF31, and AF32: AF30, AF31, and AF32 were constructed in 1984 and served as USAF's main water supply wells (AFCEE 1996a). Use of AF30 was discontinued in 1992, but the other two wells were used as potable water sources until the base was hooked up to municipal supply in 1997.	Samples were collected between 1984 and 1997 (AFBCA 1993; Air Force 1990; MDEQ 1999b). The wells were analyzed for volatile organics, pesticides, and metals. Contaminants were rarely detected and when they were present they were typically below ATSDR's drinking water CVs. Only three contaminants exceeded CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.6 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was only detected once, during a September 1994 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 29.4 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected five times; two of the detections, recorded in September 1985 and September 1994, exceeded ATSDR's CVs.)	N/A	N/A	Neither TCE nor benzene was detected above comparison values in these wells. Therefore, no harmful health effects expected from these chemicals. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.9 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected three times. The detections, which were recorded in September 1985, August 1987, and September 1994, exceeded ATSDR's CVs.)			

Table 15D. Updated Public Health Conclusions: TCE and Benzene

For ON-BASE EMPLOYEES who may have been Exposed to Water from USAF's Main Water Supply

While Working On-base for 25 Years

Assumed Well Water Exposure Route: Ingestion

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
AF1: Site representatives estimate that AF1 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF1 was being used as a potable source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in November 1977, TCE was detected at 895 ppb (AFBCA 1993).	Immunological effects Fetal Heart Defect (Pregnant Women)	2.9E-04 (Elevated)	TCE (895 ppb) Increased risk for harmful immunological health effects. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF2: AF2 was constructed in 1959 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (Ayres 1990). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, starting in 1977 and ending some time before 1983. Site representatives could not provide an exact date for AF2's return to service, so ATSDR assumed that it came back on line around January 1978. Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high	ATSDR searched site files to obtain data that was collected while AF2 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 37 ppb. (About 45 samples were analyzed for benzene between December 1979 and March 1993. The contaminant was detected nine times; seven of the detections, all of which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*Chloroform*. Detections ranged from nondetect to 6.7 ppb. (About 14 samples were analyzed for chloroform between March 1982 and March 1993. The	Immunological effects Fetal Heart Defect (Pregnant Women)	7.3E-04 (Elevated)	TCE (1,739 ppb) Increased risk for harmful non-cancer and cancer health effect in adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy Benzene (37 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
enough to require the use of AF2 (AFBCA 1999b).	contaminant was detected in more than half of the samples, but it only exceeded ATSDR's CV once, during a June 1986 sampling event.) •*Dichlorobromomethane.* Concentrations ranged from nondetect to 2.3 ppb. (About 13 samples were analyzed for this contaminant between March 1982 and March 1993. The contaminant was only detected above trace levels three times; two of the detections, recorded in May 1983 and June 1986, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,739 ppb. (More than 175 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected in the majority of samples, but only exceeded ATSDR's CVs 18 times. Only four of the samples contained TCE at concentrations greater than 20 ppb. These were detected in late 1977 [concentrations of about 130 ppb were detected] and February 1979 [concentrations of 1,666 and 1,739 were detected].)			
AF3: Site representatives estimate that AF3 was constructed in the late 1950s (AFBCA 1999b). It served as one of USAF's main water supply wells, providing potable water to on-base residents and employees, until it was removed from service in	ATSDR searched site files to obtain data that were collected while AF3 was being used as a potable water source. Site documents only listed one sampling event prior to the well's removal from service. During this event, which took place in	Immunological effects Fetal Heart Defect (Pregnant Women)	1.7E-03 (Elevated)	TCE (5,173 ppb) Increased risk for harmful non-cancer and cancer health effects for employees. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
November 1977 (USGS 1983). The well never returned to service as a potable water source (AFBCA 1999b).	November 1977, TCE was detected t 5,173 ppb (AFBCA 1993).			
AF4: AF4 was constructed in 1942 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]) Between 1984 and June 1993, the well was still used, but only on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF4 (AFBCA 1999b).	ATSDR searched site files to obtain data that was collected while AF4 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Five contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 4.1 ppb. (More than 170 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels once, during an April 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was only detected once, during a February 1993 sampling event. •*Chloroform*. Detections ranged from nondetect to 6.8 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected four times, but it only exceeded ATSDR's drinking water CVs once, during a February 1993 sampling event.)	No Harmful Health Effects Expected	6.6E-06 (Low)	TCE (14 ppb) No harmful health effects expected. Benzene (4.1 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About ten samples were analyzed for this contaminant between May 1983 and June 1993. The contaminant was detected twice, but it only exceeded ATSDR's CVs once, during a February 1993 sampling event.) •*TCE*. Concentrations ranged from nondetect to 14 ppb. (About 300 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was only detected above trace levels in 31 samples, and it only exceeded ATSDR's CVs on three occasions (i.e., during sampling events in December 1978, December 1979, and August 1980).			
AF5: AF5 was constructed in 1942 and served as one USAF's main water supply wells for many years, providing water to on-base employees and residents (AFCEE 1996a). The well operated in this capacity until 1984 when wells 30, 31, and 32 were brought on line (USGS 1983). (There was a brief period when the well was removed from service, but this only lasted for 2 months [i.e., November 1977 to January 1978] [USGS 1983]). Between 1984 and June 1993, the well was still used but only on a supplemental basis when the supply from other wells could not meet base demands	ATSDR searched site files to obtain data that was collected while AF5 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ 1999b). Seven contaminants were detected above ATSDR's drinking water CVs: •*Benzene*. Concentrations ranged from nondetect to 7.8 ppb. (About 160 samples were analyzed for benzene between December 1979 and June 1993. Benzene was only detected above trace levels on two occasions; it only exceeded ATSDR's CVs once,	Immunological effects Fetal Heart Defect (Pregnant Women)	3.8E-04 (Elevated)	TCE (1,174 ppb) Increased risk for harmful non-cancer and cancer health effects for employees. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy. Benzene (7.8 ppb) No harmful health effects expected.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). After the base closed in June 1993, demand was not high enough to require the use of AF5 (AFBCA 1999b).	during a June 1982 sampling event.) •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.7 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Chloroform*. Detections ranged from nondetect to 9.3 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.0 ppb. (About 10 samples were analyzed for this contaminant between May 1983 and June 1993. It was detected above ATSDR's CVs four times in 1993.) •*1-2-Dichloroethene* . Detections ranged from nondetect to 207 ppb. (About 165 samples were analyzed for this contaminant between December 1979 and June 1993. The contaminant was detected about 20 times, but it only exceeded ATSDR's CVs once, during a December 1985 sampling event.) •*1,1,2,2-Tetrachloroethane* . Concentrations ranged from			

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	nondetect to 4.3 ppb. (About 12 samples were analyzed for this contaminant between March 1982 and June 1993. The contaminant was detected four times. All of the detections, which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) •*TCE*. Concentrations ranged from nondetect to 1,174 ppb. (More than 250 samples were analyzed for TCE between November 1977 and June 1993. The contaminant was detected many times, but only exceeded ATSDR's drinking water CVs on four occasions. (The contaminant exceeded CVs three times in December 1979 [concentrations registered at 6.0 ppb on December 3, 1979; at 6.2 ppb on December 17, 1979; and at 1,174 ppb on December 31, 1979] and once in February 1981 [concentration registered at 6.0 ppb].)			
AF18: AF18 served as one of USAF's main water supply wells until March 1978 when it was removed from service. The well was never brought back on line (AFBCA 1999b, 1999c; USGS 1983).	ATSDR searched site files to obtain data that was collected through March 1978. TCE was the only contaminant analyzed during that time. It was sampled 13 times between November 1977 and March 1978. It was detected above ATSDR's drinking water CVs in all of the sampling events; concentrations ranged from 48.2 ppb to 91.5 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	3.0E-05 (Low)	TCE (91.5 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF19: AF19 was constructed in 1965 and served as one of USAF's main water supply wells for many years, providing potable water to on-base residents and employees	ATSDR searched site files to obtain data that was collected while AF19 was being used as a potable water source (AFBCA 1993; Air Force 1990; MDEQ	Fetal Heart Defect (Pregnant Women)	2.1E-05 (Low)	TCE (65.9 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
(Ayres 1990). AF19 operated in this capacity until August 1978, when it was temporarily removed from service (AFBCA 1999c; USGS 1983). In later years, the well was brought back on line to provide water on a supplemental basis when the supply from other wells could not meet base demands (Ayres 1990). (Site documents do not indicate exactly when AF19 was brought back on line. ATSDR assumed that it was only off line for a couple of months and started being used again in January 1979.) After the base closed in June 1993, demand was not high enough to require the use of AF19 (AFBCA 1999b).	1999b). Four contaminants were detected above ATSDR's drinking water CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 1.0 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 6.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was detected four times, but it only exceeded ATSDR's CV once, during a September 1989 sampling event.) •*Dichlorobromomethane*. Concentrations ranged from nondetect to 2.7 ppb. (About seven samples were analyzed for this contaminant between June 1983 and March 1993. The contaminant was only detected once, during a September 1989 sampling event.) •*TCE*. Concentrations ranged from nondetect to 65.9 ppb. (About 200 samples were analyzed for TCE between November 1977 and March 1993. The contaminant was detected above ATSDR's drinking water CVs 19 times, but			

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	only five of these detections, all of which were recorded between 1977 and August 1978, were above 20 ppb. No detections were recorded above ATSDR's CVs after January 1986.)			
AF30, AF31, and AF32: AF30, AF31, and AF32 were constructed in 1984 and served as USAF's main water supply wells (AFCEE 1996a). Use of AF30 was discontinued in 1992, but the other two wells were used as potable water sources until the base was hooked up to municipal supply in 1997.	Samples were collected between 1984 and 1997 (AFBCA 1993; Air Force 1990; MDEQ 1999b). The wells were analyzed for volatile organics, pesticides, and metals. Contaminants were rarely detected and when they were present they were typically below ATSDR's drinking water CVs. Only three contaminants exceeded CVs: •*Chlorodibromomethane*. Concentrations ranged from nondetect to 0.6 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was only detected once, during a September 1994 sampling event.) •*Chloroform*. Concentrations ranged from nondetect to 29.4 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected five times; two of the detections, recorded in September 1985 and September 1994, exceeded ATSDR's CVs.)	N/A	N/A	Neither TCE nor benzene was detected above comparison values in these wells. Therefore, no harmful health effects expected from these chemicals. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Well Identification and Usage History	Contamination History	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	•*Dichlorobromomethane*. Concentrations ranged from nondetect to 3.9 ppb. (Wells were sampled and analyzed for this contaminant on about 25 occasions between September 1985 and March 1997. The contaminant was detected three times. The detections, which were recorded in September 1985, August 1987, and September 1994, exceeded ATSDR's CVs.)			

Table 16D. Updated Public Health Conclusions: TCE and Benzene

For ON-BASE MILITARY MEMBERS AND ADULT FAMILY MEMBERS who were Exposed to Contaminated Tap Water

While Living in On-base Housing for 5 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
8306 Hawaii	Samples were analyzed for TCE once in December 1977. The contaminant was detected above ATSDR's drinking water CVs, registering at 148.9 ppb (AFBCA 1993).	Immunological effects Fetal Heart Defect (Pregnant Women)	2.8E-05 (Low)	TCE (148.9 ppb) Increased risk for harmful immunological effects in adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
Housing Area (Unlisted location)	Samples were analyzed for TCE about 20 times between October 1977 and April 1979. TCE was detected above ATSDR's drinking water CVs on 16 occasions. It was detected at 1,100 ppb in October 1977, at 149 ppb in November 1977, 32 ppb in December 1977, and 55 ppb in February 1978, before dropping below ATSDR's CVs for a couple months. Between June 1978 and April 1979, detections ranged between 3.0 and 78 ppb (AFBCA 1993).	Immunological effects Fetal Heart Defect (Pregnant Women)	2.1E-04 (Elevated)	TCE (1,100 ppb) Increased risk for harmful non-cancer and cancer health effect for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
8000 Area	Samples were analyzed for TCE in 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 6.0 and 32.2 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	6.0E-06 (Low)	TCE (32.2 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
Building 8509D	Samples were analyzed for TCE many times in 1979. The contaminant was detected above ATSDR's drinking water CVs during all of the sampling events. Concentrations ranged between 12.4 and 75 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	1.4E-05 (Low)	TCE (75 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
1612 A & B California	In 1979, samples were analyzed for TCE on about 25 occasions.	Fetal Heart Defect (Pregnant Women)	1.4E-05 (Low)	TCE (73.2 ppb)

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	TCE was detected during each sampling event, ranging from concentrations of 5.8 to 73.2 ppb. All of the detections exceeded ATSDR's drinking water CVs (AFBCA 1993).			Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
10500 Idaho	Samples were analyzed for TCE in May and July of 1979. TCE (2.2 to 6.8 ppb) was detected above ATSDR's drinking water CVs during the former sampling event (AFBCA 1993).	No Harmful Health Effects Expected	1.3E-06 (Low)	TCE (6.8 ppb) No harmful health effects expected.
Barracks 502	Samples were analyzed for TCE in April 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 68 and 71 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	1.3E-05 (Low)	TCE (71 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
8808 E N Vermont	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 8.9 and 9.8 ppb (AFBCA 1993).	No Harmful Health Effects Expected	1.8E-06 (Low)	TCE (9.8 ppb) No harmful health effects expected.
Building 9750 D	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 22.8 and 27.3 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	5.1E-06 (Low)	TCE (27.3 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
9752B 8th Street	Samples were analyzed for TCE in October 1979. The contaminant was not detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10037 8th Street	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged from 22.1 to 26.6 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	5.0E-06 (Low)	TCE (26.6 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
10039 8th Street	Samples were analyzed for TCE about 20 times between March 1979 and August 1979. TCE was detected during each sampling event, ranging from concentrations of 2.5 to 57 ppb. The concentration exceeded ATSDR's drinking water CVs on 17 occasions (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	1.1E-05 (Low)	TCE (57 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
10000 Area; 10205 TN	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged from 43.5 to 48.7 ppb (AFBCA 1993).	Fetal Heart Defect (Pregnant Women)	9.1E-06 (Low)	TCE (48.7 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
Barracks 225	Samples were analyzed for TCE in December 1979. TCE was detected above ATSDR's drinking water CVs in one sample, registering at 5.1 ppb (AFBCA 1993).	No Harmful Health Effects Expected	9.5E-07 (Low)	TCE (5.1 ppb) No harmful health effects expected.
9750A & B 8th Street	Samples were collected between 1979 and 1983 (AFBCA 1993). Five contaminants exceeded ATSDR's drinking water CVs: • *Benzene*. Concentrations ranged from nondetect to 15.2 ppb. (About 25 samples were analyzed for benzene between 1980 and 1983. It was detected above trace levels seven times; all of these detections exceeded ATSDR's CVs.) • *Chlorodibromomethane*. This contaminant was analyzed once in June 1980. It was detected at 1.7 ppb. • Dichlorobromomethane. This contaminant was analyzed once in	Fetal Heart Defect (Pregnant Women)	1.6E-05 (Low)	TCE (72 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy. Benzene (15.2 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	June 1980. It was detected at 2.2 ppb. • 1,1,2,2-tetrachloroethane. Concentrations ranged from 2.3 to 2.7 ppb. (Three samples were analyzed for this contaminant in 1982; the contaminant was detected in all three samples at concentrations that exceeded ATSDR's CVs.) • TCE. Concentrations ranged from nondetect to 72 ppb. (More than 150 samples were analyzed for this contaminant between April 1979 and January 1983. TCE was detected above ATSDR's CVs on 35 occasions in 1979 and once in 1981.)			
1820 Cedar St	Samples were analyzed for TCE in September 1980. The contaminant was not detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
9204A Rhode Island	Samples were collected in 1982. No contaminants were detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10059 8th Street	Samples were collected three times (i.e., in February 1982, March 1982, and November 1983). Benzene (nondetect to 8.2 ppb) was detected above ATSDR's drinking water CVs during the first two sampling events but was not detected during the third event (AFBCA 1993).	No Harmful Health Effects Expected	1.8E-06 (Low)	Benzene (8.2 ppb) No harmful health effects expected.
Building 245	One sample was collected in October 1983. No contaminants	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore,

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	exceeded ATSDR's drinking water CVs (AFBCA 1993).			no harmful health effects expected.
9215B Rhode Island	Samples were collected in November 1983. No contaminants were detected (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10060 8th Street	Samples were collected in November 1983. No contaminants were detected above trace levels (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
8032 1st Street	Samples were collected in November 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10031 7th Street	Samples were collected in August 1984 and February 1985. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
8822A 3rd Street	Samples were collected once in August 1985 (AFBCA 1993). Dichlorobromomethane (2.1 ppb) and chloroform (12.8 ppb) exceeded ATSDR's drinking water CVs.	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
10311 7th Street	Samples were collected between 1983 and 1989 (AFBCA 1993; Air Force 1990). Two contaminants were detected above ATSDR's drinking water CVs: • Benzene. Concentrations ranged from nondetect to 11 ppb. (More than 100 samples were analyzed	No Harmful Health Effects Expected	2.4E-06 (Low)	TCE (13 ppb) No harmful health effects expected. Benzene (11 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	for this contaminant between 1983 and 1989. It was only detected above trace levels twice. These detections, which occurred in March 1984 and April 1985, both exceeded ATSDR's CVs. • TCE. Concentrations ranged from nondetect to 13 ppb. (More than 100 samples were analyzed for this contaminant between 1983 and 1989. It was detected many times, but only exceeded ATSDR's CVs on two occasions. (TCE was detected at 8.1 ppb in April 1985 and at 13.0 ppb in February 1986.)			
Building 1752	Samples were collected in July 1986. No contaminants were detected (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10309 7th Street	Samples were collected on several occasions in 1989. No contaminants exceeded ATSDR's drinking water CVs (Air Force 1990).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10419 South Carolina Street	Samples were collected in 1993 (MDEQ 1999b). Three contaminants exceeded ATSDR's drinking water CVs: • Chlorodibromomethane. Concentrations ranged from nondetect to 0.8 ppb. (The contaminant exceeded ATSDR's CVs in five of the seven samples.) • Chloroform. Concentrations ranged from 1.7 to 7.3 ppb. (The contaminant exceeded ATSDR's CVs in two of the seven samples.)	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	• Dichlorobromomethane. Concentrations ranged from 0.6 to 2.7 ppb. (The contaminant exceeded ATSDR's CVs in six of the seven samples.)			

Table 17D. Updated Public Health Conclusions: TCE and Benzene

For CHILDREN of ON-BASE MILITARY MEMBERS who were Exposed to Contaminated Tap Water

While Living in On-base Housing for 5 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
8306 Hawaii	Samples were analyzed for TCE once in December 1977. The contaminant was detected above ATSDR's drinking water CVs, registering at 148.9 ppb (AFBCA 1993).	Immunological effects	1.5E-04 (Elevated)	TCE (148.9 ppb) Increased risk for harmful non-cancer and cancer health effects in children.
Housing Area (Unlisted location)	Samples were analyzed for TCE about 20 times between October 1977 and April 1979. TCE was detected above ATSDR's drinking water CVs on 16 occasions. It was detected at 1,100 ppb in October 1977, at 149 ppb in November 1977, 32 ppb in December 1977, and 55 ppb in February 1978, before dropping below ATSDR's CVs for a couple months. Between June 1978 and April 1979, detections ranged between 3.0 and 78 ppb (AFBCA 1993).	Immunological effects	1.1E-03 (Elevated)	TCE (1,100 ppb) Increased risk for harmful non-cancer and cancer health effect for children.
8000 Area	Samples were analyzed for TCE in 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 6.0 and 32.2 ppb (AFBCA 1993).	Immunological effects	3.2E-05 (Low)	TCE (32.2 ppb) Increased risk for harmful non-cancer immunological health effects for children.
Building 8509D	Samples were analyzed for TCE many times in 1979. The contaminant was detected above ATSDR's drinking water CVs during all of the sampling events. Concentrations ranged between 12.4 and 75 ppb (AFBCA 1993).	Immunological effects	7.6E-05 (Low)	TCE (75 ppb) Increased risk for harmful non-cancer health effect for children.
1612 A & B California	In 1979, samples were analyzed for TCE on about 25 occasions. TCE was detected during each	Immunological effects	7.4E-05 (Low)	TCE (73.2 ppb) Increased risk for harmful non-cancer health effect for children.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	sampling event, ranging from concentrations of 5.8 to 73.2 ppb. All of the detections exceeded ATSDR's drinking water CVs (AFBCA 1993).			
10500 Idaho	Samples were analyzed for TCE in May and July of 1979. TCE (2.2 to 6.8 ppb) was detected above ATSDR's drinking water CVs during the former sampling event (AFBCA 1993).	No Harmful Health Effects Expected	6.9E-06 (Low)	TCE (6.8 ppb) No harmful health effects expected.
Barracks 502	Samples were analyzed for TCE in April 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 68 and 71 ppb (AFBCA 1993).	Immunological effects	7.2E-05 (Low)	TCE (71 ppb) Increased risk for harmful non-cancer health effect for children.
8808 E N Vermont	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 8.9 and 9.8 ppb (AFBCA 1993).	No Harmful Health Effects Expected	9.9E-06 (Low)	TCE (9.8 ppb) No harmful health effects expected.
Building 9750 D	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged between 22.8 and 27.3 ppb (AFBCA 1993).	Immunological effects	2.8E-05 (Low)	TCE (27.3 ppb) Increased risk for harmful non-cancer health effect for children.
9752B 8th Street	Samples were analyzed for TCE in October 1979. The contaminant was not detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10037 8th Street	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged from 22.1 to 26.6 ppb (AFBCA 1993).	Immunological effects	2.7E-05 (Low)	TCE (26.6 ppb) Increased risk for harmful non-cancer health effects for children.
10039 8th Street	Samples were analyzed for TCE about 20 times between March	Immunological effects	5.8E-05 (Low)	TCE (57 ppb)

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	1979 and August 1979. TCE was detected during each sampling event, ranging from concentrations of 2.5 to 57 ppb. The concentration exceeded ATSDR's drinking water CVs on 17 occasions (AFBCA 1993).			Increased risk for harmful non-cancer health effects for children.
10000 Area; 10205 TN	Samples were analyzed for TCE in May 1979. The contaminant was detected above ATSDR's drinking water CVs. Concentrations ranged from 43.5 to 48.7 ppb (AFBCA 1993).	Immunological effects	5.8E-05 (Low)	TCE (48.7 ppb) Increased risk for harmful non-cancer health effects for children.
Barracks 225	Samples were analyzed for TCE in December 1979. TCE was detected above ATSDR's drinking water CVs in one sample, registering at 5.1 ppb (AFBCA 1993).	No Harmful Health Effects Expected	5.1E-06 (Low)	TCE (5.1 ppb) No harmful health effects expected.
9750A & B 8th Street	Samples were collected between 1979 and 1983 (AFBCA 1993). Five contaminants exceeded ATSDR's drinking water CVs: • *Benzene*. Concentrations ranged from nondetect to 15.2 ppb. (About 25 samples were analyzed for benzene between 1980 and 1983. It was detected above trace levels seven times; all of these detections exceeded ATSDR's CVs.) • *Chlorodibromomethane*. This contaminant was analyzed once in June 1980. It was detected at 1.7 ppb. • Dichlorobromomethane. This contaminant was analyzed once in June 1980. It was detected at 2.2 ppb.	Immunological effects	8.2E-05 (Low)	TCE (72 ppb) Increased risk for harmful non-cancer health effects for children. Benzene (15.2 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	• 1,1,2,2-tetrachloroethane. Concentrations ranged from 2.3 to 2.7 ppb. (Three samples were analyzed for this contaminant in 1982; the contaminant was detected in all three samples at concentrations that exceeded ATSDR's CVs.) • TCE. Concentrations ranged from nondetect to 72 ppb. (More than 150 samples were analyzed for this contaminant between April 1979 and January 1983. TCE was detected above ATSDR's CVs on 35 occasions in 1979 and once in 1981.)			
1820 Cedar St	Samples were analyzed for TCE in September 1980. The contaminant was not detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
9204A Rhode Island	Samples were collected in 1982. No contaminants were detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10059 8th Street	Samples were collected three times (i.e., in February 1982, March 1982, and November 1983). Benzene (nondetect to 8.2 ppb) was detected above ATSDR's drinking water CVs during the first two sampling events but was not detected during the third event (AFBCA 1993).	No Harmful Health Effects Expected	4.8E-06 (Low)	Benzene (8.2 ppb) No harmful health effects expected.
Child Care Center	Samples were collected between 1982 and 1996 (AFBCA 1993; Air Force 1990; MDEQ 1999b). Five contaminants exceeded ATSDR's drinking water CVs:	No Harmful Health Effects Expected	4.8E-06 (Low)	Benzene (24.4 ppb) No harmful health effects expected from exposure to benzene.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	• Benzene. Concentrations ranged from nondetect to 24.4 ppb. (About 180 samples were analyzed for benzene between 1982 and 1996. It was detected above trace levels 24 times. About 22 of these detections, all of which were recorded between February 1982 and October 1983, exceeded ATSDR's CVs.) • Chlorodibromomethane. Concentrations ranged from nondetect to 1.5 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was detected above ATSDR's CVs on nine occasions.) • Chloroform. Concentrations ranged from nondetect to 34 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was detected above ATSDR's CVs on 16 occasions.) • Dichlorobromomethane. Concentrations ranged from 0.6 to 7.0 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was detected above ATSDR's CVs on all but one occasion.) • 1,1,2,2-tetrachloroethane. Concentrations ranged from nondetect to 1.9 ppb. (This contaminant was analyzed three			Although not specifically evaluated here, the levels of the other detected chemicals are too low to cause harmful health effects.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	times in 1982 and about 20 times between 1993 and 1996. It was detected above ATSDR's CVs during the 1982 sampling events, but it was not detected in the samples that were collected in the 1990s.)			
Building 245	One sample was collected in October 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
9215B Rhode Island	Samples were collected in November 1983. No contaminants were detected (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10060 8th Street	Samples were collected in November 1983. No contaminants were detected above trace levels (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
8032 1st Street	Samples were collected in November 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10031 7th Street	Samples were collected in August 1984 and February 1985. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
8822A 3rd Street	Samples were collected once in August 1985 (AFBCA 1993). Dichlorobromomethane (2.1 ppb) and chloroform (12.8 ppb) exceeded ATSDR's drinking water CVs.	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
				these chemicals is too low to cause harmful health effects.
10311 7th Street	Samples were collected between 1983 and 1989 (AFBCA 1993; Air Force 1990). Two contaminants were detected above ATSDR's drinking water CVs: • Benzene. Concentrations ranged from nondetect to 11 ppb. (More than 100 samples were analyzed for this contaminant between 1983 and 1989. It was only detected above trace levels twice. These detections, which occurred in March 1984 and April 1985, both exceeded ATSDR's CVs. • TCE. Concentrations ranged from nondetect to 13 ppb. (More than 100 samples were analyzed for this contaminant between 1983 and 1989. It was detected many times, but only exceeded ATSDR's CVs on two occasions. (TCE was detected at 8.1 ppb in April 1985 and at 13.0 ppb in February 1986.)	No Harmful Health Effects Expected	1.3E-05 (Low)	TCE (13 ppb) No harmful health effects expected. Benzene (11 ppb) No harmful health effects expected.
Building 1752	Samples were collected in July 1986. No contaminants were detected (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10309 7th Street	Samples were collected on several occasions in 1989. No contaminants exceeded ATSDR's drinking water CVs (Air Force 1990).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
10419 South Carolina Street	Samples were collected in 1993 (MDEQ 1999b). Three contaminants exceeded ATSDR's drinking water CVs:	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore,

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	• Chlorodibromomethane. Concentrations ranged from nondetect to 0.8 ppb. (The contaminant exceeded ATSDR's CVs in five of the seven samples.) • Chloroform. Concentrations ranged from 1.7 to 7.3 ppb. (The contaminant exceeded ATSDR's CVs in two of the seven samples.) • Dichlorobromomethane. Concentrations ranged from 0.6 to 2.7 ppb. (The contaminant exceeded ATSDR's CVs in six of the seven samples.)			no harmful health effects expected.

Table 18D. Updated Public Health Conclusions: TCE and Benzene

For ON-BASE EMPLOYEES who were Exposed to Contaminated Tap Water

While Working On-base for 25 Years

Assumed Well Water Exposure Route: Ingestion

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
Hospital	Samples were collected between 1978 and 1993 (AFBCA 1993; Air Force 1990; MDEQ 1999b). Six contaminants exceeded ATSDR's drinking water CVs: • Benzene. Concentrations ranged from nondetect to 38.6 ppb. (About 125 samples were analyzed for benzene between 1982 and 1993. It was detected above trace levels 22 times; all of these detections, which were recorded between February 1982 and October 1983, exceeded CVs. • Chlorodibromomethane. Concentrations ranged from nondetect to 4.7 ppb. (This contaminant was analyzed once in March 1982 and three times in 1993. It was detected in 1982 and once in 1993. Both detections exceeded ATSDR's CVs.) • Chloroform. Concentrations ranged from 1.5 to 12.5 ppb. (This contaminant was analyzed once in March 1982 and three times in 1993. It was detected on all four occasions, but it only exceeded ATSDR's CV once, during a May 1993 sampling event.) • Dichlorobromomethane. Concentrations ranged from 0.8	No Harmful Health Effects Expected	2.5E-05 (Low)	TCE (17 ppb) No harmful health effects expected. Benzene (38.6 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	to 3.6 ppb. (This contaminant was analyzed once in March 1982 and three times in 1993. It was detected on all four occasions; all of the detections exceeded ATSDR's CVs.) • 1,1,2,2-tetrachloroethane. Concentrations ranged from nondetect to 2.8 ppb. (This contaminant was analyzed three times in 1982 and four times in 1993. It was detected above ATSDR's CVs in all of the 1982 sampling events, but it was not detected during the 1993 sampling efforts.) • TCE. Concentrations ranged from nondetect to 17 ppb. (About 100 samples were analyzed for TCE between November 1978 and May 1993. The contaminant was only detected above ATSDR's CVs twice. Both detections were recorded in 1985.)			
Building 5008	Samples were collected between 1979 and 1989 (AFBCA 1993; Air Force 1990). Five contaminants exceeded ATSDR's drinking water CVs: • *Benzene*. Concentrations ranged from nondetect to 1,510 ppb. (About 150 samples were analyzed for this contaminant between 1982 and 1989. It was detected above trace levels six times; all of these detections were above ATSDR's CVs. Benzene was detected in February 1982 [4.7 ppb], March	Hematotoxicity	7.3E-04 (Elevated)	Benzene (1510 ppb) Increased risk for harmful non-cancer and cancer health effects for adults exposed to benzene for many years. TCE (11.1 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	1982 [10.9 ppb], July 1983 [13.5 ppb], August 1983 [6.4 ppb], September 1986 [1,510 ppb], and July 1987 [10.2 ppb].) • *Chlorodibromomethane*. This contaminant was analyzed once in March 1982. It was detected at 1.3 ppb. • *Dichlorobromomethane*. This contaminant was analyzed once in March 1982. It was detected at 1.0 ppb. • *1,1,2,2-tetrachloroethane*. Concentrations ranged from 1.9 to 2.9 ppb. (Three samples were analyzed for this contaminant in 1982; the contaminant was detected in all three samples at concentrations that exceeded ATSDR's CVs.) • *TCE*. Concentrations ranged from nondetect to 11.1 ppb. (More than 100 samples were analyzed for this contaminant between 1979 and 1989. TCE was detected above ATSDR's CVs on only four occasions, all of which took place in May 1979.)			
Education Center	Samples were collected in 1982. No contaminants were detected above ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
Building 5065	Samples were collected in February and March 1982. Benzene (nondetect to 2.3 ppb) exceeded ATSDR's drinking water	No Harmful Health Effects Expected	1.1E-06 (Low)	Benzene (2.3 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	CVs during the former event (AFBCA 1993).			
Building 1700	Samples were collected between 1982 and 1989 (AFBCA 1993; Air Force 1990). Five contaminants were detected above ATSDR's drinking water CVs: • Benzene. Concentrations ranged from nondetect to 27.1 ppb. (More than 30 samples were analyzed for this contaminant between 1982 and 1989. It was detected above ATSDR's CVs 13 times; all of these elevated detections were recorded between 1982 and 1985.) • Chlorodibromomethane. Concentrations ranged from nondetect to 4.3 ppb. (Six samples were analyzed for this contaminant. It was detected three times. All of the detections, which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) • Dichlorobromomethane. Concentrations ranged from nondetect to 2.5 ppb. (Six samples were analyzed for this contaminant. It was detected four times. All of the detections, which were recorded in 1982 and 1983, exceeded ATSDR's CVs.) • 1,1,2,2-tetrachloroethane. Concentrations ranged from nondetect to 3.5 ppb. (Eight samples were analyzed for this contaminant. It was detected three times. All of the detections,	No Harmful Health Effects Expected	1.3E-05 (Low)	Benzene (27.1 ppb) No harmful health effects expected from exposure to benzene. Although not specifically evaluated here, the levels of the other detected chemicals are too low to cause harmful health effects.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	which were recorded in 1982, exceeded ATSDR's CVs.) • 1,2-dichloroethane. Concentrations ranged from nondetect to 0.5 ppb. (Five samples were analyzed for this contaminant. It was detected above trace levels twice; both detections, which were recorded in 1983, exceeded ATSDR's CVs.)			
Child Care Center	Samples were collected between 1982 and 1996 (AFBCA 1993; Air Force 1990; MDEQ 1999b). Five contaminants exceeded ATSDR's drinking water CVs: • Benzene. Concentrations ranged from nondetect to 24.4 ppb. (About 180 samples were analyzed for benzene between 1982 and 1996. It was detected above trace levels 24 times. About 22 of these detections, all of which were recorded between February 1982 and October 1983, exceeded ATSDR's CVs.) • Chlorodibromomethane. Concentrations ranged from nondetect to 1.5 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was detected above ATSDR's CVs on nine occasions.) • Chloroform. Concentrations ranged from nondetect to 34 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was	No Harmful Health Effects Expected	1.2E-05 (Low)	Benzene (24.4 ppb) No harmful health effects expected from exposure to benzene. Although not specifically evaluated here, the levels of the other detected chemicals are too low to cause harmful health effects.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	detected above ATSDR's CVs on 16 occasions.) • Dichlorobromomethane. Concentrations ranged from 0.6 to 7.0 ppb. (This contaminant was analyzed about 20 times between February 1993 and December 1996. It was detected above ATSDR's CVs on all but one occasion.) • 1,1,2,2-tetrachloroethane. Concentrations ranged from nondetect to 1.9 ppb. (This contaminant was analyzed three times in 1982 and about 20 times between 1993 and 1996. It was detected above ATSDR's CVs during the 1982 sampling events, but it was not detected in the samples that were collected in the 1990s.)			
Building 5043	Samples were collected in November 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
Building 5090	Samples were collected in November 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected.
Bioenviro. Eng. Building	Samples were collected once in 1984 and three times in 1993 (AFBCA 1993; MDEQ 1999b). Two contaminants were detected above ATSDR's drinking water CVs: • Chlorodibromomethane. Concentrations ranged from	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	nondetect to 0.7 ppb. (This contaminant was not detected in 1984, but it exceeded ATSDR's CVs during all three of the 1993 sampling events.) • Dichlorobromomethane. Concentrations ranged from nondetect to 2.3 ppb. (This contaminant was not detected in 1984, but it exceeded ATSDR's CVs during all three of the 1993 sampling events.)			not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
Aircraft Alert Area	Samples were collected in 1989. TCE (nondetect to 25 ppb) was detected above ATSDR's drinking water CVs once out of several sampling events (Air Force 1990).	No Harmful Health Effects Expected	1.2E-05 (Low)	TCE (25 ppb) No harmful health effects expected.
Building 291	Samples were collected in 1989. Chlorodibromomethane (0.9 ppb), chloroform (1.0 to 13 ppb), and dichlorobromomethane (1.5 to 3.9 ppb) were detected above ATSDR's drinking water CVs (Air Force 1990).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
Procurement Office	ATSDR found no records of tap water samples being collected when the building was serviced by AF15. Samples were collected in 1989, when the building was being serviced by the main water supply wells. Sampling data indicated that chloroform (6.4 ppb) and dichlorobromomethane (2.0 ppb) were present at concentrations that exceeded	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	ATSDR's drinking water CVs (Air Force 1990).			these chemicals is too low to cause harmful health effects.
Building 5067	Samples were analyzed for several organic compounds in May and June 1993 (MDEQ 1993). Chlorodibromomethane (0.6 to 0.7 ppb), chloroform (6.5 to 8.5 ppb) and dichlorobromomethane (2.1 to 2.8 ppb) exceeded ATSDR's drinking water CVs during both sampling events.	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
Building 5006	Samples were collected four times between February and April 1993 and analyzed for several organics. Chlorodibromomethane (0.7 to 1.0 ppb), chloroform (6.8 to 8.9 ppb), and dichlorobromomethane (2.8 to 3.4 ppb) exceeded ATSDR's drinking water CVs during all four sampling events (MDEQ 1999b).	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
Building 20	Samples were collected between March and April of 1994 (MDEQ 1999b). Two contaminants exceeded ATSDR's drinking water CVs: Chloroform. Concentrations ranged from 4.9 to 10.7 ppb. (The contaminant exceeded ATSDR's CVs in three of four samples.) • Dichlorobromomethane. Concentrations ranged from 1.9 to 3.2 ppb. The contaminant	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	exceeded ATSDR's CVs in all four samples.)			
Baker Eng. Building	Samples were collected in December 1996 (MDEQ 1999b). Chloroform (14.8 ppb) and dichlorobromomethane (1.2 ppb) exceeded ATSDR's drinking water CVs.	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.
Civil Eng. Building (Bdg. 290)	A few samples were collected in 1982 and 1983. No contaminants exceeded ATSDR's drinking water CVs (AFBCA 1993). About 14 samples were collected between 1993 and 1997 and analyzed for a variety of organic compounds (MDEQ 1999b). Only three contaminants exceeded ATSDR's drinking water CVs: • Chlorodibromomethane. Concentrations ranged from nondetect to 0.8 ppb. (The contaminant exceeded ATSDR's CVs once out of 14 sampling events.) • Chloroform. Concentrations ranged from 3.4 to 25.5 ppb. (The contaminant exceeded ATSDR's CVs eight out of 14 sampling events.) • Dichlorobromomethane. Concentrations ranged from 0.5 to 3.5 ppb. (The contaminant	N/A	N/A	Neither TCE nor benzene was detected above comparison values at this location. Therefore, no harmful health effects expected. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	exceeded ATSDR's CVs on all but one of the sampling events.)			

Table 19D. Updated Public Health Conclusions: TCE and Benzene
For MILITARY OFFICERS who were Exposed to Contaminated Tap Water
While Intermittently Visiting On-base for 2 Days per Week for 5 Years
Assumed Well Water Exposure Route: Ingestion

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
NCO Club	Samples were collected in April 1979 and November 1983. TCE (71 to 75 ppb), the only contaminant that exceeded ATSDR's drinking water CVs, was detected during the 1979 event (AFBCA 1993).	No Harmful Health Effects Expected	2.4E-06 (Low)	TCE (75 ppb) No harmful health effects expected.
Officer's Club	Samples were collected between 1979 and 1989 (AFBCA 1993; Air Force 1990). Five contaminants exceeded ATSDR's drinking water CVs: • *Benzene*. Concentrations ranged from nondetect to 30 ppb. (About 140 samples were analyzed for benzene between 1982 and 1989. The contaminant was detected above trace levels seven times. Three of these detections, which were recorded between February 1982 and January 1983, exceeded ATSDR's CVs.) • *Chlorodibromomethane*. This contaminant was analyzed in June 1980 and May 1982. It was detected above ATSDR's CVs during both events, registering between 1.9 and 6.1 ppb. • *Dichlorobromomethane*. This contaminant was analyzed once in June 1980. It was detected at 7.4 ppb.	No Harmful Health Effects Expected	2.1E-06 (Low)	TCE (27 ppb) No harmful health effects expected. Benzene (30 ppb) No harmful health effects expected.

Sample Location	Sampling Dates and Results	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	• *1,1,2,2-tetrachloroethane*. This contaminant was analyzed once in March 1982. It was detected at 1.2 ppb. • *TCE*. Concentrations ranged from nondetect to 27 ppb. (More than 150 samples were analyzed for TCE between 1979 and 1989. It exceeded ATSDR's CVs on 22 occasions. All of the detections that exceeded CVs occurred between September 1979 and June 1980, except for one, which was recorded in April 1985.)			

Table 20D. Updated Public Health Conclusions: TCE and Benzene

For ADULT VISITORS AND SHORT-TERM GUESTS who were Exposed to Contaminated Water from Area-Specific Wells

While Visiting On-base Short-term Housing for 4 Weeks

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
AF7: This well serviced the North Cottage. It has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it being used again in the future (AFBCA 1999b).	Samples were collected from AF7 and analyzed for TCE on more than 30 occasions between December 1977 and January 1980. Detections ranged from nondetect to 17.6 ppb. TCE exceeded ATSDR's drinking water CVs on 20 occasions (AFBCA 1993). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Fetal Heart Defect (Pregnant Women)	N/A: Cancer risk not determined for short-term guests.	TCE (17.6 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF8: This well serviced the South Cottage. It has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it being used again in the future (AFBCA 1999b).	Samples were collected from AF8 and analyzed for TCE on about 40 occasions between October 1978 and September 1980. Detections ranged from nondetect to 27 ppb. TCE exceeded ATSDR's drinking water CVs on nine occasions (AFBCA 1993). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Fetal Heart Defect (Pregnant Women)	N/A: Cancer risk not determined for short-term guests.	TCE (27 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
AF22: This well serviced the Burkhart Lodge for many years. (The lodge served as a visitation center for pilots.) Later in WAFB's	Samples were collected from AF22 between 1977 and 1984. TCE (trace to 30.4 ppb) was the only contaminant that exceeded	Fetal Heart Defect (Pregnant Women)	N/A: Cancer risk not determined for short-term guests.	TCE (30.4 ppb) Increased risk for a heart birth defect for babies if the mother

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
history, the lodge was serviced by USAF's main water supply wells (AFBCA 1999d).	ATSDR's drinking water CVs (AFBCA 1993). (The contaminant was sampled more than 100 times between December 1977 and February 1981. It was detected above ATSDR's CVs on all but a few occasions.) Tap water samples were collected from the lodge in 1989. TCE concentrations ranged from 12 to 18 ppb (Air Force 1990). Although TCE was detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.			was exposed to TCE during the first trimester of pregnancy.
AF23: This well serviced the Air Force Beach in the past (AFBCA 1999d).	Samples were collected from AF23 between 1979 and 1989. TCE (1.1 to 14.7 ppb) was the only contaminant detected above ATSDR's drinking water CV (Air Force 1990; AFBCA 1993). (About 80 samples were analyzed for TCE between May 1979 and August 1987. TCE was detected above ATSDR's CVs in all but a few samples.) Although TCE was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.	Fetal Heart Defect (Pregnant Women)	N/A: Cancer risk not determined for short-term guests.	TCE (14.7 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Table 21D. Updated Public Health Conclusions: TCE and Benzene

For CHILD VISITORS AND SHORT-TERM GUESTS who were Exposed to Contaminated Water from Area-Specific Wells

While Visiting On-base Short-term Housing for 4 Weeks

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
AF7: This well serviced the North Cottage. It has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it being used again in the future (AFBCA 1999b).	Samples were collected from AF7 and analyzed for TCE on more than 30 occasions between December 1977 and January 1980. Detections ranged from nondetect to 17.6 ppb. TCE exceeded ATSDR's drinking water CVs on 20 occasions (AFBCA 1993). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Immunological effects	N/A: Cancer risk not determined for short-term guests.	TCE (17.6 ppb) Increased risk for harmful non-cancer health effects for children.
AF8: This well serviced the South Cottage. It has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it being used again in the future (AFBCA 1999b).	Samples were collected from AF8 and analyzed for TCE on about 40 occasions between October 1978 and September 1980. Detections ranged from nondetect to 27 ppb. TCE exceeded ATSDR's drinking water CVs on nine occasions (AFBCA 1993). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Immunological effects	N/A: Cancer risk not determined for short-term guests.	TCE (27 ppb) Increased risk for harmful non-cancer health effects for children.
AF22: This well serviced the Burkhart Lodge for many years. (The lodge served as a visitation center for pilots.) Later in WAFB's history, the lodge was serviced by USAF's main water supply wells (AFBCA 1999d).	Samples were collected from AF22 between 1977 and 1984. TCE (trace to 30.4 ppb) was the only contaminant that exceeded ATSDR's drinking water CVs (AFBCA 1993). (The contaminant was sampled more than 100 times	Immunological effects	N/A: Cancer risk not determined for short-term guests.	TCE (30.4 ppb) Increased risk for harmful non-cancer health effects for children.

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	between December 1977 and February 1981. It was detected above ATSDR's CVs on all but a few occasions.) Tap water samples were collected from the lodge in 1989. TCE concentrations ranged from 12 to 18 ppb (Air Force 1990). Although TCE was detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.			
AF23: This well serviced the Air Force Beach in the past (AFBCA 1999d).	Samples were collected from AF23 between 1979 and 1989. TCE (1.1 to 14.7 ppb) was the only contaminant detected above ATSDR's drinking water CV (Air Force 1990; AFBCA 1993). (About 80 samples were analyzed for TCE between May 1979 and August 1987. TCE was detected above ATSDR's CVs in all but a few samples.) Although TCE was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.	No harmful health effects expected	N/A: Cancer risk not determined for short-term guests.	TCE (14.7 ppb) No harmful non-cancer health effects expected.

Table 22D. Updated Public Health Conclusions: TCE and Benzene

For ON-BASE EMPLOYEES who were Exposed to Contaminated Water from Area-Specific Wells

While Working On-base for 25 Years

Assumed Well Water Exposure Route: Ingestion

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effect(s)	Total Cancer Risk	Comments
AF14: This well serviced Building 1135 in the past (AFBCA 1999f). The well has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it to be used again in the future (AFBCA 1999b).	Well data were not available for AF14, but tap water samples were collected from Building 1135 and analyzed for TCE in June 1979. Detections ranged from 12.1 to 12.7 ppb (AFBCA 1993). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	No harmful health effects expected	5.2E-06 (Low)	TCE (12.7 ppb) No harmful non-cancer or cancer health effects expected.
AF15: This well serviced the base procurement office (Building 4004) in the past. Site representatives do not have exact documentation listing when the well stopped being used, but it was removed from service sometime before 1983 (USGS 1983). (One site representative thinks that the well may have been taken off line before 1977.) The well has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it to be used again in the future (AFBCA 1999b).	ATSDR reviewed available data that was collected through 1983. Although several contaminants were analyzed, only TCE (2.9 to 296 ppb) was detected above ATSDR's drinking water CVs (AFBCA 1993). (Samples were analyzed for TCE on about 100 occasions between December 1977 and December 1983. TCE was detected above CVs in all but a few of the sampling events. The majority of the detections were above 40 ppb, with concentrations reaching a high of 296 ppb in December 1978 [AFBCA 1993]). Although TCE was detected above ATSDR's drinking water CVs, the concentrations were not expected to pose past health hazards because the population serviced by the well was not likely to be	Fetal Heart Defect (Pregnant Women)	1.2E-04 (Elevated)	TCE (296 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effect(s)	Total Cancer Risk	Comments
	exposed to large quantities of water over a long duration.			
AF16: This well serviced the small arms firing range. The well has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it to be used again in the future (AFBCA 1999b).	Tap water samples were collected from the firing range and analyzed for volatiles in 1989 (Air Force 1990). None of the detected constituents exceeded ATSDR's drinking water CVs. In addition, samples were collected and analyzed for lead in April 1998, after the well had stopped being used as a potable water source. Neither total nor dissolved lead was detected (AFCEE 1999). Although some of the groundwater in the vicinity of the firing range has been impacted by contaminants (see Appendix B-Site 55), there is no evidence that the contaminants migrated crossgradient to impact AF16.	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. Therefore, no harmful health effects expected.
AF25: This well services Building 5098. It is the only on-base supply well that is still being used. In the past, water supplied by this well was used for potable purposes. Today, it is used only for nonpotable purposes (AFBCA 1999c).	Samples were collected from AF25 and analyzed for TCE in December 1977. Contaminant concentrations ranged from nondetect to 3.1 ppb. This concentration is below ATSDR's drinking water CV (AFBCA 1993). No contaminants were detected at concentrations that exceeded ATSDR's drinking water CVs. Thus, contaminant concentrations were too low to pose past health hazards. (Note: This well is still in use. See the main body of the text for a discussion on current and future exposures.)	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. Therefore, no harmful health effects expected.
Unlabeled well: One on-base well was used to service the Defense	Well data were not available, but tap water samples were collected	N/A	N/A	Neither TCE nor benzene was detected above comparison

Sample Location	Contamination History and Previous Public Health Conclusion	Harmful Non-Cancer Health Effect(s)	Total Cancer Risk	Comments
Reutilization Management Office (DRMO). The well has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it to be used again in the future (AFBCA 1999b).	from the DRMO in 1989 (Air Force 1990). Chloroform (nondetect to 75 ppb) and methylene chloride (nondetect to 13 ppb) were the only contaminants detected above ATSDR's drinking water CVs. Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were not expected to pose past health hazards because the population serviced by the well was not likely to be exposed to large quantities of water over a long duration.			values in this well. Therefore, no harmful health effects expected.
Unlabeled well: One on-base well was used to service the dog kennels. The well has been officially abandoned (i.e., grouted and closed), thereby removing any potential for it to be used again in the future (AFBCA 1999b).	Well data were not available, but tap water samples were collected from the dog kennels between 1977 and 1989 (AFBCA 1993; Air Force 1990). Chloroform (nondetect to 49 ppb) and methylene chloride (nondetect to 15 ppb) were the only contaminants detected above ATSDR's drinking water CVs. Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were not expected to pose past health hazards because the population serviced by the well was not likely to be exposed to large quantities of water over a long duration.	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. Therefore, no harmful health effects expected.

Table 23D. Updated Public Health Conclusions: TCE and Benzene

For ADULTS Exposed to Water from Off-base Residential Wells

While Living in Off-base Residences for 33 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

LAST TWO DIGITS OF RESIDENTIAL ADDRESSES ARE NOT SHOWN FOR PRIVACY REASONS

PLEASE CONTACT AN ATSDR REPRESENTATIVE FOR INFORMATION ON A SPECIFIC WELL

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
58** West Shore Drive	No VOCs were detected during MDEQ's January 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
58** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
58** West Shore Drive	Methylene chloride (1 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. The contaminant was not detected during a subsequent MDEQ sampling event that was conducted in August 1990 (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected. Methylene chloride is a common laboratory contaminant. The detected concentration of methylene chloride is too low to cause harmful health effects.
58** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
59** West Shore Drive	No VOCs were detected during MDEQ's January 1987 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's April 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	Methylene chloride (1.7 ppb) was detected during MDEQ's January 1991 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. Therefore, no harmful health effects expected.
59** West Shore Drive	TCE (19 to 25 ppb) was detected at concentrations that exceeded ATSDR's drinking water CVs during MDEQ's May 1990 and August 1990 sampling events (MDEQ 1999c). Although TCE was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards	Fetal Heart Defect (Pregnant Women)	3.1E-05 (Low)	TCE (25 ppb) Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
59** West Shore Drive	1,1,1-Trichloroethane (0.6 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. The contaminant was not detected during a subsequent MDEQ sampling event that took place in August 1990 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	The well at this property was constructed in 1989 (Oscoda Press, 1990a). TCE (3.0 to 3.4 ppb) was detected during MDEQ's May 1990 and August 1990 sampling events, but at concentrations below ATSDR's drinking water CVs (MDEQ, 1999c). The homeowners stopped using the well as a drinking water source in September 1990 but continued to use it for bathing until they received a municipal hookup (Oscoda Press, 1990a, 1990b). (Municipal hookups were	No harmful health effects expected	4.2E-06 (Low)	TCE (3.4 ppb) No harmful non-cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	established throughout the area in 1992 or 1993 [AFBCA 1999c].) Contaminant concentrations were too low to pose health hazards.			
60** West Shore Drive	No VOCs were detected during MDEQ's September 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	TCE (0.1 ppb) and PCE (0.2 ppb) were detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CVs. These contaminants were not detected during a subsequent MDEQ sampling event that was conducted in September 1989 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's September 1989 sampling event (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
60** West Shore Drive	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	Methyl tert-butyl ether (MTBE) (1 ppb) was detected during MDEQ's May 1991 sampling event, but at concentrations below ATSDR's drinking water CV. Acetone was also detected during this sampling event, but site records did not indicate the exact concentration. Neither MTBE or acetone were detected during previous MDEQ sampling events (i.e., August 1987 and September 1989) or subsequent MDEQ sampling events (i.e., October 1991) (MDEQ 1999c). MTBE concentrations were too low to pose health hazards. Although the concentration for acetone was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was only detected once during four sampling events, it is unlikely that the contaminant was present consistently in the private well. Also, it is possible that the detection was an error (Acetone is a common laboratory contaminant.)	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
63** West Shore Drive	No contaminants were detected during sampling events conducted in 1979, November 1983, August 1989, or May 1990 (AFBCA 1993; MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	1,4-Dichlorobenzene (0.7 ppb) was detected during MDEQ's May 1990 sampling event, but below ATSDR's drinking water CV. This contaminant was not detected during previous or subsequent MDEQ sampling events (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c) There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
63** West Shore Drive	Samples were analyzed for TCE, benzene, and 1,2-dichloroethene between 1979 and 1983, but no contaminants were detected (AFBCA 1993). Benzene (3 ppb) was detected above ATSDR's drinking water CV during MDEQ's December 1986 sampling event (MDEQ 1999c). The contaminant was not detected subsequently during MDEQ's January 1987 or May 1990 sampling events (MDEQ 1999c; AFBCA 1993). Although benzene was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.	No harmful health effects expected	4.5E-06 (Low)	Benzene (3 ppb) No harmful non-cancer or cancer health effects expected from exposure to benzene.
64** West Shore Drive	No TCE was detected during an April 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No VOCs were detected during MDEQ's October 1983 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No TCE was detected during an April 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
64** West Shore Drive	No TCE was detected during a January 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	Methylene chloride (3.0 ppb) was detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
64** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No contaminants were detected during sampling events that were conducted between 1979 and 1987 or during MDEQ's January 1987, August 1989, May 1990, or May 1991 sampling events (AFBCA 1993; MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
65** West Shore Drive	This well was used as a drinking water source until the late 1970s. In May 1979, the homeowner	Immunological effects	1.6E-03 (Elevated)	TCE (1,281 ppb)

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	collected a water sample and had it analyzed for TCE. The contaminant was detected at 760 ppb (AFCEE 1996e). Several more samples were collected in May and June 1979, revealing that TCE concentrations ranged from 500 to 837 ppb (AFCEE 1996e; AFBCA, 1993). USAF started supplying bottled water to the residence upon discovery of the contamination (AFCEE 1996e). The well continued to be used for nonpotable purposes and the Air Force installed a treatment system to reduce the amount of TCE that the residents were exposed to while the well was still used for nonpotable purposes (AFBCA 1999c). In addition, sampling continued during the period of nonpotable usage. Results indicated that TCE (nondetect to 1,281 ppb) was still present above its CV. (Air Force 1990; AFBCA 1993; MDEQ 1999c). The residence received a municipal hookup in 1992 or 1993 (AFBCA 1999c). ATSDR concluded that TCE might have been present at high concentrations for an extended period of time. Thus, ATSDR concluded that past exposures to this well might have posed potential health hazards. It should be noted, however, that it is unclear how long people were actually exposed to high TCE concentrations. Also, there is much controversy in the scientific	Fetal Heart Defect (Pregnant Women)		Increased risk for harmful non-cancer and cancer health effects adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	community regarding TCE's ability to pose adverse health effects in humans. (TCE has been shown to cause cancer in laboratory animals who receive large doses, but EPA is currently reviewing the scientific literature to determine TCE's cancer classification [USEPA 2000b].)			
65** West Shore Drive	Acetone (1 ppb) and toluene (0.9 ppb) were detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CVs. These contaminants were not detected during previous or subsequent MDEQ sampling events (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
65** West Shore Drive	No VOCs were detected during MDEQ's July 1985, August 1989, or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
65** West Shore Drive	Chloroform (33 ppb) was detected above ATSDR's drinking water CV during MDEQ's September 1988 sampling event (MDEQ 1999b). Total trihalomethanes (33 ppb) were also detected, but this concentration does not exceed EPA's recommended guidelines. No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c).	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Although chloroform was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.			
65** West Shore Drive	Chloroform (1 ppb) was detected during MDEQ's July 1985 sampling event, but below ATSDR's drinking water CV. This contaminant was not detected during a subsequent MDEQ sampling event that was conducted in May 1990 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
57** F-41 County Road	TCE (1 to 4 ppb) was detected during MDEQ's November 1983 and January 1984 sampling event, but at concentrations that were below ATSDR's drinking water CVs (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	No harmful health effects expected	4.9E-06 (Low)	TCE (4 ppb) No harmful non-cancer or cancer health effects expected.
60** F-41 County Road	TCE (45 ppb) was detected above ATSDR's drinking water CVs during a sampling event that was conducted in 1989 (Air Force 1990). Although TCE was detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Immunological effects Fetal Heart Defect (Pregnant Women)	5.6E-05 (Low)	TCE (45 ppb) Increased risk for harmful non-cancer health effects for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
60** F-41 County Road	Methylene chloride (98 ppb) was detected above ATSDR's drinking water CV during a sampling event that was conducted in 1989 (Air Force 1990).	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Although methylene chloride was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.			
60** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No VOCs were detected during MDEQ's September 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No VOCs were detected during MDEQ's August 1989 or September 1991 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No contaminants were detected during a May 1979 sampling event or MDEQ's August 1989, September 1990, or September 1991 sampling events (AFBCA 1993; MDEQ 1999c). Samples were also collected in late 2000 and analyzed for a wide variety of VOCs. No contaminants were detected (Montgomery Watson 2000). There is no evidence suggesting that the well was ever contaminated. Thus, it is	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	improbable that past exposures led to public health hazards. (Note: ATSDR believes that this well could still be in use. See the main body of the text for a discussion on current and potential future exposures.)			
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	Dichlorodifluoromethane (4.4 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. A freon-type compound was also detected during this sampling event, but its concentration was not listed (MDEQ 1999c). No contaminants were detected during a subsequent MDEQ sampling event that was conducted in August 1990 (MDEQ 1999c).	N/A	N/A	No contaminants detected in this well above applicable comparison values. Therefore, no harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Dichlorodifluoromethane concentrations were too low to pose health hazards. Although the concentration for the freon-type compound was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was not detected during a subsequent sampling event, it does not appear that the contaminant was present consistently in the private well.			
61** F-41 County Road	MDEQ collected samples in August 1989, September 1989 and November 1989. Trans-1,2-dichloroethene (0.4 to 2.0 ppb), cis-1,2-dichloroethene (1.0 to 2.0 ppb), and MTBE (3 ppb) were detected, but at concentrations below ATSDR's drinking water CVs (MDEQ 1999c). Total trihalomethanes (0.4 ppb) were also detected, but below EPA's recommended guidelines. Available data indicate that contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No volatile aromatics or halocarbons were detected during a sampling event that took place in September 1986 (AFBCA 1993). 1,1-Dichloroethene (0.6 ppb) and TCE (13 ppb) were detected	No harmful health effects expected	1.6E-05 (Low)	TCE (13 ppb) No harmful non-cancer or cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	above ATSDR's drinking water CVs in May 1989 (Air Force 1990). No VOCs were detected during MDEQ's November 1983, August 1989, or May 1990 sampling events (MDEQ 1999c). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.			
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	1,1,1-Trichloroethane (0.1 ppb) was detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
61** F-41 County Road	No TCE was detected during a January 1979 sampling event (AFBCA 1993), but TCE (13 to 15 ppb), 1,1-dichloroethene (0.5 ppb), and 1,1,1,-trichloroethane (37 to 43 ppb) were detected in 1989 (Air Force 1990; MDEQ 1999c). The TCE and 1,1-dichloroethene concentrations exceeded ATSDR's drinking water CVs. Although contaminant concentrations were detected above ATSDR's drinking water	No harmful health effects expected	1.9E-05 (Low)	TCE (15 ppb) No harmful non-cancer or cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	CVs, the concentrations were too low to pose health hazards.			
66** F-41 County Road	Acetone was detected during MDEQ's May 1991 sampling event, but site records did not indicate the exact concentration. This contaminant was not detected in a subsequent sampling event that MDEQ conducted in October 1991 (MDEQ 1999c). Although the concentration for acetone was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was only detected once, it is unlikely that the contaminant was present consistently in the private well. Also, it is possible that the detection was an error (Acetone is a common laboratory contaminant.)	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
67** F-41 County Road	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.

Table 24D. Updated Public Health Conclusions: TCE and Benzene

For CHILDREN Exposed to Water from Off-base Residential Wells

While Living in Off-base Residences for 33 Years

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

LAST TWO DIGITS OF RESIDENTIAL ADDRESSES ARE NOT SHOWN FOR PRIVACY REASONS

PLEASE CONTACT AN ATSDR REPRESENTATIVE FOR INFORMATION ON A SPECIFIC WELL

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
58** West Shore Drive	No VOCs were detected during MDEQ's January 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
58** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
58** West Shore Drive	Methylene chloride (1 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. The contaminant was not detected during a subsequent MDEQ sampling event that was conducted in August 1990 (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected. Methylene chloride is a common laboratory contaminant. The detected concentration of methylene chloride is too low to cause harmful health effects.
58** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
59** West Shore Drive	No VOCs were detected during MDEQ's January 1987 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's April 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	Methylene chloride (1.7 ppb) was detected during MDEQ's January 1991 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. Therefore, no harmful health effects expected.
59** West Shore Drive	TCE (19 to 25 ppb) was detected at concentrations that exceeded ATSDR's drinking water CVs during MDEQ's May 1990 and August 1990 sampling events (MDEQ 1999c). Although TCE was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards	Immunological effects	5.0E-05 (Low)	TCE (25 ppb) Increased risk for harmful non-cancer health effects for children.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
59** West Shore Drive	1,1,1-Trichloroethane (0.6 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. The contaminant was not detected during a subsequent MDEQ sampling event that took place in August 1990 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
59** West Shore Drive	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	The well at this property was constructed in 1989 (Oscoda Press, 1990a). TCE (3.0 to 3.4 ppb) was detected during MDEQ's May 1990 and August 1990 sampling events, but at concentrations below ATSDR's drinking water CVs (MDEQ, 1999c). The homeowners stopped using the well as a drinking water source in September 1990 but continued to use it for bathing until they received a municipal hookup (Oscoda Press, 1990a, 1990b). (Municipal hookups were	No harmful health effects expected	6.9E-06 (Low)	TCE (3.4 ppb) No harmful non-cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	established throughout the area in 1992 or 1993 [AFBCA 1999c].) Contaminant concentrations were too low to pose health hazards.			
60** West Shore Drive	No VOCs were detected during MDEQ's September 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	TCE (0.1 ppb) and PCE (0.2 ppb) were detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CVs. These contaminants were not detected during a subsequent MDEQ sampling event that was conducted in September 1989 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	No VOCs were detected during MDEQ's September 1989 sampling event (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
60** West Shore Drive	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
60** West Shore Drive	Methyl tert-butyl ether (MTBE) (1 ppb) was detected during MDEQ's May 1991 sampling event, but at concentrations below ATSDR's drinking water CV. Acetone was also detected during this sampling event, but site records did not indicate the exact concentration. Neither MTBE or acetone were detected during previous MDEQ sampling events (i.e., August 1987 and September 1989) or subsequent MDEQ sampling events (i.e., October 1991) (MDEQ 1999c). MTBE concentrations were too low to pose health hazards. Although the concentration for acetone was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was only detected once during four sampling events, it is unlikely that the contaminant was present consistently in the private well. Also, it is possible that the detection was an error (Acetone is a common laboratory contaminant.)	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
63** West Shore Drive	No contaminants were detected during sampling events conducted in 1979, November 1983, August 1989, or May 1990 (AFBCA 1993; MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	1,4-Dichlorobenzene (0.7 ppb) was detected during MDEQ's May 1990 sampling event, but below ATSDR's drinking water CV. This contaminant was not detected during previous or subsequent MDEQ sampling events (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c) There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.
63** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
63** West Shore Drive	Samples were analyzed for TCE, benzene, and 1,2-dichloroethene between 1979 and 1983, but no contaminants were detected (AFBCA 1993). Benzene (3 ppb) was detected above ATSDR's drinking water CV during MDEQ's December 1986 sampling event (MDEQ 1999c). The contaminant was not detected subsequently during MDEQ's January 1987 or May 1990 sampling events (MDEQ 1999c; AFBCA 1993). Although benzene was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.	No harmful health effects expected	4.3E-06 (Low)	Benzene (3 ppb) No harmful non-cancer or cancer health effects expected from exposure to benzene.
64** West Shore Drive	No TCE was detected during an April 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No VOCs were detected during MDEQ's October 1983 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No TCE was detected during an April 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c).	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	There is no evidence suggesting that the well was ever contaminated.			
64** West Shore Drive	No TCE was detected during a January 1979 sampling event (AFBCA 1993). In addition, no VOCs were detected during MDEQ's August 1989 or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	Methylene chloride (3.0 ppb) was detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
64** West Shore Drive	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
64** West Shore Drive	No contaminants were detected during sampling events that were conducted between 1979 and 1987 or during MDEQ's January 1987, August 1989, May 1990, or May 1991 sampling events (AFBCA 1993; MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
65** West Shore Drive	This well was used as a drinking water source until the late 1970s. In May 1979, the homeowner	Immunological effects	2.6E-03 (Elevated)	TCE (1,281 ppb)

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	collected a water sample and had it analyzed for TCE. The contaminant was detected at 760 ppb (AFCEE 1996e). Several more samples were collected in May and June 1979, revealing that TCE concentrations ranged from 500 to 837 ppb (AFCEE 1996e; AFBCA, 1993). USAF started supplying bottled water to the residence upon discovery of the contamination (AFCEE 1996e). The well continued to be used for nonpotable purposes and the Air Force installed a treatment system to reduce the amount of TCE that the residents were exposed to while the well was still used for nonpotable purposes (AFBCA 1999c). In addition, sampling continued during the period of nonpotable usage. Results indicated that TCE (nondetect to 1,281 ppb) was still present above its CV. (Air Force 1990; AFBCA 1993; MDEQ 1999c). The residence received a municipal hookup in 1992 or 1993 (AFBCA 1999c). ATSDR concluded that TCE might have been present at high concentrations for an extended period of time. Thus, ATSDR concluded that past exposures to this well might have posed potential health hazards. It should be noted, however, that it is unclear how long people were actually exposed to high TCE concentrations. Also, there is much controversy in the scientific			Increased risk for harmful non-cancer and cancer health effects for children.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	community regarding TCE's ability to pose adverse health effects in humans. (TCE has been shown to cause cancer in laboratory animals who receive large doses, but EPA is currently reviewing the scientific literature to determine TCE's cancer classification [USEPA 2000b].)			
65** West Shore Drive	Acetone (1 ppb) and toluene (0.9 ppb) were detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CVs. These contaminants were not detected during previous or subsequent MDEQ sampling events (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
65** West Shore Drive	No VOCs were detected during MDEQ's July 1985, August 1989, or May 1990 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
65** West Shore Drive	Chloroform (33 ppb) was detected above ATSDR's drinking water CV during MDEQ's September 1988 sampling event (MDEQ 1999b). Total trihalomethanes (33 ppb) were also detected, but this concentration does not exceed EPA's recommended guidelines. No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c).	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well. The detected chemicals are common drinking water disinfection byproducts. Although not specifically evaluated in this document, the concentration of these chemicals is too low to cause harmful health effects.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Although chloroform was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.			
65** West Shore Drive	Chloroform (1 ppb) was detected during MDEQ's July 1985 sampling event, but below ATSDR's drinking water CV. This contaminant was not detected during a subsequent MDEQ sampling event that was conducted in May 1990 (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
57** F-41 County Road	TCE (1 to 4 ppb) was detected during MDEQ's November 1983 and January 1984 sampling event, but at concentrations that were below ATSDR's drinking water CVs (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	No harmful health effects expected	8.1E-06 (Low)	TCE (4 ppb) No harmful non-cancer or cancer health effects expected.
60** F-41 County Road	TCE (45 ppb) was detected above ATSDR's drinking water CVs during a sampling event that was conducted in 1989 (Air Force 1990). Although TCE was detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.	Immunological effects	9.1E-05 (Low)	TCE (45 ppb) Increased risk for harmful non-cancer health effects for children.
60** F-41 County Road	Methylene chloride (98 ppb) was detected above ATSDR's drinking water CV during a sampling event that was conducted in 1989 (Air Force 1990).	N/A	N/A	Neither TCE nor benzene was detected above comparison values in this well.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Although methylene chloride was detected above ATSDR's drinking water CV, the concentrations were too low to pose health hazards.			
60** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No VOCs were detected during MDEQ's September 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No VOCs were detected during MDEQ's August 1989 or September 1991 sampling events (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
60** F-41 County Road	No contaminants were detected during a May 1979 sampling event or MDEQ's August 1989, September 1990, or September 1991 sampling events (AFBCA 1993; MDEQ 1999c). Samples were also collected in late 2000 and analyzed for a wide variety of VOCs. No contaminants were detected (Montgomery Watson 2000). There is no evidence suggesting that the well was ever contaminated. Thus, it is	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	improbable that past exposures led to public health hazards. (Note: ATSDR believes that this well could still be in use. See the main body of the text for a discussion on current and potential future exposures.)			
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's May 1990 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	Dichlorodifluoromethane (4.4 ppb) was detected during MDEQ's May 1990 sampling event, but at concentrations below ATSDR's drinking water CV. A freon-type compound was also detected during this sampling event, but its concentration was not listed (MDEQ 1999c). No contaminants were detected during a subsequent MDEQ sampling event that was conducted in August 1990 (MDEQ 1999c).	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Dichlorodifluoromethane concentrations were too low to pose health hazards. Although the concentration for the freon-type compound was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was not detected during a subsequent sampling event, it does not appear that the contaminant was present consistently in the private well.			
61** F-41 County Road	MDEQ collected samples in August 1989, September 1989 and November 1989. Trans-1,2-dichloroethene (0.4 to 2.0 ppb), cis-1,2-dichloroethene (1.0 to 2.0 ppb), and MTBE (3 ppb) were detected, but at concentrations below ATSDR's drinking water CVs (MDEQ 1999c). Total trihalomethanes (0.4 ppb) were also detected, but below EPA's recommended guidelines. Available data indicate that contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	No volatile aromatics or halocarbons were detected during a sampling event that took place in September 1986 (AFBCA 1993). 1,1-Dichloroethene (0.6 ppb) and TCE (13 ppb) were detected	No harmful health effects expected	2.6E-05 (Low)	TCE (13 ppb) No harmful non-cancer or cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	above ATSDR's drinking water CVs in May 1989 (Air Force 1990). No VOCs were detected during MDEQ's November 1983, August 1989, or May 1990 sampling events (MDEQ 1999c). Although contaminant concentrations were detected above ATSDR's drinking water CVs, the concentrations were too low to pose health hazards.			
61** F-41 County Road	No VOCs were detected during MDEQ's August 1989 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.
61** F-41 County Road	1,1,1-Trichloroethane (0.1 ppb) was detected during MDEQ's August 1989 sampling event, but at concentrations below ATSDR's drinking water CV (MDEQ 1999c). Contaminant concentrations were too low to pose health hazards.	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
61** F-41 County Road	No TCE was detected during a January 1979 sampling event (AFBCA 1993), but TCE (13 to 15 ppb), 1,1-dichloroethene (0.5 ppb), and 1,1,1,-trichloroethane (37 to 43 ppb) were detected in 1989 (Air Force 1990; MDEQ 1999c). The TCE and 1,1-dichloroethene concentrations exceeded ATSDR's drinking water CVs. Although contaminant concentrations were detected above ATSDR's drinking water	No harmful health effects expected	3.0E-05 (Low)	TCE (15 ppb) No harmful non-cancer or cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	CVs, the concentrations were too low to pose health hazards.			
66** F-41 County Road	Acetone was detected during MDEQ's May 1991 sampling event, but site records did not indicate the exact concentration. This contaminant was not detected in a subsequent sampling event that MDEQ conducted in October 1991 (MDEQ 1999c). Although the concentration for acetone was not listed in the laboratory report, it is unlikely that this contaminant posed a health hazard. Because it was only detected once, it is unlikely that the contaminant was present consistently in the private well. Also, it is possible that the detection was an error (Acetone is a common laboratory contaminant.)	N/A	N/A	No contaminants were detected in this well above applicable comparison values. Therefore, no harmful health effects expected.
67** F-41 County Road	No VOCs were detected during MDEQ's May 1991 sampling event (MDEQ 1999c). There is no evidence suggesting that the well was ever contaminated.	N/A	N/A	No VOC contaminants were detected in this well. No harmful health effects expected.

Table 25D. Updated Public Health Conclusions: TCE and Benzene

For ADULTS and CHILDREN Exposed to Water from Off-base Residential Wells

While Visiting for 4 Weeks[a]

Assumed Well Water Exposure Routes: Ingestion, Inhalation, Dermal

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
Knights of Columbus Lodge	This well was used as a drinking water source until 1986 when the lodge received a municipal water hookup (Oscoda Press 1990c). More than 100 water samples were collected between 1980 and 1986 (AFBCA 1993). TCE (nondetect to 36 ppb) was the only contaminant that exceeded ATSDR's drinking water CV. It only exceeded ATSDR's screening values on four occasions (AFBCA 1993). Although TCE was detected above ATSDR's drinking water CV, concentrations were not high enough to pose health hazards.	Immunological effects Fetal Heart Defects (Pregnant Women)	N/A: Cancer risk not determined for these short-term exposures.	TCE (36 ppb) Increased risk for harmful non-cancer health effect for adults. Increased risk for a heart birth defect for babies if the mother was exposed to TCE during the first trimester of pregnancy.
Van Etten State Park (Wells CG#1 and CG#2)	Two wells (referred to as CG#1 and CG#2) are located at Van Etten State Park. Up until 1999, both of these wells were used to provide potable water to people who visited the park's 40 rustic campsites (MDEQ 1999a). Samples were collected from the wells in May 1991. MTBE (1 ppb), chloroform (1.1 ppb), and total trihalomethanes (1.1 ppb) were detected, but at concentrations below ATSDR's drinking water CVs and EPA's recommended guidelines. Acetone was also detected, but its concentration was not recorded in site documents (MDEQ 1999c). The	No harmful health effects expected	N/A: Cancer risk not determined for these short-term exposures.	TCE (3.4 ppb) No harmful non-cancer health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	wells were resampled in 1999 and analyzed for several volatiles. TCE (2.4 to 3.4 ppb) was detected in CG#2, but no VOCs were detected in CG#1 (MDEQ 1999a; District 1999e, 2000a, 2000b). CG#2 was removed from service immediately upon discovery of the contamination even though detections were below ATSDR's drinking water CVs (MDEQ 1999a). Contaminant concentrations were too low to pose past health hazards. (Note: Well CG#1 is still being used and well CG#2 could be brought back on line in the future.)			
Camp Nissokone (6836 F-41 County Road)	The Camp Nissokone property has been used as a YMCA summer camp since 1914 (ATSDR 1998a). About 700 campers attend the camp each summer. Staff members live on the property for about nine weeks of the summer. Also, a caretaker and his family live on the property year-round. In the past, three private wells were located upon the property. One of the wells, which was fairly large, supplied the majority of the camp's water. The other two wells serviced single structures. One supplied Staff Cabin #5 and the other supplied a maintenance shop. Neither of these two wells was ever used for potable purposes (Camp Nissokone 2000b).	No harmful health effects expected	N/A: Cancer risk not determined for these short-term exposures.	No VOC contaminants were detected in this well. No harmful health effects expected.

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	Site documents indicate that the Northern Landfill Plume had migrated to Camp Nissokone by 1981. To determine whether the plume had impacted the camp's water supply, tap water samples were collected from the camp's dining hall and kitchen and a house that is located at the camp. These data, which were collected in 1979, 1982, and 1984, indicated that no contaminants were present (AFBCA 1993). Well samples were collected in June 1987, September 1988, August 1990, and May 1991. No contaminants were detected (MDEQ 1999c). In October 1993, the camp was hooked up to municipal water supplies and the large well was removed from service (ATSDR 1998a). From this point on, children that visited the camp were not exposed to water that was supplied by wells. At some point in the 1990s, the large well that had supplied most of the water to the camp was officially sealed and abandoned so that it could not be brought back into service. However, the well that supplied Staff Cabin #5 remained operational until it was officially abandoned during the summer of 2000 (Camp Nissokone 2000a, 2000b). Exposure to the water that was supplied by the Staff Cabin #5 well was infrequent. As noted above, this well was never used for potable purposes. Staff			

Well Location	Contamination History & Past Public Health Conclusion	Harmful Non-Cancer Health Effects	Total Cancer Risk	Comments
	members may have used the water provided to Staff Cabin #5 for bathing, but only on a very infrequent basis. The well that supplies the maintenance shop is still operational, but it will be abandoned in summer 2001 (Camp Nissokone 2001). Exposure to the water supplied by this well is also infrequent. The water supplied to the maintenance shop is only used to service a toilet and a sink. According to a Camp Nissokone representative, very few people use the maintenance shop, and those who do are aware of the groundwater problems that exist in the area (Camp Nissokone 2000b). There is no evidence that the wells that supplied the camp were ever contaminated. (Children used water that was supplied by the camp's wells prior to 1993. No contaminants were detected during sampling events that took place in the late 1970s, 1980s, and early 1990s. Throughout the 1990s, some adults continued to use water [for nonpotable purposes] that was supplied to the Staff #5 cabin and the maintenance shop. The wells were not located in areas that were impacted by the Northern Landfill Plume [Camp Nissokone 2000a].)			

Notes:

[a] As discussed in the Contamination History & Past Public Health Conclusion section, the exposure duration used for the Camp Nissokone calculations is 9 weeks.

APPENDIX E:

RESPONSE TO PUBLIC COMMENT

Response to Public Comment

ATSDR received the following comments during the public comment period (July 27 to September 30, 2018) for the Former Wurtsmith Air Force Base Re-evaluation of Past Exposures to VOC Contaminants in Drinking Water Health Consultation (HC) (July 27, 2018). For comments that questioned the validity of statements made in the HC, ATSDR verified or corrected the statements. Several of the comments received by ATSDR quoted portions of text from the HC. Notes have been added in brackets referencing the portions of the quoted HC text in order to distinguish it from the commenters' questions or comments, which are presented in **bold type**. The public comments are grouped based on the HC sections.

Summary

No.	*Public Comment*	*ATSDR's Response*
1	Summary – Conclusion 1, Basis for Conclusion For clarity, recommend indicating the heart malformations related to TCE exposure are a developmental effect, as was done for the immunotoxicity effect. Make the clarification in the text. Page iii	The text has been revised as follows for clarity: Critical adverse non-cancer effects associated with TCE include developmental effects (heart malformations), adult immunological effects, and developmental immunotoxicity.
2	Summary – Conclusion 2, Basis for Conclusion For clarity, recommend explaining what level of risk represents an "elevated cancer risk". Appendix D appears to categorize risks below 10^{-4} as "low" and risk above 10^{-4} as "elevated". Revise the text for clarification. Page iv	For the Wurtsmith Air Force Base re-evaluation effort, a cancer risk at or exceeding 1 x 10^{-4} is considered to be an elevated level of concern for lifetime cancer risk. An estimated additional cancer risk of 1 x 10^{-4} means that a population of 10,000 people exposed for a lifetime (78 years) at a certain chemical dose may have one additional cancer case. Although a 1 x 10^{-4} (one-in-ten thousand) risk level may be viewed as an elevated cancer risk, it is important to understand the exposure assumptions that went into estimating this risk and to remember that we cannot determine an individual's cancer risk or predict actual cancer cases; the estimated cancer risk refers to the risk for a population of people with similar chemical exposure. The cancer risk estimate is a tool used to determine whether health impacts are possible and if public health recommendations are needed.
3	Summary and Recommendations – Line 10 in the summary on page v and line 7 in the recommendations on page 21 Delete the recommendation "ATSDR recommends continued investigative actions to define the nature and extent of contamination on and surrounding the WAFB." The draft Health Consultation report does not provide any supportive discussion for the need for this recommendation. ATSDR uses historical drinking water data to develop Basis for Conclusions not environmental data. Delete the recommendation. Page v and 21	Thank you for your comment. ATSDR stands by this recommendation because a variety of hazardous substances (e.g., fuels, solvents, pesticides, and firefighting foam) have been handled, stored, and disposed of at WAFB. The extent of the contamination has not been fully defined. Further, the VOC groundwater pump and treat systems installed in the late 1970s and early 1980s have changed how groundwater flows under WAFB. This change in groundwater flow direction could cause groundwater contamination to flow in a different direction than what was originally occurring.

Background – Site Description and History

No.	Public Comment	ATSDR's Response
4	Figure 1 Wurtsmith Air Force Base Site Map For clarity, better depict what the pink dashed line represents. Revise for clarity. Page 3	The legend has been revised to show that the dashed pink line represents the 1-mile buffer around the site boundary.
5	Figure 1 Wurtsmith Air Force Base Site Map Define what 'GRASP' is in the foot note. Add a footnote defining 'GRASP'. Page 3	GRASP is an acronym for ATSDR's Geospatial Research, Analysis, and Services Program. The map has been revised accordingly.

Background – ATSDR's 2001 Public Health Assessment

No.	Public Comment	ATSDR's Response
6	[ATSDR note: This comment quotes the 2001 Public Health Assessment conclusions summary bullets on page 4 and a portion of Table A on page 5 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] ATSDR's primary conclusions in 2001 were as follows: • *Past exposures to groundwater may have posed an increased risk* **(How much of an increase?)** *of developing adverse health effects* **(acute/chronic?)**. Several on-base and off-base water supply wells were used in the past to service residential areas, facility buildings, and recreational areas. Contaminants were detected in some of these wells and in samples collected from building faucets. Although TCE concentrations in on-base water supply wells and one off-base well were high enough to warrant concern, it is unknown whether the concentrations persisted at high enough levels for long enough durations to actually pose a public health hazard **(Uncertainty)** • *Current and potential future exposures to groundwater are not expected to pose a public health hazard*. The majority of on-base and off-base areas receive their drinking water supplies from the Huron Shores Regional Utility Authority, a source that is not located near WAFB, and which meets all federal and state safe drinking water standards. A few well are still in service, but exposure to the water that they provide is not expected to pose current or future health hazards because the wells do not contain high contaminant concentrations, they are only rarely used, and/or exposure durations are expected to be short. Institutional controls are in place to prevent new wells from being installed in contaminated areas in the future. • *ATSDR concluded that past, present, and future exposures to surface water and sediment are not expected to pose a public health hazard*. Contaminants from WAFB have been released to Van Etten Lake, the Au Sable River, Duell Lake, and a wetland area located in the southern portion of the base. Although these surface water bodies have been and continue to be used for recreational activities, contaminant concentrations are low and/or exposure is too infrequent to result in health hazards. **(Furthermore)** "Specifically, we **(ATSDR)** updated the toxicological information for TCE, which indicates health effects at lower doses and from shorter-term exposures than previously understood. Also, we updated our chronic Minimal Risk Level (MRL) for benzene in 2007."	The commenter's questions and comment about the increased acute or chronic adverse health effects are referring to the 2001 Public Health Assessment conclusions. The conclusions from the 2001 document are provided for reference purposes only. In this health consultation, we re-evaluated the data and past exposures to VOC contamination in the drinking water and provided updated conclusions that respond to the questions raised by the commenter.

Discussion – Environmental Contamination

No.	Public Comment	ATSDR's Response
7	[ATSDR note: This comment quotes the first paragraph under the "Environmental Contamination" heading on page 9 of the Health Consultation. The commenter's comments below are in **bold type**.] Environmental sampling data are critical inputs to the public health evaluation process. Environmental data indicate the levels of chemicals found in the environment. In this re-assessment, ATSDR used past drinking water data collected on or near the WAFB for our evaluation. **(Commenter: No determination of changes in levels of TCE in water.)** **Note by commenter: ATSDR did not collect additional new data or evaluate current use patterns/concentrations and exposures.**	Correct, there was no determination of changes in the levels of TCE in water for this health consultation. Also, ATSDR did not collect additional new data or evaluate current use patterns, concentrations and exposures. As mentioned on pages iii, 5, and 9, the previous drinking water results were used to re-evaluate potential health effects of TCE and benzene based on new science regarding these contaminants. No new sampling data was obtained for this health consultation.
8	[ATSDR note: This comment quotes the second paragraph under the "Environmental Contamination" heading on page 9 of the Health Consultation. The commenter's question below is in **bold type**.] If contaminant concentrations are above these environmental screening values (or CVs), ATSDR assigns exposure parameters (for example, duration and frequency; see below), and analyzes the toxicology of the contaminant and epidemiology studies for possible health effects. During this part of the evaluation process, ATSDR estimates site-specific exposure doses and compares them to health guideline values and calculates cancer risk estimates to further evaluate the potential for harmful health effects from exposures. **(Commenter Note: How are the cancer risks calculations made?)**	The cancer risk calculations for TCE are provided in Appendix B, page 36, along with example calculations on pages 37-39. The cancer risk calculations for benzene are provided on pages 17-18.

Discussion – Uncertainty and Data Limitations

No.	Public Comment	ATSDR's Response
9	[ATSDR note: This comment quotes the majority of the text under the "Uncertainty and Data Limitations" heading on pages 10 and 11 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] When limitations or uncertainty existed, ATSDR chose to be more conservative in an effort to be **"**protective of people's health.**"** Therefore, actual exposures may have been different from those described in this document. The major uncertainties and limitations are: • ATSDR selected the highest exposure point (maximum concentration) detected in each well to calculate exposure doses. This assumption is conservative because it assumes that people were exposed to the maximum detected concentration over the entire duration of exposure. **(Note: Unrealistic)** The actual exposure levels likely fluctuated over time, which means that the levels could have been higher or lower than the maximum detected concentration. • The contaminant dose a person receives depends on the concentration of chemical in the water at a given time. However, sometimes we have limited sampling data to evaluate the chemical concentrations in a well over time. This limitation makes it difficult to accurately estimate the contaminant levels people might have been exposed to in the past. The concentration of chemical in a well at any given time depends on the proximity to the source of the contamination, the migration of the groundwater plume, and many other environmental factors. Therefore, it is likely that the contamination levels in each well varied over time. We do not account for that variability in our estimates. **(Commenter note: The probability of residents utilizing this water at the maximum high doses, which were still relatively low, is unlikely and extremely conservative.)** The exact duration of exposure for each potentially exposed population is unknown. The contamination was first detected in 1977; however, the wells could have contaminated for many years before the initial discovery in 1977. The base opened in 1923, and served in various capacities[3] throughout its history. Some of the base operations are the potential source(s) of the contamination. Therefore, the timeframe in which the hazardous substances were released into the environment and reached wells is unknown.	The use of maximum concentrations is an intentionally health-protective approach used in an effort to be especially protective of people's health. We note this limitation in our discussion.
10	Have there been known health effects in the U.S. from TCE at non-industrial exposures levels? What about industrial and at again at what exposure levels? How long has TCE been used in the U.S. and have there any abroad known and verified issues?	A substantial amount of toxicological data have been collected on TCE, providing robust support for and confidence in our conclusions regarding the health effects associated with TCE exposures.

		To address some of your general questions about the TCE literature, ATSDR suggests the following resources: 1. ATSDR's Toxicological Profile for TCE (October 2014) reflects ATSDR's assessment of relevant, peer-reviewed, animal toxicological studies and epidemiological studies among people. In addition, the profile is peer-reviewed by a nongovernmental panel and then made available for public review and comment. Therefore, we stand by our conclusions regarding the toxicity of TCE. https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=173&tid=30 2. EPA's IRIS Toxicological Review for TCE (September 2011) provides scientific support and rationale for the hazard and dose-response assessment in IRIS pertaining to chronic exposure to TCE. https://www.epa.gov/iris/supporting-documents-trichloroethylene Questions regarding TCE uses and potential issues abroad are outside the scope of this document.

Health Effects Evaluation: Estimating Non-Cancer Health Effects

No.	Public Comment	ATSDR's Response
11	[ATSDR note: This comment quotes the first paragraph under the "Estimating Non-Cancer Health Effects" heading on page 12 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] ATSDR calculated exposure doses for the past completed drinking water pathway at this site. Often, ingestion exposure is the most significant source of exposure to hazardous substances in drinking water. However, in the case of VOC contamination, combined inhalation and dermal exposures can make a significant contribution **(Commenter: How much?)** to the total exposure dose. Studies have shown that exposures to VOCs from routes other than ingestion might be as large as the exposure from ingestion alone. Showering is considered a major **(Commenter: Again, based on what data?)** contributor to overall exposure because VOC evaporate quickly from hot water into the air, and showering is typically done in a small, enclosed space where VOC concentrations might build up. **(Q…..evidence of this elsewhere? Note rodent breathing differences stated by the commenter in this report, as well as the instability of this chemical in the air)** The inhalation dose due to volatization during a shower may equal to the ingestion dose and 50% to 90% of VOCs in water may volatize during showering, laundering, and other activities [Moya *et. al.* 1999; Giardino and Andelman 1996]. In addition to breathing in the VOC from the air, people can absorb the chemical through their skin. Therefore, ATSDR included inhalation and dermal contact doses, as well as the ingestion dose, to estimate total exposures to TCE and benzene. **Commenter Notes: There has been a decades long history of safe use of TCE, yet in 2011 there seems to have been a change in opinions by the EPA from the highly publicized TCE contamination of groundwater at Camp Lejeune, NC, and the parade of reported health effects improbably associated with drinking that water, provided EPA and ATSDR with the opportunity to elevate this common chemical with a long history of safe use to the level of a known human carcinogen.** **Yet in the late 1980s, EPA had withdrawn its cancer assessment and RfD for TCE because the evidence of serious adverse effects in humans was inconclusive. The chemical remained "under review" for the next two decades, during which time no convincing evidence of human carcinogenicity emerged.** **Some facts know about TCE:** **(1) TCE has been known to be a very weak mutagen in mice and rats;** **(2) the rodent cancer data were irrelevant to humans because the former involved a species-specific mechanism of action (peroxisome proliferation) which did not occur in humans; and;**	The significance of inhalation exposure to chemicals volatilizing from water while showering is well-documented in the scientific literature. We cited work from several well-known scientists in the area (Moya et al. 1999, and Giardino and Andelman 1996). Numerous researchers in this area have stated that inhalation exposure from volatilized chemicals can equal or even exceed the exposure that occurs from drinking contaminated water (Andelman 1990, ATSDR 2005, Jo *et al.* 1990a, Jo *et al.* 1990b). The half-life of TCE in air is 7 days (ATSDR 2014); therefore, TCE exposure from showering and being in the house afterwards is not affected by the instability implied by the commenter. For the Wurtsmith Air Force Base re-evaluation, the inhalation and dermal exposures accounted for 67% and 39% of the total exposures to children and adults, respectively. For EPA's comprehensive review of the TCE toxicity data, please refer to EPA's IRIS Toxicological Review of TCE (September 2011) at https://www.epa.gov/iris/supporting-documents-trichloroethylene.

	(3) the proximate carcinogen in rodents was generated only at very high doses of no relevance to the human condition. Metabolism of the relatively low doses that occur in humans does not yield a proximate carcinogen. **All of these facts were once used in part to determine the science behind any health effects by TCE.** **It should also be noted that the differences in breathing mechanisms" referenced in this report must take into account that rats are so-called "obligate nose-breathers" which means that they can only breathe through their noses. Thus, rats cannot reduce the dose of an irritating to nasal tissues by breathing through their mouths the way humans can.**	
12	[ATSDR note: This comment quotes the first paragraph under the "Estimating Non-Cancer Health Effects" heading on page 12 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] ATSDR calculated exposure doses for the past completed drinking water pathway at this site. Often, ingestion exposure is the most significant source of exposure to hazardous substances in drinking water. However, in the case of VOC contamination, combined inhalation and dermal exposures can make a significant contribution to the total exposure dose. Studies have shown that exposure to VOCs from routes other than ingestion might be as large as the exposure from ingestion alone **(Credible studies?)**. Showering is considered a major contributor to overall exposure because VOC evaporate quickly from hot water into the air, and showering is typically done in a small, enclosed space where VOC concentrations might build up **(Commenter's note: once again, please see my reference to rodent breathing and TCE instability in air)**. The inhalation dose due to volatization during a shower may equal **(Commenter note: assumption based on no science)** to the ingestion dose and 50% to 90% of VOCs in water may volatize during showering, laundering, and other activities [Moya et. al. 1999; Giardino and Andelman 1996]. In addition to breathing in the VOC from air, people can absorb the chemical through their skin. Therefore, ATSDR included inhalation and dermal contact doses, as well as the ingestion dose, to estimate total exposures to TCE and benzene.	The significance of inhalation exposure to chemicals volatilizing from water while showering is well-documented in the scientific literature. We cited work from several well-known scientists in the area (Moya et al. 1999, and Giardino and Andelman 1996). Numerous researchers in this area have stated that inhalation exposure from volatilized chemicals can equal or even exceed the exposure that occurs from drinking contaminated water (Andelman 1990, ATSDR 2005, Jo *et al.* 1990a, Jo *et al.* 1990b). The half-life of TCE in air is 7 days (ATSDR 2014); therefore, TCE exposure from showering and being in the house afterwards is not affected by the instability implied by the commenter.
13	[ATSDR note: This comment quotes the third paragraph under the "Estimating Non-Cancer Health Effects" heading on page 12 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] Tables 7C – 10C in Appendix C present the combined oral, inhalation and dermal exposure doses for children and adults, including pregnant women. (It should be noted that ATSDR did not estimate inhalation and dermal exposures from showering for children less than 1 year of age because these very young children are more likely to take baths than showers.) ATSDR paid special attention to the exposure doses for young children	ATSDR recognizes the well-accepted premise within the scientific community that developing fetuses, infants, and children can be more sensitive to exposures than are adults in communities faced with contamination of water, soil, air, or food. (See ATSDR's Public Health Assessment Guidance Manual at https://www.atsdr.cdc.gov/hac/phamanual/ch8.html#8.5.3). It is ATSDR's policy that children's health issues must be considered at *all* sites. ATSDR places emphasis on children as a potentially sensitive population, and believes that

	and pregnant women because the scientific data indicate that the developing heart and nervous system in fetuses and young children may be especially sensitive to the toxic effects of TCE [ATSDR 2014a]. **(Commenter note: What scientific data? There are reams of information and studies that indicate that children may or may not be more susceptible to environmental chemicals, based on varying metabolism and other factors.)** **Furthermore, larger body weights effectively dilute the final concentration of the toxicant at the cellular level; slower ventilation rates effectively reduce the frequency of exposure; and, longer-lived mammals tend to have more efficient immune systems and other defense mechanisms. (That's why they live longer.)"**	physiologically, children are not just small adults. Children are more vulnerable when exposed to environmental contaminants for the following reasons, among others: • Children undergo many different and rapid stages of growth and development before age five years. During these stages, organ systems, including the brain and lungs, can easily be disturbed by environmental contaminants. Additionally, children's bodies might not readily repair such damage, which might affect their health now and later in life. • Children's rates of breathing and breathing zone are different than adults. • Children's metabolic rates are higher relative to their size. • Children have a larger ratio of surface area to body mass. • Children drink more water per kilogram body weight than do adults.

Health Effects Evaluation: Estimating Non-Cancer Health Effects – Non-Cancer Health Effects – TCE

No.	Public Comment	ATSDR's Response
14	The Frank R. Lautenberg Chemical Safety for the 21st Century Act amends the Toxic Substances Control Act (TCSA) and was signed into law June 22, 2016. It created a mandatory requirement for EPA to evaluate existing chemicals which clear and enforceable deadlines, to do so in a transparent fashion, and to do so using risk-based chemical assessments rather than rely on simple epidemiological correlations. Exposure to TCE The US Agency for Toxic Substances and Disease Registry (ATSDR) of 2014 states that TCE is commonly found in outdoor air at levels far less than 1 part per million (ppm) but levels as high as about 0.02 ppm have sometimes been measured inside homes and in public places. In workplace air at facilities that use TCE for metal degreasing, it has been measured from 1 ppm up to 100 ppm but it is not chemically stable in air and is broken down quickly. TCE has also been found in drinking water samples in the United States, at levels far less than those found in air, typically less than 30 parts per billion (ppb). In contrast to air, TCE breaks down slowly in surface water (such as lakes and rivers) and is removed from these waters mostly through evaporation. TCE can also slowly enter groundwater from surface water. In these cases, TCE is expected to remain in groundwater for long periods of time because it is contained and cannot readily evaporate. TCE is also found in soil; it can move through soil to the groundwater or evaporate to air. Like its fate in groundwater, TCE breaks down only in soil and is removed mostly through evaporation. TCE in soil (and to some extent in groundwater) may evaporate and migrate into air spaces beneath buildings and possibly enter the indoor building air, a process termed *vapor intrusion*. TCE Health Effects TCE is quickly eliminated from the body by breathing, whether exposed occurs through breathing or oral ingestion, find both ATSDR (2014) and EPA (2011). What remains in the body is changed by the liver to other chemicals that are quickly eliminated in the urine. When the body absorbs more TCE than it can eliminate quickly, some of it is stored in body fat. However, once exposure ceases, TCE and its breakdown products are quickly eliminated as above. Like exposure to any chemical, toxicity of TCE depends on the level to which one is exposed and the length of time of exposure. Both ATSDR (2014) and EPA (2011) report that environmental monitoring data suggest TCE levels, which the public might encounter by direct contact through air, water, food, or soil, are generally much lower than the levels at which adverse health effects are elicited in experimental animal studies. However,	Thank you for your comment.

	some drinking water sources and working environments have been found to contain levels of TCE that may cause health problems in humans. TCE Safe Levels The federal and state governments develop regulations and recommendations to protect public health. Regulations and recommendations are often expressed as a safe or virtually safe level, that is, a level of a substance in air, water, soil, or food that is not expected to cause any adverse health effect, even in people who are sensitive to the chemical's effects. These safe levels are usually based on information from experiments with animals (usually rodents) at much higher levels of the chemicals than humans would typically encounter. The higher animal exposures are used to see what the adverse health effects could be. Sometimes these safe levels differ among federal and state organizations because they used different assumptions for human exposure, different animal studies, or employ methods that differ slightly. Other times these recommendations differ because new science develops that suggests different levels are toxic or safe. ATSDR (2014) and NLM (2018b) give examples of these differing recommendations for TCE among government organizations. Recommendations and regulations are also updated periodically as more information becomes available. Ongoing Controversy Over Trichloroethylene (TCE) The assessment of TCE toxicity has led to controversy because not all authorities or government agencies consider TCE to be a known human carcinogen. Rodents are not little people, and TCE has only been shown to definitively cause cancer in experimental animals (see for example, NLM, 2018b). In addition, EPA (2011) accepted a study showing developmental toxicity in the hearts of experimental animals at low doses based on a controversial study of TCE exposure in drinking water that is controversial (Johnson el al., 1998, 2003), in part because other studies in experimental animals showed no such effects, including one study specifically designated to replicate these findings (Fisher et al., 2001). Additional and ongoing attempts at replicating this controversial study have proved to be difficult since the concentration of TCE cannot be readily maintained in the drinking water, leading to additional questions regarding use of that lone study as the basis for EPA's safe level. To seek better answers, the Alliance for Risk Assessment (*ARA*) was petitioned by the Alliance for Site Closures, a small company in Indiana composed of retired state government scientists, to develop a collaboration of interested groups to review EPA's non-cancer toxicity assessment of TCE and to improve the understanding of current EPA	

	methods to develop risk assessment values. The resulting range of values included EPA's current safety standards for TCE, which were based in part on the controversial Johnson et al. (2003) study which was never successfully peer reviewed (i.e.no subsequent research studies came up with the same results). The Steering Committee of the *ARA*, composed almost exclusively of government officials, asked that the collaboration focus instead on building a range in EPA's risk values, based on EPA methods, but using TCE as an example. The collaboration team included scientists from a number of organizations, including the ATSDR and the nonprofit organization Toxicology Excellence for Risk Assessment (TERA). The team developed a method that was independently vetted by a team of risk assessment experts, including EPA scientists, and was published in a peer reviewed journal (Dourson et al., 2016). Johnson, P.; Goldberg, S.; Mays, M.; Dawson, B. 2003. Threshold of trichloroethylene contamination in maternal drinking waters affecting fetal heart development in the rat. Environ Health Perspectives, 111, 289-292. http://www.ncbi.nlm.nih.gov/pubmed/12611656 U.S. Agency for Toxic Substances and Disease Registry (ATSDR). 2014. Toxicological Profile for Trichloroethylene. October. Available at: https://www.atsdr.cdc.gov/toxprofiles/tp19.pdf. U.S. National Library of Medicine. 2018b. International Toxicity Estimates for Risk (*ITER*) database. Found at: https://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/~kZPiEp:1 Toxicology Excellence for Risk Assessment (*TERA*) of Cincinnati, Ohio, a 501c3 nonprofit organization created in 1995 with a mission to protect public health.	
15	[ATSDR note: This comment quotes the first paragraph under the "Non-Cancer Health Effects – TCE" heading on page 13 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] Non-Cancer Health Effects – TCE Harmful non-cancer effects associated with oral TCE exposure include decreased body weight, liver and kidney effects, and neurological, immunological, reproductive, and developmental effects. Previous epidemiological studies of women living in areas where the drinking water was contaminated with TCE, as well as other VOCs, have suggested an increased risk of several types of birth defects [ATSDR 2014a]. **(Note: At what levels and are there any identified effects.)** Studies in Arizona and New Jersey suggested an	Please refer to the Toxicological Profile for TCE, which can be found at https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=173&tid=30, under the following heading: Developmental Effects, Section 3.2.2.6. This section of the Toxicological Profile references numerous studies in which women are exposed to drinking water contaminated with TCE. The exposure levels and identified developmental effects vary per study.

	association between TCE contamination in public drinking water wells and cardiac defects, and the New Jersey study also found an increased risk of oral clefts and neural tube defects [Bove et. al., 1995, Goldberg et. al, 1990]. Studies of women exposed to TCE-contaminated drinking water have shown some evidence of increased risks of low or very low birth weight, term low birth weight, and small for gestational age. In laboratory animals, exposure to high levels of TCE has damaged the central nervous system, immune system, liver and kidneys, and adversely affected reproduction and development of offspring [ATSDR 2014a].	
16	[ATSDR note: This comment quotes the first several sentences in the first paragraph on page 14 of the Health Consultation under the "Non-Cancer Health Effects – TCE" heading. The commenter's question below is in **bold type**.] *Based on estimated doses, some babies born to mothers who were exposed to TCE during pregnancy may be at increased risk for heart defects* **(evidence?)**. (See Tables 11D – 14D in Appendix D.) One of the studies supporting the RfD is based on the critical effect of fetal heart malformations in rats.	Please refer to the Toxicological Profile for TCE, which can be found at https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=173&tid=30, under the following heading: Developmental Effects, Section 3.2.2.6. This section of the Toxicological Profile references numerous studies in which women are exposed to drinking water contaminated with TCE.

Health Effects Evaluation: Estimating Cancer Health Effects – Cancer Health Effects – TCE

No.	Public Comment	ATSDR's Response
17	How Natural Variations Became Environmental Crises: The Word Game The *final* draft of EPA s new CRAGs was not actually published until 2005, but, 5 years earlier (2000), dioxin (2, 3, 7, 8-tetradichlorodibenzodioxin) became the first chemical to which the new CRAGs were applied, resulting in that chemical s re-classification as a known human carcinogen. None of these 3 chemicals (dioxin, TCE and formaldehyde) is actually known to cause cancer in humans, because there is no epidemiological evidence of a cause-and-effect relationship. Nevertheless, ever since EPA redefined the word known to mean whatever the Agency wants it to mean, evidence of a cause-and-effect relationship has become unnecessary. During the run up to the esoteric re-definition of dioxin as a known human carcinogen, EPA was fond of stating that human cancer patients who had been exposed to dioxin had similar concentrations of dioxin in their tissues as did lab rats that developed cancer after chronic treatment with dioxin. However, what they *didn't acknowledge* was that their in-house definition of the word similar was *within* a factor of ten. Note: By that definition, 10 and 99 aspirin tablets would represent similar doses of acetylsalicylic acid. Except that 10 tablets would upset your stomach, while 99 would likely *kill* you. The general public does not know that, when EPA uses *non*-technical words like similar, and risk (as in carcinogenic risk), and known (as in the known human carcinogen, dioxin) and equivalent (as in human equivalent concentration), those terms have been redefined in house, *without* the public s knowledge, with esoteric meanings that bear little or no resemblance to those same words as they are defined in Websters Dictionary. If you think that such shenanigans are *not* tantamount to *lying* to the general public, then I have some swamp land in Florida I d like to sell you.	Thank you for your comment.
18	[ATSDR note: This comment quotes the first paragraph under the "Cancer Health Effects – TCE" heading on page 16 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] TCE exposures can cause cancer, with increased **(how high?)** susceptibility for early-life exposures. The occupational studies of relatively high TCE exposures have shown increased risks **(how high and what types of cancers?)** for several types of cancer. The most consistent evidence has been for kidney, liver, and esophageal cancers and non-Hodgkin's lymphoma [ATSDR 2014a]. Additional evidence from occupational studies	Various agencies have determined that TCE is a human carcinogen, including the International Agency for Research on Cancer (IARC), the National Toxicology Program at the National Institutes of Environmental Health Sciences (NTP), and EPA. Please refer to the Toxicological Profile for TCE, which can be found at https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=173&tid=30, under the following heading: Cancer, Section 3.2.1.7. In this section of the Toxicological Profile, the cancer classification for trichloroethylene by the IARC, NTP, and EPA are reviewed. Conclusions made in comprehensive reviews regarding associations between trichloroethylene exposure and specific cancer types also are summarized.

	points to possible relationships between TCE exposure and increased risk of Hodgkin's disease, cervical cancer, multiple myeloma, bladder cancer, female breast cancer, and prostate cancer [Krishnadasan et al., 2007; Sung et al., 2007; Siegel Scott and Chiu, 2006; Zhao et al., 2005; Hansen et al., 2001; Wartenberg et al., 2000; ATSDR 2014a]. Many of these studies have strong limitations including unknown exposure levels and small sample sizes. In addition, many of these studies were unable to adequately separate the effects of TCE from other solvents present in the workplace. **NOTE: How can anyone say TCE can cause cancer yet then switch to Occup Exposure studies that have "strong limitations."** **The Word Game: (1)** **Originally, EPA classified chemicals as known, probable or possible carcinogens. These classifications were strictly defined. In particular, a substance could be classified as a known Human Carcinogen *only* if sufficient epidemiological evidence existed to establish a cause-and-effect relationship between cancer and exposure to that substance. However, in 1996 (the date of the first draft), EPA rewrote its Cancer Risk Assessment Guidelines (CRAGs) to allow it to classify substances as known human carcinogens in the *absence* of any epidemiological evidence of a cause-and-effect relationship.** **The *final* draft of EPA s new CRAGs was not actually published until 2005, but, 5 years earlier (2000), dioxin (2, 3, 7, 8-tetradichlorodibenzodioxin) became the first chemical to which the new CRAGs were applied, resulting in that chemical s re-classification as a known human carcinogen.** **(1) How Natural Variations Became Environmental Crises: The Word Game** **From Effects, to Exposure, to Concern: I believe the TCE report based on much hypothetical risk and lack of credible, and sound science peer reviews leaves much to be desired.)** **"If one decides that even *lower* hypothetical numbers are required to keep the fear alive, then it becomes necessary to abandon altogether the concept of adverse health effects caused by chemical exposures and replace it with something subtler. The focus on levels of effect has apparently been replaced by a focus on *exposure*, regardless of the presence or absence of exposure-related adverse health effects.** **Even measurable exposure is no longer an absolute requirement.** **The focus has shifted from exposure and effects to levels of concern. Thus, did a major U.S. public health agency switch its focus from the Objective to the**	The cancer risk calculations for TCE are provided in Appendix B, page 36, along with example calculations on pages 37-39. For additional discussions regarding the referenced TCE studies, please refer to EPA's IRIS Toxicological Review of TCE (September 2011) at https://www.epa.gov/iris/supporting-documents-trichloroethylene The "strong limitations" refers to the occupational studies that provide additional evidence that TCE causes cancer.

	Subjective. From the perspective of the environmental activist, *and* the federal agencies that pandered to them, this was a tidal shift in a spectacularly useful direction. For, no longer was it necessary to demonstrate even the remotest possibility that an actual adverse effect was causally associated with a measurable exposure. A sufficiently uninformed and propagandized individual could be deeply concerned in the complete *absence* of *either* an exposure or an effect. **From this point forward, real science has become so politicized as to be utterly irrelevant to the effective propagation of public health scares."**	
19	Cancer Health Effects – TCE – 1 This paragraph also references an "increased risk" for cancer health effects but it is not clear what level of risk represents an "increased risk". For transparency, recommend clarifying what level of risk represents an increased cancer risk. It seems this may be explained in a way on Page 18, 2nd paragraph. However the concept has been used multiple times before this information is provided it seems. Appendix D appears to categorize risks below 10^{-4} as "low" and risk above 10^{-4} as "elevated". Make a revision for clarification. Page 17	For the Wurtsmith Air Force Base re-evaluation effort, a cancer risk at or exceeding 1 x 10^{-4} is considered to be an elevated level of concern for lifetime cancer risk. An estimated additional cancer risk of 1 x 10^{-4} means that a population of 10,000 people exposed for a lifetime (78 years) at a certain chemical dose may have one additional cancer case. Although a 1 x 10^{-4} (one-in-ten thousand) risk level may be viewed as an elevated cancer risk, it is important to understand the exposure assumptions that went into estimating this risk and to remember that we cannot determine an individual's cancer risk or predict actual cancer cases; the estimated cancer risk refers to the risk for a population of people with similar chemical exposure. The cancer risk estimate is a tool used to determine whether health impacts are possible and if public health recommendations are needed.

Recommendations:

No.	Public Comment	ATSDR's Response
3 dup	Summary and Recommendations – Line 10 in the summary on page v and line 7 in the recommendations on page 21 Delete the recommendation "ATSDR recommends continued investigative actions to define the nature and extent of contamination on and surrounding the WAFB." The draft Health Consultation report does not provide any supportive discussion for the need for this recommendation. ATSDR uses historical drinking water data to develop Basis for Conclusions not environmental data. Delete the recommendation. Page v and 21	Thank you for your comment. ATSDR stands by this recommendation. A variety of hazardous substances (e.g., fuels, solvents, pesticides, and firefighting foam) have been handled, stored, and disposed of at WAFB. The extent of the contamination has not been fully defined. Further, the VOC groundwater pump and treat systems installed in the late 1970s and early 1980s have changed how groundwater flows under WAFB. This change in groundwater flow direction could cause groundwater contamination to flow in a different direction than what was originally occurring.
20	[ATSDR note: This comment quotes the bullets under the "Recommendations" heading on page 21 of the Health Consultation. The commenter's questions and comments below are in **bold type**.] RECOMMENDATIONS • ATSDR supports ongoing activities by the Michigan Department of Environmental Quality (MDEQ) to ensure that the community around WAFB is provided safe drinking water. • ATSDR recommends ongoing monitoring of potable wells by MDEQ in areas that are known to be, or that could be, affected by contamination from the site. • ATSDR recommends continued investigative actions to define the nature and extent of contamination on and surrounding the WAFB. **Commenter's Note: Agree with recommendations. However, this commenter also would agree with a recommendation of reevaluating the science of TCE (et al) going back to the pre-Johnson research study that has not been replicated and provided evidence for any of the current thinking on TCE.**	Thank you for your comment.

Appendix A: Exposure Assumptions and Dose Calculations

No.	Public Comment	ATSDR's Response
21	Example of Dermal Absorption Calculation Provide a reference for the guidance describing the approach for converting a dermal exposure to a 24-hour equivalent air concentration so it can be compared to an inhalation guideline. Add the guidance as a reference. Page 34	The references for the dermal exposure calculations are as follows: [EPA] US Environmental Protection Agency. 2004. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. EPA/540/R/99/005. OSWER 9285.7-02DEP; PB99-963312. Available online at https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e [Accessed 2018 Feb 6]. [EPA] US Environmental Protection Agency. 2011. Exposure Factors Handbook: 2011 Final. Washington DC. National Center for Environmental Assessment, Washington, DC. EPA/600/R-090/052A. Available online at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252 [Accessed 2018 Feb 6]. [Brown] Brown HS, Bishop DR, Rowan CA. 1984. The role of skin absorption as a route of exposure for volatile organic compounds in drinking water. Am J Pub Health 74:479-484.

Appendix B: Evaluating TCE Cancer Risks

No.	Public Comment	ATSDR's Response
22	Evaluating TCE Cancer Health Effects – 4 The paragraph seems to indicate remedial action may be warranted if cancer risk exceeds 10^{-6}. The NCP and OSWER Directive 9355.0-30 (Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions) states that if cumulative cancer risk exceeds 10^{-4} then remedial action is generally warranted. Conversely, if cumulative cancer risk does not exceed 10^{-4}, then remedial action is generally not warranted. When cumulative cancer risk is below 10^{-6}, remedial action is generally not warranted. After remedial action is triggered, then the preference is to achieve chemical-specific cleanup levels of 10^{-6}. Make a revision for clarification. Page 36	The commenter is correct. This statement lacks clarity regarding EPA's remedial action process and has been removed.

Appendix D: Updated Public Health Conclusions for Individual Wells

No.	Public Comment	ATSDR's Response
23	The groundwater at Wurtsmith is an unconfined water aquifer. Many documented spills had occurred around the original main drinking wells AF1, AF2, AF3, AF4, AF5, AF18 and AF19. The main drinking wells were treated and pumped into an on-site reservoir to be used by the majority of the base. They did not drink directly from each of the above listed wells. The ATDSR has listed each well, along with estimated health risks, be it a cancer risk or chronic long term health effect. We do not understand why each well was rated individually since the water was combined into a main reservoir. You would assume that the numbers would need to be averaged.	It is correct that, in some instances, water from individual wells was pumped to a distribution center and mixed with water that was provided by other wells before being distributed for use. Therefore, the contaminant concentrations detected in individual wells may not necessarily reflect the concentrations present at the faucet. However, ATSDR assumed the maximum contaminant concentration detected in each individual well to represent the level that would have been detected in the faucet. We understand that this is a conservative assumption and we note the limitation in our discussion. As also previously stated, ATSDR used the same sampling data and exposure point concentrations as the 2001 report to complete this evaluation.

Health Concerns

No.	Public Comment	ATSDR's Response
24	Around 1977 Wurtsmith Air Force Base ceased adding a treatment solution to their drinking water. It was around that time in 1977 when a resident on base complained because of the smell and taste of the water. In response to this complaint, a tap water sample was collected from an on-base housing unit and TCE was detected at 1,100 ug/L. Since that time millions of dollars have been spent trying to clean up Wurtsmith Air Force Base while the health risks to military personnel, their families, civilian base workers and surrounding residences have been ignored.	Thank you for your comment.
25	The Air Force Hazard Assessment Rating Methodology (HARM) rated the TCE spill by the NW base housing area as a 72, which made it a HIGH risk area. from AF22. Since the 1940s, many hazardous and potentially hazardous wastes have been generated by industrial shop operations at Wurtsmith AFB. (AF22)	Thank you for your comment. As acknowledged on page 2, a variety of hazardous substances (e.g., fuels, solvents, pesticides and firefighting foam) have been handled, stored, and disposed of at WAFB.
26	You have chosen to only re-evaluate for two chemicals, TCE and Benzene. How is this going to show the true risk to all of those exposed? The base has documented contaminants of the following: ... hazardous substances including ethylbenzene, toluene, xylenes, acenaphthene, and naphthalene, have been detected in soil exceeding Michigan Department of Environmental Quality (MDEQ) Part 201 Industrial Drinking Water Protection/Groundwater-Surface Water Interface (GSI) criteria for soil. The impacted soils are the source for the groundwater and surface water exposure pathways Benzene, cis-l,2-dichloroethene (DCE), ethylbenzene, methylene chloride, vinyl chloride (VC), xylenes, naphthalene, 1,2,4-trimethylbenzene (TMB), chlorobenzene, mercury, and manganese have been detected in groundwater at concentrations exceeding MDEQ Part 201 Industrial Drinking Water/GSI criteria for groundwater. From https://semspub.epa.gov/work/HQ/178906.pdf	ATSDR was asked by a group of concerned citizens and veterans to re-evaluate VOCs in drinking water (on- and off-base water supply wells) only. ATSDR previously evaluated other contaminants (VOCs, SVOCs, and metals) and pathways (soil, surface water, sediment and seeps) in our 2001 Public Health Assessment document. The document is currently available at https://www.atsdr.cdc.gov/HAC/pha/WurtsmithAFB/Wurtsmith2001_PHA.pdf. Only TCE and benzene were re-evaluated in the current document because they were the only VOCs detected above comparison values and for which we had significant new toxicological information.
27	In addition ashes from an old coal—fired heating plant were disposed of at several landfill sites at the base. It has since been determined that Arsenic is one of the most common, and most dangerous, pollutants from coal ash. The EPA also found that living near ash ponds increases the risk of damage from cadmium, lead, and other toxic metals.	Thank you for your comment. As stated on page 1, the purpose of this health consultation was to re-evaluate the past exposures to volatile organic compound (VOC) contamination in drinking water and to draw new health-based conclusions.
28	PFAS have been found at the base at extremely high levels. The DOD and VA with the help of the ATDSR seem to want to ignore the human damage that has been done. It took years of fighting and legal battles for Camp Lejeune to get some of their earned health benefits.	ATSDR received a petition regarding PFAS exposure at WAFB. ATSDR decided not to conduct any additional public health activities because there is not sufficient information available to determine when the on-base WAFB drinking water became contaminated with PFAS or the level of PFAS contamination in the on-base WAFB drinking water.

	H.R.1627 - Honoring America's Veterans and Caring for Camp Lejeune Families Act of 2012 Veterans' health care In accordance with the 2012 Camp Lejeune health care law, VA provides cost-free health care for certain conditions to Veterans who served at least 30 days of active duty at Camp Lejeune from January 1, 1957 and December 31, 1987. Qualifying health conditions include: Esophageal cancer Breast cancer Kidney cancer Multiple myeloma Renal toxicity Female infertility Scleroderma Non-Hodgkin's lymphoma Lung cancer Bladder cancer Leukemia Myelodysplastic syndromes Hepatic steatosis Miscarriage Neurobehavioral effects What will Wurtsmith have to do to get at least those benefits? Based on all of the research that has been done, we can not see what the differences are between the two bases that would cause the US Government to treat them so differently. Camp Lejeune chemicals studied by ATDSR which included a contamination modeling study: Maximum TCE level detected in drinking water was 1400 parts per billion (ppb) in May 1982 Tetrachloroethylene (PCE/PERC) - a dry cleaning solvent Benzene -a fuel component Vinyl chloride - forms when TCE/PERC break down Trans 1,2 -dichloroethylene (1,2 -tDCE) - forms when TCE/PERC break down	ATSDR appreciates receiving comments from community members and civic organizations and takes into account your concerns. ATSDR is a public health agency that evaluates exposure to hazardous substances but does not provide benefits to military service members. Veterans benefits are under the purview of the Department of Veterans Affairs (VA). Please refer to the VA for benefits information. https://www.va.gov/disability/eligibility/hazardous-materials-exposure/ Although the reconstructive modeling used for Camp Lejeune was not used for this consultation, modeling tools were used, such as to estimate inhalation exposures at the site.

	Wurtsmith chemicals studied by ATDSR in the latest report and no advanced contamination modeling study done: Maximum TCE level detected in drinking water was at least 5,173 parts per billion (pbb). Beneze Wurtsmith requires a thorough study, using the best modeling tools to identify past chemical exposures. Let us provide free health care to those that offered their lives for this country and not make it another Agent Orange battle.	
29	I was stationed at the former Wurtsmith Air Force base Oscoda, Iosco County, Michigan from 9/1977 to 9/1981 and lived on base. Recently I was diagnosed and treated for testicular cancer, where I had to have one of my testicies removed. I am interested in following up on this study and how the results affect me. My son was born on base.	ATSDR appreciates receiving comments from community members, and we take into account your concerns. In laboratory studies of rats, lifetime exposure to TCE resulted in increased testicular cancer. (See EPA's IRIS Toxicological Review of TCE at https://www.epa.gov/iris/supporting-documents-trichloroethylene.) However, we cannot determine an individual's cancer risk when performing a public health assessment or health consultation. In this document, the estimated cancer risk refers to the risk for a population of people with similar chemical exposure. Please understand that cancer is a complex subject with many possible causes. Factors that may play a role in cancer development include: • Lifestyle choices (what we eat or drink, and whether we smoke, use tobacco, carry excess body weight or exercise); • Natural causes (including sunlight and radon) and medical radiation; • Workplace exposures; • Drugs; • Socio-economic factors; • Viruses and other infections; and • Chemicals in our air, water, soil or food. Aging and individual susceptibility, such as genetic predisposition, are also important factors in cancer development. In the United States, half of all men and one-third of all women will develop cancer in their lifetime [American Cancer Society 2009].

General

No.	Public Comment	ATSDR's Response
30	General Reconcile CERCLA requirements and level of health risk discussion in the report to address differences and interrelationships between these two areas. Make revisions for clarification. Page N/A	This comment lacks clarity, and ATSDR is unable to formulate a response.
31	(Commenter's note: Hill's Criteria of Causality is being listed here as a reference because I think it is important to know this from a research standpoint) Hill introduced nine criteria that researchers should consider before declaring that A causes B: (1) Strength of association. We have never performed a clinical trial for smoking, in which we randomly assigned people to smoke cigarettes. Yet, we know for a fact that smoking causes cancer. Why? Because observational studies have shown that smoking increases a man's risk of lung cancer by 2,300% and a woman's by 700%. That association is so strong, that it cannot be disputed. However, studies that show that A increases the risk of B by merely a few percentage points are far less convincing. (2) Consistency. Do all or most studies indicate that A causes B? If the experiment is repeated in another country or at another time, are similar data produced? We cannot cherry-pick evidence that supports a causal relationship but ignore evidence that disputes it. (3) Specificity. If A truly causes B, it beggars belief to argue that A also causes C, D, E, F, and G. We should be suspicious when a single risk factor becomes an all-purpose boogeyman. Consider endocrine disruptors, which have been linked to a myriad of conditions, such as obesity, diabetes, behavioral anomalies, reproductive anomalies, and early puberty. As more diseases are linked to endocrine disruptors, the *less* believable the argument becomes. (4) Temporality. If A causes B, then A must also precede B. However, the reverse is not true: Just because A precedes B does not mean A causes B. A good example is the association between drug use and mental illness. While drugs may contribute to mental illness, it is also likely that people who take drugs are doing so to self-medicate against their mental illness. (5) Biological gradient ("dose-response"). The more a person is exposed to A, the likelier he should be to get disease B. The more cigarettes a person smokes, the likelier he is to get lung cancer. This notion, known as dose-response,	Thank you for your comment.

	presents another challenge to endocrine disruptors. Researchers who contend that endocrine disruptors cause disease say they only do so at low concentrations as opposed to high concentrations (a phenomenon called "hormesis"). While that's theoretically possible, it is also rather difficult to believe. (6) Plausibility. There should be a reasonable biological mechanism to explain why A causes B. Arguing that vegetable oil will turn girls into lazy, TV-watching diabetics fails this criterion rather spectacularly. (7) Coherence. A hypothesis that A causes B should make sense in the context of what we already know about A and B. This is why we should blame the pizza, not the box that in comes in, for obesity. (8) Experiment. For obvious ethical reasons, it is usually not possible to conduct clinical trials to determine disease etiology. However, any data gathered from interventions should support the claim that A causes B. If air pollution causes lung cancer and cardiovascular disease, then a city that passes a law to decrease air pollution should eventually observe fewer cases of lung cancer and cardiovascular disease. (9) Analogy. We already know that viruses, such as rubella and cytomegalovirus, can cause birth defects. Therefore, it should not be difficult for us to accept that Zika also causes birth defects. Limits to Hill's Criteria of Causality It is important to note that these nine criteria should be thought of more as guidelines than a checklist. Quite simply, even if A truly causes B, A still might not meet all nine criteria. On the other hand, a risk factor that meets all nine criteria might just be a confounder rather than a true cause. As usual, rigid adherence to a list is not an adequate substitute for wisdom and sound judgement.	
32	[ATSDR note: This comment quotes the first several sentences in the first paragraph on page 14 of the Health Consultation under the "Non-Cancer Health Effects – TCE" heading. The commenter's questions and comments below are in **bold type**.] **Commenter note: There are many hypothetical statements made in this report, using terms like "suggested" or "may be," etc.** *Based on estimated doses, some babies born to mothers who were exposed to TCE during pregnancy may be at increased risk for heart defects* **(evidence?)**. (See Tables 11D – 14D in Appendix D.) One of the studies supporting the RfD is based on the critical effect of fetal heart malformations in rats.	These terms are used to indicate uncertainty. Uncertainty refers to our inability to know for sure, often due to incomplete data. Uncertainties are inherent in all scientific undertakings and cannot be avoided. We acknowledge in this document the uncertainty (and limitations) that could most affect our decision-making.