Public Health Assessment for

BOUNTIFUL/WOODS CROSS 5TH PCE PLUME
BOUNTIFUL, WEST BOUNTIFUL, AND WOODS CROSS,
DAVIS COUNTY, UTAH
EPA FACILITY ID: UT0001119296
APRIL 18, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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PUBLIC HEALTH ASSESSMENT

BOUNTIFUL/ WOODS CROSS 5TH SOUTH PCE PLUME

BOUNTIFUL, WEST BOUNTIFUL, AND WOODS CROSS, DAVIS COUNTY, UTAH

EPA FACILITY ID: UT0001119296

Prepared by:
Environmental Epidemiology Program
Office of Epidemiology
Utah Department of Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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SUMMARY

The Bountiful/Woods Cross 5th South PCE Plume is located about 11 miles north of Salt Lake City, in the cities of Bountiful, West Bountiful, and Woods Cross, in Davis County, Utah. The contaminated groundwater plume is approximately 245 acres in size. The United States Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (UDEQ) continue to study the extent of the contamination. The primary contaminants in the groundwater are tetrachloroethene (PCE), trichloroethene (TCE), and associated volatile organic chemicals (VOCs) such as vinyl chloride, cis-1,2-dichloroethene (cis-1,2-DCE), methyl-tert-butyl ether (MTBE), chloroethane, and benzene. The Agency for Toxic Substances and Disease Registry (ATSDR) has requested that the Environmental Epidemiology Program (EEP) of the Utah Department of Health conduct this public health assessment to identify public health hazards posed by this plume.

As early as 1986, monitoring wells in the area detected PCE and TCE contamination in the groundwater. A year later, an investigation was prompted in an attempt to identify the source of contamination. Sufficient levels of PCE and TCE were identified up-gradient of the monitoring wells to account for the contaminants identified in 1986 sampling (UDEQ 1996).

Investigations conducted by EPA and UDEQ confirmed PCE and TCE contamination in the groundwater in the Bountiful/Woods Cross area. PCE is a synthetic chemical used for dry cleaning of fabrics and metal-degreasing, as well as other industrial uses. TCE can also be used for metal-degreasing, and is a breakdown product of PCE. A source of contamination has not been identified. Other chemicals of potential health concern that have been detected over several years of sampling include: vinyl chloride, cis-1,2-DCE, MTBE, and benzene. In the Bountiful/Woods Cross area, exposure to these chemicals is possible from drinking contaminated groundwater from residential wells. Water from municipal wells is considered safe to drink. Indoor air sampling also identified elevated levels of benzene, PCE, toluene, and trimethylbenzenes. Other possible routes of exposure include ingestion, inhalation or skin contact with contaminated soils near the unknown source of contamination, inhalation of VOCs in the ambient air, and drinking from or swimming in irrigation canals that may contain contaminated groundwater.

At present, the shallow groundwater is not a source of municipal drinking water. However, if the contaminants are not removed or contained, migration of contaminants to the deeper aquifers could occur, and the drinking water supply for over 77,000 area residents could be jeopardized.

EPA and UDEQ continue to investigate the site and are focusing on remediation alternatives. The former Hatchco/J.B. Kelley Trucking facility has been identified as a responsible party for a three-acre area located within the site boundaries. PCE releases may have also occurred while a septic tank/leach field was in operation on the property currently owned by the Bountiful Family Cleaners (CDM 2005b). MTBE contamination may be attributed to a former oil refinery that is now owned by Holly Refining and Marketing Company (CDM 2005a). EPA recently released cleanup plans for the Hatchco property. Additional site cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood.

There is no apparent public health hazard for groundwater at the Bountiful/Woods Cross 5th South PCE Plume. Elevated levels of PCE, TCE, vinyl chloride, 1,2-DCE, MTBE, and benzene have been detected in the shallow aquifer. There are several residential wells in the area that are completed in the shallow aquifer. Most are used for irrigation; however, it is estimated that 13 homes had, in the past, used residential well water as their primary source of drinking water. Municipal wells have not shown elevated levels of contaminants, and water from these wells is considered safe to drink.

A completed exposure pathway was identified for homes with residential wells that have shown contamination of PCE; a filter has been placed on one of the wells reducing contamination to below the MCL for PCE. Past exposure occurred for residents whose wells showed levels of contamination. No completed exposure pathways currently exist for the general population.

There is currently no public health hazard for air, soil and sediment. Limited sampling data was available to assess exposures to soil, air, and surface water. The data that is available show that contaminants in air and soil samples are below their respective comparison values and therefore do not pose a public health hazard.

The EEP public health action plan, designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment from the Bountiful/Woods Cross 5th South PCE Plume, consists of the following actions:

1. The EEP community health educator has completed an environmental health needs assessment of the community and will use this as a guide to address future community concerns. The health educator will also provide the community with all available information regarding the site. A pamphlet discussing the results of the final public health assessment will be created and provided to area residents.

2. EEP will collaborate with EPA, UDEQ, and local water suppliers to monitor the area drinking water supplies until remediation is complete and contaminants are shown not to be entering the drinking water supply.

3. UDEQ and the EPA will continue to research the site, including plume delineation and remediation alternatives.

4. EEP will continue to monitor sampling of the residential wells conducted by EPA and UDEQ that are reported to be drinking water sources. EEP will provide residential well owners with information on the contaminants identified in the groundwater and potential health effects associated with these contaminants.

5. EEP will continue to monitor sampling of air, soil, soil vapors, and surface water conducted by EPA and UDEQ in order to evaluate all possible routes of human exposure.

6. EEP will encourage Holly Refining and Marketing Company to conduct annual sampling of the two groundwater wells that occasionally serve employees at the Woods Cross

Refinery, until the source of contamination has been identified and/or until contaminants are shown not to be migrating into the deeper aquifers.

7. EEP, in coordination with the Davis County Health Department, will monitor the development of commercial property near the site and activities on the site that could further facilitate migration of contaminants off-site.

8. The EEP will provide the communities living near the Bountiful/Woods Cross 5th South PCE Plume with cancer and site remediation information. A health consultation of the cancer cluster investigation performed by EEP has been released to the public.

PURPOSE AND HEALTH ISSUES

The Agency for Toxic Substances and Disease Registry[1] (ATSDR) requested that the Environmental Epidemiology Program (EEP) of the Utah Department of Health conduct this public health assessment to identify public health hazards posed by the Bountiful/Woods Cross 5th South PCE Plume [EPA ID No. UT0001119296]. This site was added to the Environmental Protection Agency's (EPA) National Priorities List (NPL) on September 13, 2001.

The objective of a public health assessment is to identify public health actions that should be taken at a site. The public health assessment process is designed to complement remediation efforts at a site, but should not be confused with a risk assessment used for remedial design purposes.

For this document, EEP analyzed results from groundwater, soil, and air samples to determine the contaminants of concern. EEP then evaluated groundwater, soil, and air exposure pathways to determine public health implications. Ultimately, this assessment provides conclusions on the public health issues relevant to the Bountiful/Woods Cross 5th South PCE Plume and makes recommendations to protect the health of residents in the area.

BACKGROUND

Site Description

The Bountiful/Woods Cross 5th South PCE Plume (henceforth referred to as the Bountiful Plume) is located between the streets 400 North to 750 South, and 400 West to 1100 West in the cities of Bountiful, West Bountiful, and Woods Cross, in Davis County, Utah. The site is in north-central Utah, about 11 miles north of Salt Lake City and is sandwiched between the Wasatch Mountains to the west and the Great Salt Lake to the east (Figures 1 and 2). More specifically, "the site is bounded by private residences and agricultural lands on the west, commercial properties and residences to the south, industrial sites and residential properties to the north, and interstate highway 15, railroad tracks, and commercial properties progressively farther east" (EPA 2001). Following the NPL listing, the site was subdivided into two operable units for the purpose of source identification.

The extent of the contaminated groundwater is approximately 245 acres (EPA 2001). The vertical depth of contamination is unknown, but may be over 100 feet deep (EPA 2001). The plume has not yet been completely defined, and the investigation is still underway. Multiple sources are likely in this area (EPA 1999). The former W. S. Hatchco/J. B. Kelley Trucking facility located at 643 South 800 West has been identified as a responsible party for a three-acre portion of the site. This facility once operated as a specialized carrier of bulk petroleum and petroleum products, petroleum solvents, and asphalts. The facility was also used to service, clean and park tractor-trailers and tank trucks (EPA 2004b). PCE releases may have also occurred

[1] The 1986 Superfund Amendments and Reauthorization Act to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 directs ATSDR to perform specific public health activities associated with actual or potential exposures to hazardous substances released into the environment. Among those activities, ATSDR was mandated to perform a public health assessment for each facility/site listed or proposed to be listed on the NPL within one year of the listing. In addition, ATSDR may conduct a public health assessment for a particular facility or release when petitioned by a person or group of persons.

while a septic tank/leach field was in operation on the property currently owned by the Bountiful Family Cleaners (CDM 2005b). MTBE contamination may be attributed to a former oil refinery that is now owned by Holly Refining and Marketing Company (CDM 2005a).

The region is characterized by a semi-arid climate, with temperature fluctuations of up to 100°F between winter and summer months. Wind patterns for the region vary according to season and location of storm fronts. The average annual precipitation is 13 to 15 inches, with a 24-hour maximum rainfall of 2.15 inches. The land surface slopes slightly to the northwest (UDEQ 1999).

The site is on the southern portion of the primarily confined East Shore Aquifer system. The East Shore Aquifer system consists of three artesian aquifers: shallow (60-250 feet below ground (bgs)), intermediate (250-500 feet bgs), and deep (greater than 500 feet bgs). The primary recharge area is nearest the mountain front, which is underlain mainly by permeable sands and gravel that enhance the recharge water movement. These aquifers are hydraulically connected; however, little work has been conducted to define the boundaries between them. The shallow and deep aquifers likely conjoin into a single aquifer in the recharge area, which lies less than half a mile east of the site. These aquifer systems are composed of mudflow deposits that are poorly sorted and only slightly permeable.

Groundwater flow direction along the Wasatch front is generally in the direction of the Great Salt Lake; in the Bountiful/Woods Cross area, the flow is generally from the east–southwest toward the west (EPA 2004a). Groundwater investigations at the Woods Cross Refinery indicate that groundwater flows in a northwest direction (USGS 1991; USGS 1994). Groundwater west of the site is near or at the ground surface (UDEQ 1999). Surface water in the area consists of irrigation canals.

Several residential wells in the area are completed in the shallow aquifer. Currently, this aquifer is not believed to be a primary drinking water source but, historically, has been used for industrial and irrigation purposes (USGS 1991; USGS 1994). The shallow aquifer is classified by the State of Utah as a Class II drinking water source (drinking water quality groundwater). Although it is believed that the residential wells are currently used mainly for irrigation, it is possible, (and has been reported), that current and future residents may use the water for drinking and other domestic purposes (EPA 2004a). Several residential wells used for irrigation discharge water into the nearby canals (UDEQ 1996). There are 45 municipal wells within a four-mile radius of the site. The wells are public supply wells for the south Davis County area and are part of a blended drinking water system.

Land Use and Demographics

The Bountiful Plume site is located in the cities of Bountiful, West Bountiful, and Woods Cross, in Davis County, Utah. The site contains residential, commercial, industrial, and agricultural areas, including a shopping plaza on the eastern boundary and the Woods Cross Refinery near the center. Railroad tracks and a portion of Interstate-15 are also located on-site. The refinery employs approximately 140 people (SL Tribune, 2003); it is unknown how many additional employees are in the area.

According to 1990 U.S. Census Bureau data, 14,733 people, mainly in the city of Bountiful, live within one mile of the site (Figure 3). Of those residents, 2,307 are children age five and under. In 1990, an estimated 639 people lived on-site, with 98 children age five and under, and 189 under 18 years of age. Residents who live near the plume are a predominantly white population with less than three percent having Asian, African American, or Hispanic backgrounds. The average household size in the area is 3.32 persons per household.

The number of people in this area has grown since 1990. According to 2000 U.S. census data, Bountiful has a population of 41,301, which is 10 percent larger than in 1990. The current population of Woods Cross is 6,419, and West Bountiful, 4,484. The total estimated population of Davis County is 238,994 (USCB 2000).

Site History

The Woods Cross Refinery is located at 393 South 800 West, in Woods Cross, Utah. Phillips 66 operated the refinery for approximately 35 years. Prior to Phillips' operations, the Woods Cross Cannery occupied the location. In June 2003, Holly Refining and Marketing Company acquired the refinery.

As part of a storm water pond closure in 1984, Phillips installed routine groundwater monitoring wells down-gradient (west) of the refinery. Subsequent sampling of the wells in 1986 identified tetrachloroethene (PCE) and trichloroethene (TCE) in the part per billion[2] (ppb) range both up-gradient and down-gradient of the refinery. In 1987, Phillips commissioned an additional investigation to try to further identify the source of the contamination. Four exploratory borings were installed to the east and up-gradient of the refinery, and soil and groundwater samples were collected. Sufficient levels of PCE and TCE were identified in the up-gradient borings to account for the contaminants identified in 1986 sampling (UDEQ 1996).

Groundwater sampling conducted in 1996 confirmed PCE and TCE contamination, in addition to detecting elevated levels of cis-1,2-dichloroethylene (cis-1,2-DCE), vinyl chloride, and related chemicals. PCE is a synthetic chemical used for dry cleaning of fabrics and metal-degreasing, as well as other industrial uses. TCE, DCE, and vinyl chloride are breakdown products of PCE. Other chemicals detected during years of monitoring include methyl-tert-butyl-ether (MTBE) and benzene. Several sources such as dry cleaners, trucking companies, automotive maintenance facilities, and an oil refinery may have contributed to the contamination.

In 1999, West Bountiful officials identified approximately 14 residential wells located in proximity to and down- or cross-gradient from contaminated monitoring wells (UDEQ 1999). At the time, eight of the wells were being used as drinking water sources; four had unidentified uses; and the additional two were used exclusively for irrigation. Today, at least five of the wells are still in service, either for drinking or irrigation purposes. A sixth well is currently being used during the remodeling of the home, but is not being used as a drinking source. The home will be connected to municipal water upon completion (EEP 2004). All six wells are located down- or cross-gradient, north and northwest of the site (Figure 4).

[2] One ppb is equivalent to 1 µg/L, and can be compared to 1 pinch of salt in 10 tons of potato chips.

Twenty-one additional residential wells have been identified down-gradient, near the western portion of the site. Six of the wells have been reported as drinking water sources; two are used for drinking and stock watering; 12 are being used for stock or irrigation; and one has unreported usage (UDEQ, unpublished data, 2004).

Of the 45 municipal wells in the area, three of the wells are within a quarter of a mile of the site, and two are located on the Woods Cross Refinery property. These wells occasionally serve employees for all water uses, including drinking. Both wells are at an approximate depth of 600 feet and are monitored for water quality every three years (George Fink, Holly Refining and Marketing Company, personal communication, 2004).

In October 2001, the site was subdivided into two operable units for the purpose of source identification. The former Hatchco/J. B. Kelley Trucking facility has been named as the responsible party for Operable Unit 1 (OU1) (EPA 2002). The remaining area is comprised of Operable Unit 2 (OU2). The source areas for OU2 have been identified as the Bountiful Family Cleaners and the David Early Property (CDM 2005a).

A Remedial Investigation report for the OU1 site was completed in 2003, and a cleanup plan for OU1 was released for public comment in August 2004. A Remedial Investigation report for the OU2 portion of the site was finalized in July 2005.

DISCUSSION

Nature and Extent of Contamination

Chemicals detected at the Bountiful Plume include PCE, TCE, vinyl chloride, cis-1,2-DCE, MTBE, and benzene. Possible sources for these types of contaminants include businesses that routinely use solvents, generally as cleaning agents. Dry cleaners, automotive and machinery shops, and facilities with waste oil tanks (often inappropriately used to containerize solvents) are among the most likely sources for this type of contamination. Migration routes for contaminants include spills, leaks from containers, and leaks from sewer lines.

Detections of PCE and TCE in the groundwater of monitoring wells at the Woods Cross Refinery were first noted in 1986. Ten years later, in 1996, EPA conducted sampling of residential and monitoring wells located down- and cross-gradient of the contaminated monitoring wells. Four residential wells on-site were determined to contain elevated levels of PCE. Low levels of PCE contamination have been detected in other residential wells on-site. Of the three municipal wells operating within a quarter of a mile of the site, one has been inactivated because of PCE contamination.

EPA and UDEQ have since conducted numerous investigations to identify potential sources of contamination. Subsurface soil gas sampling has been performed in an attempt to delineate the nature and extent of the contamination. The extent of the contaminated groundwater is approximately 245 acres. The vertical depth of contamination is unknown, but may be over 100 feet deep (EPA 2001). Indoor air sampling was also performed at three businesses on the OU2 portion of the site.

Groundwater

In February 1996, the EPA sampled eight residential wells located down- or cross- gradient to the contaminated monitoring wells (UDEQ 1996). Well depths range from less than 50 feet to over 300 feet below ground. Two of the wells, located at 22 North 1100 West and 90 North 1100 West, had PCE concentrations of 30 and 24 ppb respectively (UDEQ 1996). The maximum contaminant level[3] (MCL) for PCE in drinking water is 5 ppb. The residents were notified and education for minimizing exposure was provided. EPA also provided bottled water until the residents were connected to the municipal water system (UDEQ 1999). Retesting at these homes, and two additional homes, occurred in March and June of 1996 (UDEQ 1999). The results of this sampling confirmed PCE levels in excess of the MCL in the two previously tested homes, as well in the two additional homes (Table 1). Soon after, these homes were also connected to municipal water. In 1999, Phillips acquired and demolished the three homes located at 22, 74, and 90 North and 1100 West (EEP 2003). Domestic well testing also detected 1,1-dichloroethene (Table 2).

Three municipal wells are located within a quarter of a mile of the site. Two of the wells belong to the Woods Cross Refinery. These wells are at a depth of 600 feet below ground and occasionally serve employees for all water uses, including drinking. These wells are routinely sampled every five years[4]. Recent sampling results indicate that all contaminants are below the detectable limit of 0.5 µg/L (Holly 2001, 2002). In 1995, sampling of the third municipal well, the Woods Cross Well #1, located at 300 West 1500 South, revealed contamination. Increasing levels of PCE prompted Woods Cross water officials to take the well out of service in 1999. Several other municipal wells located along 1500 South (south of the study area) have revealed low levels of PCE contamination (UDDW 2003).

Annual sampling conducted by Phillips showed elevated PCE and TCE concentrations in three down-gradient monitoring wells on the western side of the refinery (Table 3). UDEQ sampling at the Phillips Refinery detected PCE, TCE, and benzene (Table 4). Detection of high concentrations of PCE associated with the second sand layer below the water table suggests that there is a potential that contamination exists deeper in the aquifer (UDEQ 1999). In 1996, EPA collected samples at four different periods during the year from monitoring wells on the OU2 site and found TCE at a maximum concentration of 980 ppb (Table 5). The drinking water comparison value for TCE is 5 ppb. A maximum concentration of vinyl chloride of 110 ppb was also detected (URS 1996a, URS 1996b, URS 1996c, URS 1997). The drinking water comparison values for vinyl chloride are 0.03 ppb for cancer and 30 ppb and 100 ppb for children and adults non-cancer values. Levels of trans-1,2-DCE, 1,1-dichloroethane, and other chemicals were also detected in the monitoring wells. These chemicals are likely a result of the natural decomposition of PCE.

Additional sampling occurred in the summer of 2002. UDEQ and EPA contractor CDM began Phase I of the Remedial Investigation to identify the source of contamination. A total of 71 groundwater samples were collected and analyzed, including 14 samples from residential wells.

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[3] Maximum contaminant level: (MCL) an enforceable standard calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water.
[4] Both wells have had the frequency of sampling relaxed due to being “reliable and consistent” (George Fink, Holly Refining and Marketing Company, personal communication, 2004).

PCE, TCE, and their associated breakdown products were detected in both the shallow and intermediate aquifers. The highest PCE level detected was again near the Bountiful Family Cleaners and David Early properties at 400 µg/L. Levels of PCE appeared to decrease with distance from this area. However, relatively high PCE levels in residential wells along 1100 West suggest deeper or secondary PCE contamination. Twelve of the 14 residential wells sampled revealed PCE contamination; seven of these had PCE levels above the MCL. Several wells at the southern portion of the site revealed MTBE contamination.

Phase II of the Remedial Investigation continued throughout 2003 with quarterly sampling of eight monitoring wells and 7 residential wells. Five of the monitoring wells were located on-site and intersected the upper, middle, and lower aquifer zones. Three additional wells were placed up-gradient of the suspected sources. Additional groundwater sampling was performed in April 2005 as part of Phase III of the Remedial Investigation. Domestic well groundwater data for OU2 from Phases I-III are summarized in Table 6; monitoring well data is found in Table 7 (CDM 2005a, CDM 2005b).

Groundwater was also sampled from monitoring wells at the OU1 site (Hatchco site). In 1997, sampling detected elevated concentrations of TCE, benzene, cis-1,2-dichloroethene, and vinyl chloride (UDEQ 1998). This sampling is summarized in Table 8. Further sampling was performed in 2003 (Table 9) and as part of the EPA Remedial Investigation (Table 10).

Groundwater contaminant data found at the Bountiful Plume site from 1986-2005, with corresponding comparison values, are presented in Tables 1-10.

Soil

Limited soil sampling has been conducted at the site. In 2003, several chemicals were detected in surface soil samples, but only at concentrations much lower than ATSDR's soil comparison values (Table 11). Sampling of subsurface soils found elevated levels of vinyl chloride, TCE, and 1,3,5-trimethylbenzene (Tables 12-14). In addition, other chemicals detected included ethylbenzene, m,p-xylene, naphthalene, o-xylene, toluene, and benzene. None of these chemicals exceeded ATSDR's soil comparison values (Tables 12-14). However, it is possible that the volume released at the source(s) may have been significant enough to travel a great distance to reach the groundwater, contaminating soils at the source and below.

Air

Limited air sampling has been conducted at the site. In 2005, indoor air and sub-slab vapor sampling was performed at three businesses on the OU2 site (CDM 2005b). PCE and two forms of trimethylbenzene were detected at elevated levels in indoor air samples from Bountiful Family Cleaners. These chemicals along with benzene were also detected in sub-slab samples. The hallway of a neighboring retail store had elevated levels of 1,2,4-trimethylbenzene, benzene, and toluene in indoor air and PCE, trimethylbenzenes, and benzene in the sub-slab air samples. The David Early Property was only tested for sub-slab air. Elevated levels of PCE, trimethylbenzenes, and benzene were found at this business. Indoor air and sub-slab vapor data are presented in Table 15.

Exposure Pathways Analysis

To determine if nearby residents, visitors, and workers are exposed to contaminants related to a site, ATSDR evaluates the environmental and human components that lead to human exposure. An exposure pathway consists of five elements (ATSDR 2005):

(1) A source of contamination;
(2) Transport through an environmental medium;
(3) A point of exposure;
(4) A route of human exposure; and
(5) A receptor population.

ATSDR categorizes an exposure pathway as either *completed*, *potential*, *or eliminated*. In a *completed* exposure pathway, all five elements exist and indicate that exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In a *potential* exposure pathway, at least one of the five elements has not been confirmed, but it may exist. Exposure to a contaminant may have occurred in the past, may be occurring, or may occur in the future. An exposure pathway can be *eliminated* if at least one of the five elements is missing and will never be present (ATSDR 2005).

When an exposure pathway is identified, comparison values (CVs) for air, soil, or drinking water are used as guidelines for selecting contaminants that require further evaluation (ATSDR 2005). To protect susceptible populations, the CVs for children are used when available. Calculations used to determine CVs in drinking water are presented in Appendix A.

The main route of exposure identified at the Bountiful Plume is the groundwater pathway. Insufficient sampling of soil, air, and surface water at the Bountiful Plume site make it difficult to eliminate any pathways of exposure.

Completed Exposure Pathways

Residential Wells: past, present, and future exposure

At the Bountiful Plume site, exposure to contaminated groundwater occurred in the past when PCE was identified in four residential wells. All five elements have existed in the past and may currently exist for the residents using water from contaminated residential wells:

Exposure element	Bountiful Plume
1) A source of contamination……………….....	plume site
2) Transport through environmental medium...	groundwater from residential wells
3) A point of exposure………………………..	faucets from homes with residential wells
4) A route of human exposure…………….….	ingestion, skin contact, and inhalation
5) A receptor population……………………...	residents and workers

Residents of the four homes with contaminated wells were exposed in the past by drinking, bathing in, and inhaling vapors from contaminated well water. Three of these households reportedly used the water for all daily uses, and one for irrigation. Applying the 2000 Census average of 3.32 persons per household, an estimate of 14 people may have been exposed to contaminated well water on a daily basis in the past.

Current and future exposure to PCE may occur in an estimated 13 homes with residential wells who have either not been connected to municipal water and/or who reportedly use the wells as a drinking source. A filter has been placed in one of the homes to reduce present exposure, but future exposure is possible if the filter is not maintained, or if the filter is removed. An estimate of 43 residents may currently be exposed to contaminated well water on a daily basis.

An estimated 140 workers at the Woods Cross Refinery are at risk for future exposure to PCE in well water if the contaminants migrate deeper in the aquifer. Sampling of the wells in 2001 and 2002 did not reveal contamination above the detection limit.

Estimated exposure doses and the health effects associated with exposure to PCE and other contaminants are discussed in the "Exposure Dose Estimates and Toxicologic Evaluation" section of this document.

Indoor Air

Groundwater contaminants can volatilize, migrate via soil gas, and enter indoor air. Therefore, if there is enough soil gas contamination, (which is possible if a spill occurred at the source), the indoor air near the site of the release could become contaminated with VOCs. Nearby residents and workers may be exposed by breathing the air.

Limited indoor air and sub-slab air sampling has been conducted in an attempt to define the scope of contamination. PCE, TCE, and BTEX (benzene, toluene, ethylbenzene, xylene) contaminants were detected. Therefore, it is plausible that air contamination exists. Workers at the businesses sampled for air contamination may be inhaling these contaminants.

Exposure element	Bountiful Plume
1) A source of contamination…………………	Bountiful Family Cleaners/David Early Property
2) Transport through environmental medium…	indoor air
3) A point of exposure......................................	air inside the workplace
4) A route of human exposure..........................	inhalation
5) A receptor population..................................	workers

Potential Exposure Pathways

Ambient Air

When soil gas reaches the ground surface, the contaminants will pass into the ambient (outdoor) air. Therefore, if there is enough soil gas contamination, (which is possible if a spill occurred at the source), the outdoor air near the site of the release could become contaminated with VOCs. Nearby residents and workers may be exposed by breathing the air.

Subsurface soil gas sampling has been conducted in an attempt to define the scope of contamination. Sufficient levels of PCE were identified. Therefore, it is plausible that air contamination exists. Only two elements of this pathway exist, 1) the source of contamination (contamination in the air) and 2) its transport through an environmental medium (air), and the other three may exist in the future.

<u>Exposure element</u>	<u>Bountiful Plume</u>
1) A source of contamination…………………	multiple sources
2) Transport through environmental medium…	ambient air
3) *A point of exposure*......................................	*missing*
4) *A route of human exposure*...........................	*missing*
5) *A receptor population*..................................	*missing*

Soil

Limited soil sampling has been conducted at this site, therefore it not possible to fully evaluate this pathway. Two pathway elements currently exist, 1) the source of contamination (contamination in the soil) and 2) its transport through an environmental medium (soil), and the other three may exist in the future (Table 5).

<u>Exposure element</u>	<u>Bountiful Plume</u>
1) A source of contamination…………………	multiple sources
2) Transport through environmental medium...	soil
3) *A point of exposure*...	*missing*
4) *A route of human exposure*...........................	*missing*
5) *A receptor population*..................................	*missing*

Limited sampling has shown levels of contaminants in the soil. Although the chemicals detected were below ATSDR's soil CVs, because the source of contamination is presently unknown, it is possible that the volume released at the source(s) may have been significant enough to travel a great distance to reach the groundwater, and therefore contaminating soils at the source and below. Contaminated soils could present a risk to residents and workers near the source(s) of contamination.

Surface Water

Potential exposures from the surface water pathway cannot be evaluated because only two surface water samples have been collected. Both samples revealed no evidence of contamination. However, migration of potentially contaminated groundwater to surface water is possible and water from several of the irrigation wells flows into nearby surface water canals. A route of human exposure and the exposed population has not been observed, but may include children playing in the canals during the summer months.

<u>Exposure element</u>	<u>Bountiful Plume</u>
1) *A source of contamination*...........................	*missing*
2) *Transport through environmental medium*...	*missing*
3) *A point of exposure*......................................	*missing*
4) *A route of human exposure*...............................	*missing*

5) *A receptor population..................................missing*

Public Health Implications

Levels of contaminants that exceed comparison values will not necessarily cause adverse health effects upon exposure. The potential for exposed persons to experience adverse health effects depends on many factors, including:

(1) The amount of each chemical to which a person is or has been exposed;
(2) How long a person is exposed;
(3) The route by which a person is exposed (breathing, drinking, skin contact);
(4) The health condition of the person;
(5) The nutritional status of the person; and
(6) Exposure to other chemicals (such as cigarette smoke or chemicals in the work place).

Evaluation Process

In the process of evaluating the Bountiful/Woods Cross site, EEP examined the types and concentrations of each chemical of concern for each media type (soil, groundwater, etc.) in which the chemical was measured. ATSDR and EPA comparison values were used to screen for chemicals of concern that would warrant further evaluation for a possible risk to human health. Comparison values (CVs) are media-specific concentrations of contaminants that can be reasonably assumed to be harmless when assuming default conditions of exposure. CVs are generally conservative concentrations to ensure the protection of sensitive populations. Values of contaminants that exceed the CVs do not indicate that a health risk actually exists, this merely indicates that further evaluation is required for these chemicals. CV calculations are found in Appendix A and CV definitions are found in Appendix B.

Exposure Dose Estimates and Toxicologic Evaluation

The chemicals of concern for the Bountiful Plume site are PCE, TCE, benzene, chloroethane, cis-1,2-DCE, methylene chloride, MTBE, 1,1,2,2-tetrachloroethane, and vinyl chloride. These chemicals are present in groundwater at concentrations that may be of potential health concern for adults and children residing or working in the area. As previously discussed, ingestion of water contaminated by PCE occurred in the past and may presently be occurring. Exposure doses for children and adults have been calculated and are discussed below.

For present and future exposure, ingestion of groundwater from contaminated residential wells is the most likely exposure pathway. Other potential exposure pathways include soil or surface water ingestion, inhalation of ambient air or dust, and skin contact with soil or surface water. Because limited soil, air, and surface water sampling data are available, only the groundwater ingestion pathway has been evaluated further. Except where past exposure data were available, the EEP used the most recent analytical data (UDEQ 1996, URS 1996a, URS 1996b, URS 1996c, URS 1997, Golder 1987, UDEQ 1998, UDEQ 1999, CDM 2002, CDM 2005a, CDM 2005b, HDR 2003) to evaluate exposure doses in this public health assessment.

Contaminants that exceeded a comparison value underwent further toxicological evaluation. A site-specific exposure dose was calculated for both adults and children for each contaminant that exceeded a media-specific CV. Exposure dose calculations are shown in Appendix A. These calculated exposure doses were then compared to an appropriate health guideline. These guidelines are conservative health-protective values that have been developed using human exposure data when it is available from scientific literature. When human data is not available, animal exposure data is used. Health guidelines used in this report include ATSDR's Minimal Risk Levels (MRLs) and EPA's Reference Doses (RfDs). Exposure doses that are lower than the MRL or RfD are considered to be without appreciable risk to human health. When a calculated exposure dose exceeds the health guideline, the exposure dose is then compared to values from individual studies documented in scientific literature that have reported health effects. These values may be No Observable Adverse Effect Levels (NOAEL) or Lowest Observable Adverse Effect Levels (LOAEL). If a contaminant has been determined by the scientific literature to be cancer causing (carcinogenic), a cancer risk is also estimated (ATSDR 2005).

Tetrachloroethene (PCE)

PCE has many names. Among these are tetrachloroethylene, perchloroethylene, perc, perclene, and perchlor. PCE is a synthetic chemical that is widely used for dry cleaning of fabrics and metal-degreasing, as well as other industrial uses (ATSDR 1997a). Exposure to PCE can occur by using certain consumer products. Examples include spot removers, adhesives, wood cleaners, and water repellents.

Exposure to PCE occurred in the past when residents were drinking water from residential wells with levels as high as 30 ppb. Exposure doses were calculated for both children and adults and compared to ATSDR's Minimal Risk Levels (MRLs). The MRL is considered an estimate of the daily human oral exposure to PCE that is likely to be without appreciable risk of adverse non-cancer health effects. This number is based on studies performed with laboratory mice for 60 days where changes in behavior were observed at 5 mg/kg/day (Fredriksson et al. 1993). The estimated drinking water exposure doses to PCE for children (0.003 mg/kg/day) and adults (0.0009 mg/kg/day) are below the MRL for this chemical (0.05mg/kg/day). Exposure dose estimates were also calculated for children and adults exposed to the maximum concentration of PCE (264 ppb) detected in the groundwater. Again, these results were below the MRL, with child exposure estimated at 0.03 mg/kg/day, and adult exposure at 0.008 mg/kg/day (Table 18). Therefore, adverse health effects are unlikely at the current PCE concentrations found in the groundwater or residential wells.

Despite the identification of the MRL, the human health effects of drinking water with low levels of PCE are not definitely known. The effects of exposing infants to PCE through breast milk are unknown. PCE has been used as a general anesthetic agent and at high concentrations can cause dizziness, amnesia, and loss of consciousness. PCE has also been used to treat hookworm and other intestinal worms (ATSDR 1997a).

The EPA is currently reviewing the carcinogenicity of PCE. A cancer slope factor for PCE is not currently available and therefore, a theoretical cancer risk for this chemical cannot be determined. The International Agency for Research on Cancer (IARC) has determined that, based on limited human evidence and sufficient evidence in animals, PCE probably causes cancer in humans. The National Toxicology Program (NTP) identifies PCE as “reasonably anticipated to be a carcinogen” (ATSDR 2004a).

In 2004 the EEP conducted an investigation of cancer incidence in the Bountiful/Wood Cross area (ATSDR 2004b). That investigation evaluated cancer incidence in four census tracts; 126901, 127002, 127003, and 127004. These census tracts comprise the Bountiful/Woods Cross area. The results of that investigation did not find any cancer type that was statistically significantly increasing at a greater frequency in the four census tracts as compared to the state of Utah from 1978–2001. A copy of that report is presented in Appendix D.

Trichloroethene (TCE)

TCE (also called trichloroethylene, Triclene®, or Vitran®) is a non-flammable, colorless liquid with a sweet taste. It has a sweet odor that is noticeable beginning at a level of about 100 ppm. The largest source of trichloroethene (TCE) in the environment is evaporation from factories that use TCE as a solvent to remove grease from metals. TCE can also be found in typewriter correction fluid, paint removers, and adhesives. When TCE is released into groundwater, it takes much longer to break down because of less opportunity for evaporation (ATSDR 1997b).

People can be exposed to TCE by drinking or bathing in contaminated water. When a person drinks water that contains TCE, the majority of the contaminant is absorbed directly into the bloodstream. Once TCE is in the body, the liver converts it to other chemicals that are excreted in the urine within a day. If exposure continues, TCE and its breakdown products can build up in body fat (ATSDR 1997b).

The EPA established the MCL of TCE that is permissible in community water systems at 5 ppb. Some studies in humans exposed to TCE in drinking water reported impaired fetal development in pregnant women (ATSDR 1997b). A New Jersey survey suggested an association between TCE exposure at levels averaging about 55 ppb in water (level >10 ppb) to oral clefts, central nervous system defects, neural tube defects, and major cardiac defects (ATSDR 1997b). Interpretation of the findings of that study was limited by the small case numbers and exposure classification.

Exposure doses for ingesting groundwater contaminated with TCE at the highest concentration detected (1,380 ppb) were estimated for children and adults. The exposure dose for children is estimated to be 0.1 mg/kg/day, and for adults, 0.04 mg/kg/day. The MRL for TCE is 0.2 mg/kg/day (Table 6). Therefore, adverse health effects are unlikely at the current TCE concentrations found in the groundwater.

Exposure doses for ingesting residential well water contaminated with TCE at the highest concentration detected (6 ppb) were estimated for children and adults. The exposure dose for children is estimated to be 0.0006 mg/kg/day, and for adults, 0.0002 mg/kg/day. The MRL for TCE is 0.2 mg/kg/day (Table 6). Therefore, adverse health effects are unlikely at the current TCE concentrations found in residential well water.

The IARC has determined that, based on limited human evidence and sufficient animal evidence, TCE probably causes cancer in humans (ATSDR 2004a). The EPA classifies TCE as a probable human carcinogen; and the NTP has established that TCE is reasonably anticipated to be a carcinogen. However, more research is needed to establish the relationship between TCE exposure and cancer.

The previous cancer assessment for TCE has been withdrawn and is currently under review, therefore the cancer risk from exposure to TCE is unknown (EPA 2006a). An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancer types associated with TCE exposure that was statistically significantly increasing in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b).

Benzene

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities (ATSDR 1997c).

Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals that are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke (ATSDR 1997c).

Most people are exposed to a small amount of benzene on a daily basis. Exposure can occur in the outdoor environment, in the workplace, and in the home. Exposure of the general population to benzene is mainly through breathing air that contains benzene (ATSDR 1997c).

Although definitive scientific data are not available on oral absorption of benzene in humans, case studies of accidental or intentional poisoning indicate that benzene is absorbed by the oral route. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death (ATSDR 1997c).

For most people, the level of exposure to benzene through food, beverages, or drinking water is not as high as through air. Typical drinking water contains less than 0.1 ppb benzene. Leakage from underground gasoline storage tanks or from landfills and hazardous waste sites containing benzene can result in benzene contamination of well water. People with benzene-contaminated tap water can be exposed from drinking the water or eating foods prepared with the water. In addition, exposure can result from breathing in benzene while showering, bathing, or cooking with contaminated water (ATSDR 1997c).

Benzene has been detected at the Bountiful Plume site at levels that exceed ATSDR's comparison value for drinking water. The EPA has set the maximum permissible level of benzene in drinking water at 5 ppb. The levels of benzene detected in groundwater at the Bountiful Plume site are as high as 150 ppb. Exposure doses have been calculated for children and adults drinking groundwater with benzene at this level. ATSDR has not determined an oral MRL for benzene; therefore, the estimated doses were compared to EPA's acute oral reference dose (RfD) of 0.004 mg/kg/day. This RfD value is based on a LOAEL value of 1.2 mg/kg/day as calculated by EPA (EPA 2002). The estimated adult exposure dose to benzene is 0.004

mg/kg/day, which is below the RfD The estimated exposure dose for children is 0.02 mg/kg/day, which exceeds the RfD. However the estimated exposure dose for children is 60 times below the LOAEL. Therefore, harmful effects from drinking water contaminated with the maximum amount of benzene detected at the Bountiful Plume site are not likely.

The major effect of benzene from chronic (365 days or longer) exposure is on the blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection (ATSDR 1997c). Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men. The EPA, IARC, and the NTP have determined that benzene is a known human carcinogen. It is unlikely that residents were exposed to benzene as it was not detected in sampling from residential wells.

The cancer slope factor for benzene is 0.055 $(mg/kg/day)^{-1}$. The theoretical lifetime cancer risk for children is 1×10^{-3} and adults is 2×10^{-4} based on the maximum estimated exposure level from groundwater. This means that if 100,000 people were exposed to benzene in groundwater at the concentrations, frequencies, and exposure durations assumed in the calculations for cancer risk, there would be a theoretical increase of 20 (for adults) and 100 (for children) cancers above the number of cancers that would normally be expected to occur in the population of 100,000 people. Background rates of cancer in the United States are one in two or three (NCI 2001). This means that in a population of 100,000, background numbers of cancer cases would be approximately 33,000 to 50,000. Benzene exposures could result in a theoretical increase of 20 (for adults) and 100 (for children) cancer cases above the background number of 33,000 to 50,000 cancer cases. This represents a relatively low increased cancer risk for children and adults.

An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancer type associated with exposure to benzene that were statistically significantly increasing in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b).

Chloroethane

Chloroethane is a colorless gas with a characteristically sharp smell. It is used in the production of cellulose, dyes, medicinal drugs, and other products. Chloroethane is used to numb the skin before certain medical procedures and as a treatment in sports injuries. It does not occur naturally in the environment. Chloroethane breaks down fairly rapidly in the air (about half disappears in 40 days). In groundwater, it reacts with water to form ethanol and a chloride salt. Some types of bacteria can also degrade chloroethane into smaller compounds (ATSDR 1998).

People can be exposed to chloroethane through the air they breathe from factory releases, evaporation from landfills, and occupational use of the chemical. People can be exposed through drinking water as a result of chlorination (ATSDR 1998).

Chloroethane was detected in groundwater samples at levels that exceed EPA Region 3's risk-based concentration for drinking water (EPA 2005). Exposure doses for adults and children were calculated using the maximum concentration of chloroethane detected, 3.65 ppb. The exposure dose for adults is 0.0001 mg/kg/day and 0.0004 mg/kg/day for children. Neither value exceeds the EPA oral reference dose of 0.4 mg/kg/day. Therefore, harmful effects from drinking water contaminated with the maximum amount of chloroethane detected at the Bountiful Plume site are not likely. Chloroethane was not detected in any of the residential wells. NTP and IARC has given chloroethane a non-cancer rating or a "not classifiable" rating.

cis-1,2-Dichloroethene

Cis-1,2-dichloroethene (also called 1,2-dichloroethylene) is a highly flammable, colorless liquid with a sharp odor that is noticeable in very small amounts, beginning at a level of about 17 parts per million (ppm) in air. The chemical is commonly released into the environment from industries involved in solvent production, pharmaceutical manufacturing, and rubber extraction. When 1,2-DCE is released into air, it takes five to 12 days for half of any amount to break down. When it is released into groundwater, it takes 13–48 weeks for half of a given amount to break down because of less opportunity for evaporation. Small amounts of 1,2-DCE may break down into vinyl chloride, a more toxic chemical. Also, 1,2-DCE is a breakdown product of other volatile compounds such as trichloroethene (ATSDR 1996a).

People can be exposed to 1,2-DCE by drinking or bathing in contaminated water. Animal studies have shown that once 1,2-DCE is in the body, it is absorbed by the blood and other tissues and is eventually broken down by the liver (ATSDR 1996a).

Because levels of cis-1,2-DCE detected at the site exceeded ATSDR comparison values for drinking water, exposure doses were estimated for children and adults. If children were to drink groundwater contaminated with the maximum level of cis-1,2-DCE detected on-site (3,720 ppb), the exposure dose is estimated to be 0.4 mg/kg/day. The exposure dose for adults is estimated to be 0.1 mg/kg/day. The exposure dose for children exceeds the MRL of 0.3 mg/kg/day. The MRL for cis-1,2-DCE is based on a NOAEL from an oral study in rats. In this study, the NOAEL was 32 mg/kg/day. Therefore, harmful effects from drinking water contaminated with the maximum amount of 1-2-DCE detected at the Bountiful Plume site are not likely. Although cis-1,2-DCE was detected in domestic well water, contaminant levels did not exceed drinking water comparison values; adverse health effects are therefore, unlikely.

EPA has given cis-1,2-DCE a non-cancer rating or a "not classifiable" rating. No NTP or IARC classification exists. An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancers that were statistically significantly increasing in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b).

Methylene Chloride

Methylene chloride, also known as dichloromethane, is a colorless liquid with a mild, sweet odor. It does not occur naturally in the environment. It is used as an industrial solvent, paint stripper, is found in pesticide products, and is used in the manufacture of photographic film (ATSDR 2000).

Methylene chloride usually enters the environment through releases into the air. It does not dissolve well in water, but small amounts may be found in drinking water. Inhaling large amounts of methylene chloride can lead to dizziness, nausea, and tingling or numbness in the fingers and toes. Skin contact causes burning and redness of the skin (ATSDR 2000).

Methylene chloride was detected in groundwater samples at levels that exceed ATSDR's comparison values for drinking water. The maximum concentration of 10 ppb exceeded the cancer risk evaluation guide (CREG) but did not exceed the comparison values for non-cancer health effects. Some studies in animals provide suggestive evidence that methylene chloride may increase the incidence of liver cancer.

Exposure doses for adults and children were calculated using the maximum concentration of methylene chloride detected, 10 ppb. The exposure dose for adults is 0.0003 mg/kg/day and 0.001 mg/kg/day for children. The cancer slope factor for methylene chloride is 0.0075 $(mg/kg/day)^{-1}$. The theoretical cancer risk for children is 8×10^{-6} and 2×10^{-6} for adults, equivalent to 8 out of a million (for children) and 2 out of a million (for adults) increased cancer cases above background. These numbers suggest that the lifetime risk for an individual developing cancer from drinking groundwater is very low. An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancer type associated with exposure to vinyl chloride that was statistically significantly increasing in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b). Methylene chloride levels did not exceed the CREG in domestic well sampling.

Methyl Tert-Butyl Ether (MTBE)

MTBE is the common name for a synthetic chemical called methyl tert-butyl ether. It is a flammable liquid made from combinations of chemicals like isobutylene and methanol. It has a distinctive odor that most people find disagreeable. It was first introduced as an additive for unleaded gasoline in the 1980s to enhance octane ratings. MTBE is an oxygenating agent that enables fuel to burn more efficiently during the winter months. When MTBE is mixed with gasoline, people can come in contact with it if exposed to automobile fuel vapors or exhausts. MTBE has other special uses as a laboratory chemical and in medicine to dissolve gallstones (ATSDR 1996b).

MTBE will evaporate quickly from open containers. In the open air, it will quickly break down into other chemical compounds, with half of it disappearing in about four hours. Like most ethers and alcohols, MTBE dissolves readily in water. If MTBE is spilled on the ground, rainwater can dissolve it and carry it through the soil into the groundwater. Spills or leaks from storage containers can seep into deeper soil layers and pollute groundwater, especially near manufacturing sites, pipelines, and shipping facilities. Leakage from underground storage tanks, such as tanks at gasoline filing stations, can also add MTBE to groundwater. MTBE is not expected to concentrate in fish or plants found in lakes, ponds, and rivers (ATSDR 1996b). Exposure to MTBE can occur from auto exhaust when driving or from gasoline while fueling their cars. People can also be exposed to MTBE if they drink polluted groundwater. Low levels of MTBE can be present in both indoor and outdoor air, and are mostly linked with the use of MTBE as a gasoline additive.

More is known about how MTBE affects the health of animals than the health of humans. There is evidence that MTBE can affect kidney function in male and female rats exposed at doses as low as 100 mg/kg/day (90 days, oral gavage). At higher doses and longer exposure duration (250 and 1000 mg/kg/day respectively, oral gavage for two years), there is evidence that MTBE caused lymphoma and leukemia in female rats and testicular Leydig cell tumors in male rats (Belpoggi et al, 1995 as described in ATSDR 1996b).

Exposure dose estimates for MTBE at the Bountiful Plume site are estimated to be 1.3 mg/kg/day for children and 0.4 mg/kg/day for adults based on a maximum concentration of 13,000 ppb. These levels exceed the minimal risk level of 0.3 mg/kg/day for MTBE (ATSDR 1996). The MRL for MTBE is based on a LOAEL from an oral study in rats. In this study, the LOAEL was 100 mg/kg/day based on decreases in kidney function. Therefore, harmful effects from drinking water contaminated with the maximum amount of MTBE detected at the Bountiful Plume site are not likely.

Cancer classification for MTBE is currently under review, therefore the cancer risk from exposure to MTBE is unknown (EPA 2006b). An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancers that were statistically significantly increasing in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b). MTBE was not detected in domestic well samples and exposure doses from monitoring well groundwater are below the LOAEL. Adverse health effects from MTBE are therefore unlikely.

1,1,2,2-Tetrachloroethane

1,1,2,2-tetrachloroethane is a manufactured, colorless chemical. It is volatile and has a sweet odor. Historically, 1,1,2,2-tetrachloroethane was used to produce other chemicals, as a solvent to clean and degrease metals, and in paints and pesticides. Commercial production of 1,1,2,2-tetrachloroethane for these uses has stopped in the United States. It is presently only used as a chemical intermediate in the synthesis of other chemicals (ATSDR 1996c).

In the environment, 1,1,2,2-tetrachloroethane can be found in the air or groundwater. Breakdown of this chemical in water is relatively slow. It does not accumulate in the bodies of fish or other organisms and has not been reported in food or soil (ATSDR 1996c).

The highest level of 1,1,2,2-tetrachloroethane found in groundwater at this site was a sample that contained 33 ppb. This concentration did not exceed the drinking water comparison value of 400 ppb for children or 1,000 ppb for adults. Therefore, non-cancer health effects due to 1,1,2,2-tetrachloroethane are not expected.

The maximum concentration of 1,1,2,2-tetrachloroethane detected, 33 ppb, exceeds the comparison value for cancer effects of 0.2 ppb. Based on a concentration of 33 ppb, the estimated exposure dose for children is calculated to be 0.003 mg/kg/day and for adults it is 0.0009 mg/kg/day. The cancer slope factor for 1,1,2,2-tetrachloroethane is 0.2 $(mg/kg/day)^{-1}$. The theoretical cancer risk for children is 6×10^{-4} and 2×10^{-4} for adults. This means that if 100,000 people were exposed to 1,1,2,2-tetrachloroethane in groundwater at the concentrations, frequencies, and exposure durations assumed in the calculations for cancer risk, there would be a theoretical increase of 20 (for adults) and 60 (for children) cancers above the number of cancers that would normally be expected to occur in the population of 100,000 people. Background rates of cancer in the United States are one in two or three (NCI 2001). This means that in a population of 100,000, background numbers of cancer cases would be approximately 33,000 to 50,000. 1,1,2,2-Tetrachloroethane exposures could result in a theoretical increase of 20 (for adults) and 60 (for children) cancer cases above the background number of 33,000 to 50,000 cancer cases. This represents a relatively low increased cancer risk for children and adults. The EPA has classified 1,1,2,2-tetrachloroethane as a possible human carcinogen (no human studies and only limited animal studies); the IARC and NTP have found 1,1,2,2-tetrachloroethane to be "not classifiable". 1,1,2,2-tetrachloroethane was not detected in any of the domestic well sampling. Therefore, the cancer risk for humans exposed to this level of 1,1,2,2-tetrachloroethane is likely to be much lower than the theoretical risks indicate.

Vinyl Chloride

Vinyl chloride is a colorless gas at normal temperature. It is also known as chloroethene, chloroethylene, ethylene monochloride, or monochloroethylene. All vinyl chloride is manufactured or results from the breakdown of other manufactured substances, such as trichloroethene, trichloroethane, and tetrachloroethene. Most of the vinyl chloride produced in the United States is used to make polyvinyl chloride (PVC). PVC is used in the manufacturing of a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Other uses include furniture and automobile upholstery, wall coverings, housewares, and automotive parts (ATSDR 2004).

Liquid vinyl chloride evaporates easily into the air. Vinyl chloride in water evaporates rapidly if it is near the surface. Vinyl chloride released into the air will break down within a few days. The breakdown of vinyl chloride in air often results in the formation of other harmful chemicals. A limited amount of vinyl chloride can dissolve in water. It can enter groundwater and can also be found in groundwater with other chemicals (ATSDR 2004).

Vinyl chloride is regulated in drinking water, food, and air. Because it is a hazardous substance, regulations on its disposal, packaging, and other forms of handling also exist. EPA requires that the amount of vinyl chloride in drinking water not exceed 0.002 milligrams per liter (mg/L) of water (2 ppb). Under the EPA's Ambient Water Quality Criteria for the protection of human health, a concentration of zero has been recommended for vinyl chloride in ambient water (ATSDR 2004).

No studies were located regarding health effects in humans after oral exposure to vinyl chloride. Results from several studies in animals have suggested that breathing air or drinking water containing low levels of vinyl chloride may increase the risk of cancer. Chronic exposure of rats to vinyl chloride has resulted in tumors of the lung, liver, glands, and other organs. The effects of drinking high levels of vinyl chloride are unknown. Animal studies suggest that dermal absorption of vinyl chloride is not likely to be significant (ATSDR 2004).

The maximum concentration of vinyl chloride found in the plume was 1,560 ppb. The estimated exposure doses based on the maximum concentration of vinyl chloride detected at the Bountiful Plume were 0.2 mg/kg/day for children and 0.04 mg/kg/day for adults. Child and adult exposure doses for drinking water at the maximum level of vinyl chloride exceeded ATSDR's MRL of 0.003 mg/kg/day. ATSDR's MRL for vinyl chloride is based on a NOAEL on liver changes from a study with rats. In this animal study, the NOAEL was 0.17 mg/kg/day and the LOAEL was 1.7 mg/kg/day. The calculated exposure dose for adults for the Bountiful/Woods Cross site is less than both the NOAEL and LOAEL. The exposure dose for children is less than the LOAEL. Therefore, adverse non-cancer health effects are unlikely at the current vinyl chloride concentrations found in the groundwater.

The Department of Health and Human Services, the IARC, and the EPA have determined vinyl chloride to be a human carcinogen (ATSDR 2004). Animal studies suggest that infants and children might be more susceptible than adults to cancer induced by vinyl chloride. The cancer slope factor for vinyl chloride is 1.4 $(mg/kg/day)^{-1}$ for children and 0.72 $(mg/kg/day)^{-1}$ for adults. The theoretical cancer risk for children is 3×10^{-1} and 8×10^{-3} for adults, suggesting that the lifetime risk for an individual developing cancer from drinking groundwater is high. However, vinyl chloride has not been detected in any of the domestic well samples. Past exposure to vinyl chloride through drinking water may therefore be much lower than the concentrations found in the monitoring wells may indicate. An investigation of cancer incidence in the Bountiful/Wood Cross area did not find any cancer type associated with exposure to vinyl chloride that was statistically significantly increased in the Bountiful/Wood Cross area as compared to the state of Utah from 1978–2001 (ATSDR 2004b).

Multiple Chemical Exposure Evaluation

The potential for the toxic effects from the chemical mixture interactions of the contaminants found in groundwater at the Bountiful/Woods Cross Plume were evaluated. The health impact of exposure to chemical mixtures and the potential for combined action of chemicals may be of concern at hazardous waste sites. This evaluation included the calculation of a Hazard Index (HI) that included all of the contaminants. The HI is defined as the sum of the quotients of the estimated dose of a chemical divided by its MRL or comparable value. If the HI is less than 1.0, it is highly unlikely that significant additive or toxic interactions would occur. If the HI is greater than 1.0, further evaluation is necessary (ATSDR 2005). Using exposure doses for children, the Hazard Index for the mixture of benzene, chloroethane, cis-1,2-dichloroethene, MTBE, 1,1,2,2-tetrachloroethane, tetrachloroethene, trichloroethene, and vinyl chloride for groundwater at this site is 78.5 (the major part of this score comes from one chemical, vinyl chloride).

Since the HI for the chemical mixture at this site is greater than 1.0, the estimated doses for each individual chemical were then compared to their NOAELs or comparable values. Doses of chemicals that are less than one-tenth of their respective NOAELs are unlikely to contribute to significant additive or interactive effects with other chemicals in the mixture. Benzene, chloroethane, cis-1,2-dichloroethene, MTBE, 1,1,2,2-tetrachloroethane, tetrachloroethene, and trichloroethene all had exposure doses less than one-tenth of their respective NOAEL values and no further evaluation was performed for these chemicals. Vinyl chloride was then considered for any possible additive interactions.

Following the strategy recommended by ATSDR’s Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures (ATSDR 2004c), one ATSDR Interaction Profile was referenced for the health effects of mixtures containing 1,1,1-trichloroehtane, 1,1-dichloroethane, trichloroethylene, and tetrachloroethylene (ATSDR 2004d). This Interaction Profile listed one possible effect concerning vinyl chloride and trichloroethylene. Physiologically based pharmacokinetic (PBPK) model simulations demonstrated a less-than-additive interaction of competitive metabolic interactions between vinyl chloride and trichloroethylene with respect to liver enzyme levels. However, these interactions only occurred at relatively high concentrations.

Cancer Incidence

In 2004 the EEP conducted an investigation of cancer incidence in the Bountiful/Wood Cross area (ATSDR 2004b). A copy of that report is presented in Appendix D. That investigation evaluated cancer incidence in four census tracts; 126901, 127002, 127003, and 127004, respectively. These census tracts comprise the Bountiful/Woods Cross area.

Cancer data for that investigation were obtained from the Utah Cancer Registry for the state of Utah (comparison population) and four census tracts. These tracts surround the Bountiful/Woods Cross 5th South PCE plume and include Bountiful, West Bountiful, and the Woods Cross area. The data were broken down into the following periods: 1978–1981 (4 years), 1982–1986 (5 years), 1987–1991 (5 years), 1992–1996 (5 years), 1997–2001 (5 years), and 1978–2001 (24 years). The year 2001 was the most recent year for which complete data were available.

Standardized incidence ratios were calculated for each period and used to determine if a greater or lower risk of developing cancer exists as compared with the comparison population. Confidence intervals (95%) were applied to determine if a statistically significant difference had occurred in the number of observed cases versus the number of expected cases. Incidence rates were also age-adjusted to the 2000 U.S. Standard population (per 100,000 person years).

The results of that investigation did not find any cancer type that was statistically significantly increased at a greater frequency in the four census tracts as compared to the state of Utah from 1978–2001. However, several cancers that were not significantly increased demonstrated incidence rates consistently higher than the state of Utah in at least five of the periods evaluated (includes the cumulative period of 1978–2001). Testicular cancer demonstrated high incidence rates in five of the periods, and cancer of the soft tissue demonstrated consistently higher rates in all the periods evaluated.

CHILD HEALTH CONSIDERATIONS

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Children are at a greater risk than are adults from certain kinds of exposures to hazardous substances emitted from waste sites and emergency events. Children are more likely to be exposed because they play outdoors and because they often bring food into contaminated areas. They are more likely to come into contact with dust, soil, and heavy vapors close to the ground. Also, they receive higher doses of chemical exposures because of lower body weights. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Based on the estimated exposure doses for each chemical of concern, children are at risk for adverse health effects from drinking groundwater with the maximum reported levels of benzene, cis-1,2-dichloroethene, MTBE, and vinyl chloride.

The cancer incidence investigation conducted by the EEP in 2004 that evaluated cancer incidence rates in four census tracts (126901, 127002, 127003, and 127004) also examined the incidence of pediatric cancers in the Bountiful/Wood Cross area and found no excess of cancer among the age group of 0 to 18 years of age.

COMMUNITY HEALTH CONCERNS AND COMMENTS

In addition to the community needs assessment for the Bountiful Plume, (Appendix C), the Utah Department of Health and the Davis County Health Department conducted an analysis of community health concerns in March 2002.

The top five environmental concerns were: air pollution, over development, drinking water, noise pollution, and water quality. The top five health concerns in the community were: cancer, drugs, allergies, adequate health care, and asthma. The residents expressed their concern about environmental health risks in the area, and over half the residents responded that they were very concerned about the health risk from shallow groundwater contamination. Many residents are concerned with the decrease of property values. Residents voiced specific comments and questions that were addressed during the open house held at the Bountiful City Hall, Bountiful Utah on September 17, 2002. These comments have been reprinted in Appendix C and confidentiality has been respected. The public health assessment was released for public comment September 16, 2002, and copies of the draft document were available at the open house. An article was published in the local newspaper, the Davis County Clipper, on September 19th, 2002 notifying the public of the open house, release of the public health assessment and the public comment period. Flyers were also posed in the Davis County Health Department, local clinics surrounding the site, a post office, and grocery stores near the site. The public comment period ended October 17, 2002. No comments were received during the public comment period.

CONCLUSIONS

There is no apparent public health hazard for groundwater at the Bountiful/Woods Cross 5th South PCE Plume. Elevated levels of PCE, TCE, vinyl chloride, 1,2-DCE, MTBE, and benzene have been detected in the shallow aquifer. There are several residential wells in the area that are completed in the shallow aquifer. Most are used for irrigation; however, it is estimated that 13 homes had, in the past, used residential well water as their primary source of drinking water. Municipal wells have not shown elevated levels of contaminants, and water from these wells is considered safe to drink.

A completed exposure pathway was identified for homes with residential wells that have shown contamination of PCE; a filter has been placed on one of the wells reducing contamination to below the MCL for PCE. Past exposure occurred for residents whose wells showed levels of contamination. No completed exposure pathways currently exist for the general population.

There is currently no public health hazard for air, soil and sediment. Limited sampling data was available to assess exposures to soil, air, and surface water. The data that is available show that contaminants in air and soil samples are below their respective comparison values and therefore do not pose a public health hazard. At present, the shallow groundwater is not a source of municipal drinking water. However, if the contaminants are not removed or contained, migration of contaminants to the deeper aquifers could occur, and the drinking water supply for over 77,000 area residents could be jeopardized.

EPA and UDEQ continue to study the site and are studying remediation alternatives. The former Hatchco/J. B. Kelley Trucking facility has been named as the responsible party for Operable Unit 1 (OU1) (EPA 2002). The remaining area is comprised of Operable Unit 2 (OU2). The source areas for OU2 have been identified as the Bountiful Family Cleaners and the David Early Property (CDM 2005a). EPA recently released cleanup plans for the OU1 portion of the site; additional cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood.

Significant concern over health and environmental issues exists in the area. Community members expressed a desire for information regarding health and environment and will continue to obtain such details from newspapers, newsletters, and word-of-mouth.

There were no cancers that were significantly increasing at a greater frequency in the Bountiful, West Bountiful, and the Woods Cross area as compared to the state of Utah from 1978–2001.

RECOMMENDATIONS

- Provide the communities living near the Bountiful/Woods Cross 5th South PCE Plume site with available information.
- Continue to monitor area drinking water supplies until remediation is complete and contaminants are shown not to be entering drinking water aquifers.
- Characterize and identify sources of the plume contamination.
- Conduct periodic sampling of the thirteen residential wells at homes where it has been reported that the wells are used for drinking.
- Conduct annual sampling of the two groundwater wells at the Woods Cross Refinery that occasionally serve employees.
- Monitor development of commercial and residential property near the site and activities on the site that could further facilitate migration of contaminants.

PUBLIC HEALTH ACTION PLAN

The following public health action plan is being implemented by the UDOH EEP and other government agencies at and near the vicinity of the Bountiful/Woods Cross 5th South PCE Plume. The purpose of the public health action plan is to ensure that this public health assessment provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment from the Bountiful/Woods Cross 5th South PCE Plume.

1. The EEP community health educator has completed an environmental health needs assessment of the community and will use this as a guide to address future community concerns. The health educator will also provide the community with all available information regarding the site. A pamphlet discussing the results of the final public health assessment will be created and delivered to area residents.

2. EEP will collaborate with EPA, UDEQ and local water suppliers to monitor the area drinking water supplies until remediation is complete and contaminants are shown not to be entering the drinking water supply.

3. UDEQ and the EPA will continue to research the site, including plume delineation and remediation alternatives.

4. EEP will continue to monitor sampling of the residential wells conducted by EPA and UDEQ that are reported to be drinking water sources. EEP will provide residential well owners information on the contaminants identified in the groundwater and potential health effects.

5. EEP will continue to monitor sampling of air, soil, and surface water conducted by EPA and UDEQ in order to evaluate all possible routes of human exposure.

6. EEP will encourage Holly Refining and Marketing Company to conduct annual sampling of the two groundwater wells that occasionally serve employees at the Woods Cross Refinery, until the source of contamination has been identified and/or until contaminants are shown not to be migrating into the deeper aquifers.

7. EEP, in coordination with the Davis County Health Department, will monitor the development of commercial property near the site and activities on the site that could further facilitate migration of contaminants off-site.

8. The EEP will provide the communities living near the Bountiful/Woods Cross 5th South PCE Plume with cancer and site remediation information.

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CERTIFICATION

This Public Health Assessment, **Bountiful/Woods Cross 5th South PCE Plume, Bountiful, West Bountiful, and Woods Cross, Davis County, Utah**, was prepared by the Utah Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun. Editorial review was completed by the Cooperative Agreement partner.

Jennifer Freed
Technical Project Officer, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Alan Yarbrough
Cooperative Agreement Team Leader, DHAC, ATSDR

FIGURES AND TABLES

Figure 1. Map Showing Location of the Bountiful/Woods Cross 5th South PCE Plume

The blue square is approximately 1 mile by 1 mile

The top of the map is north.

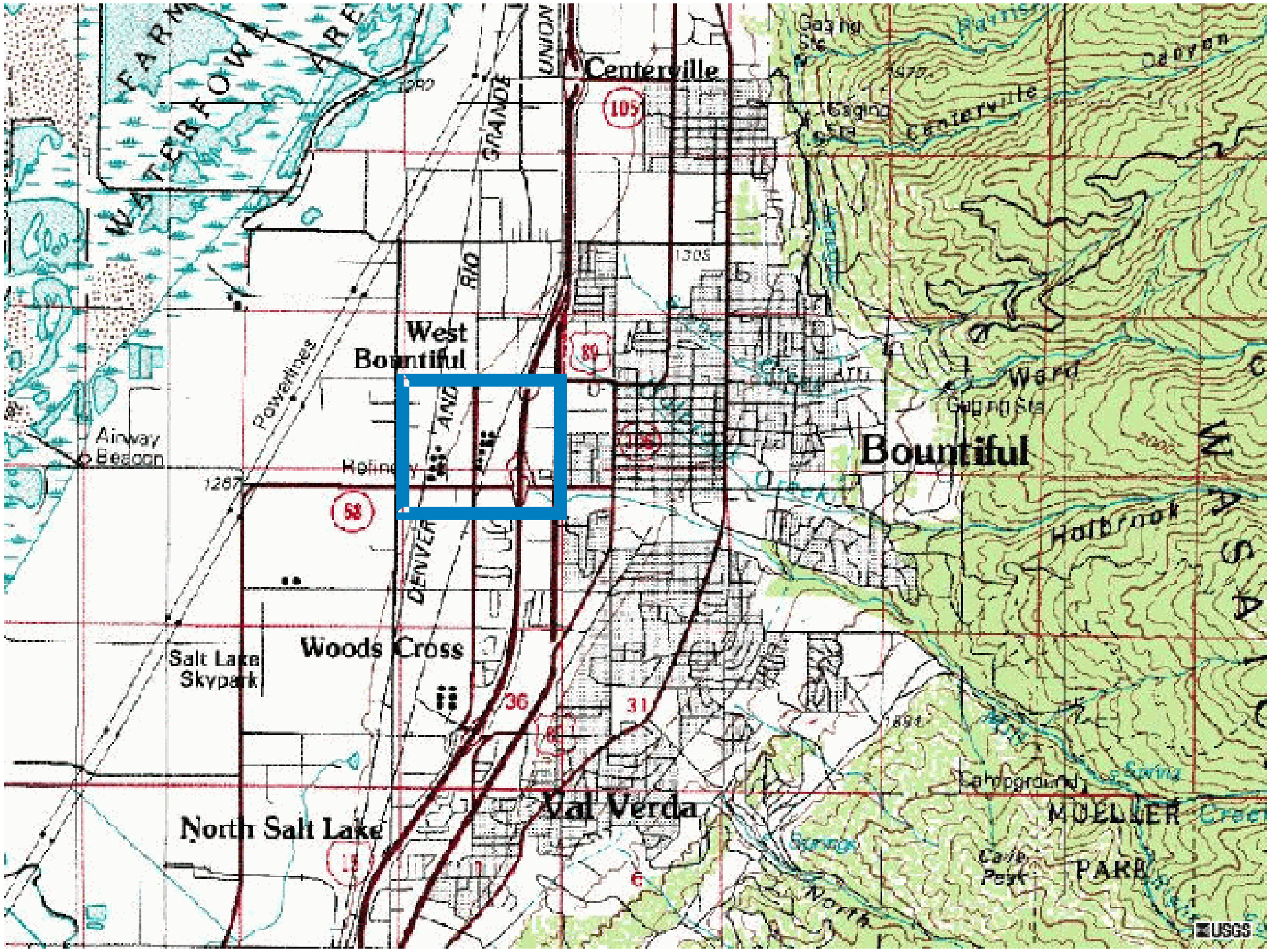

Figure 2. Plume Site Boundary.

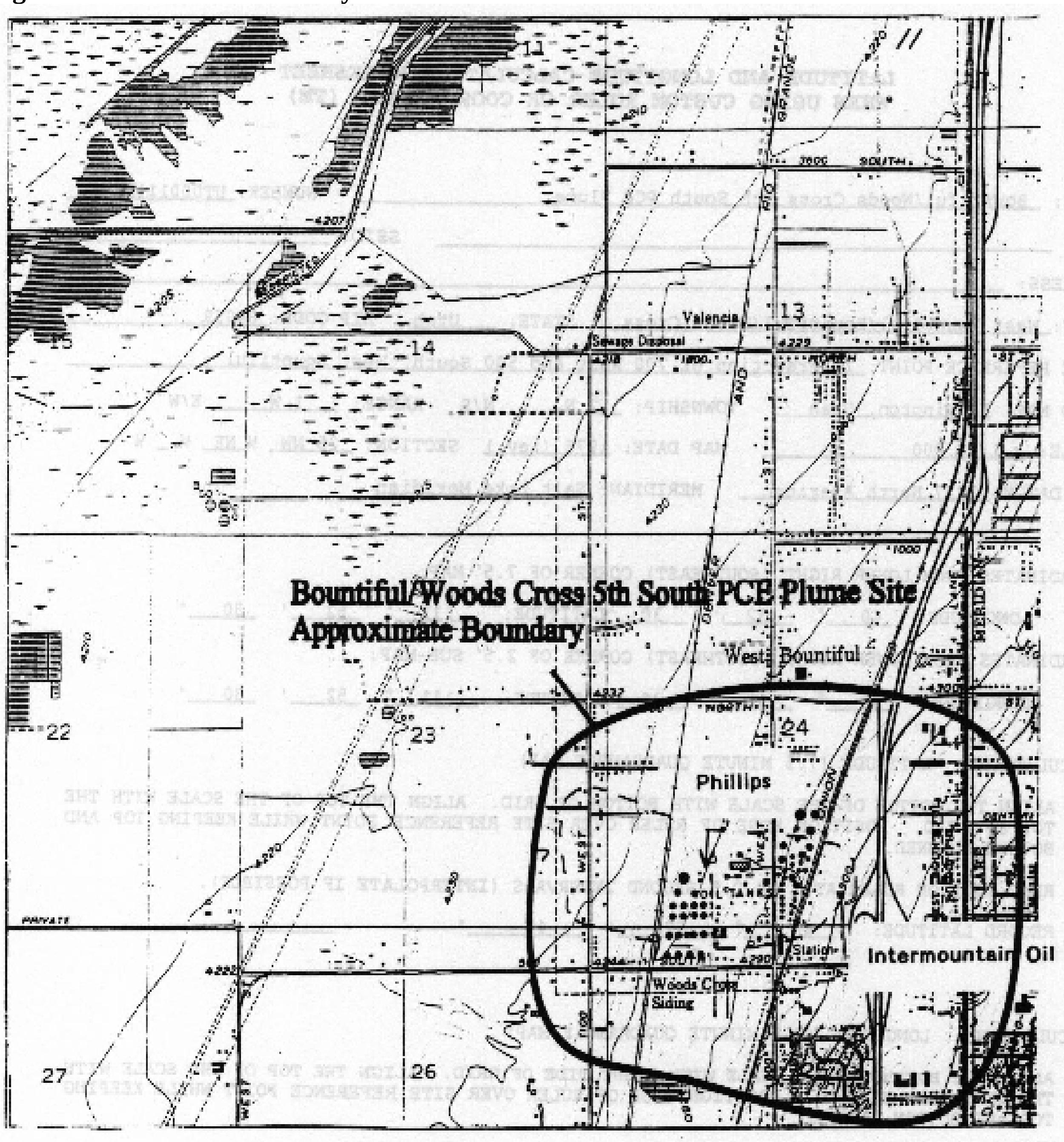

Figure 3. Demographics Introductory Map

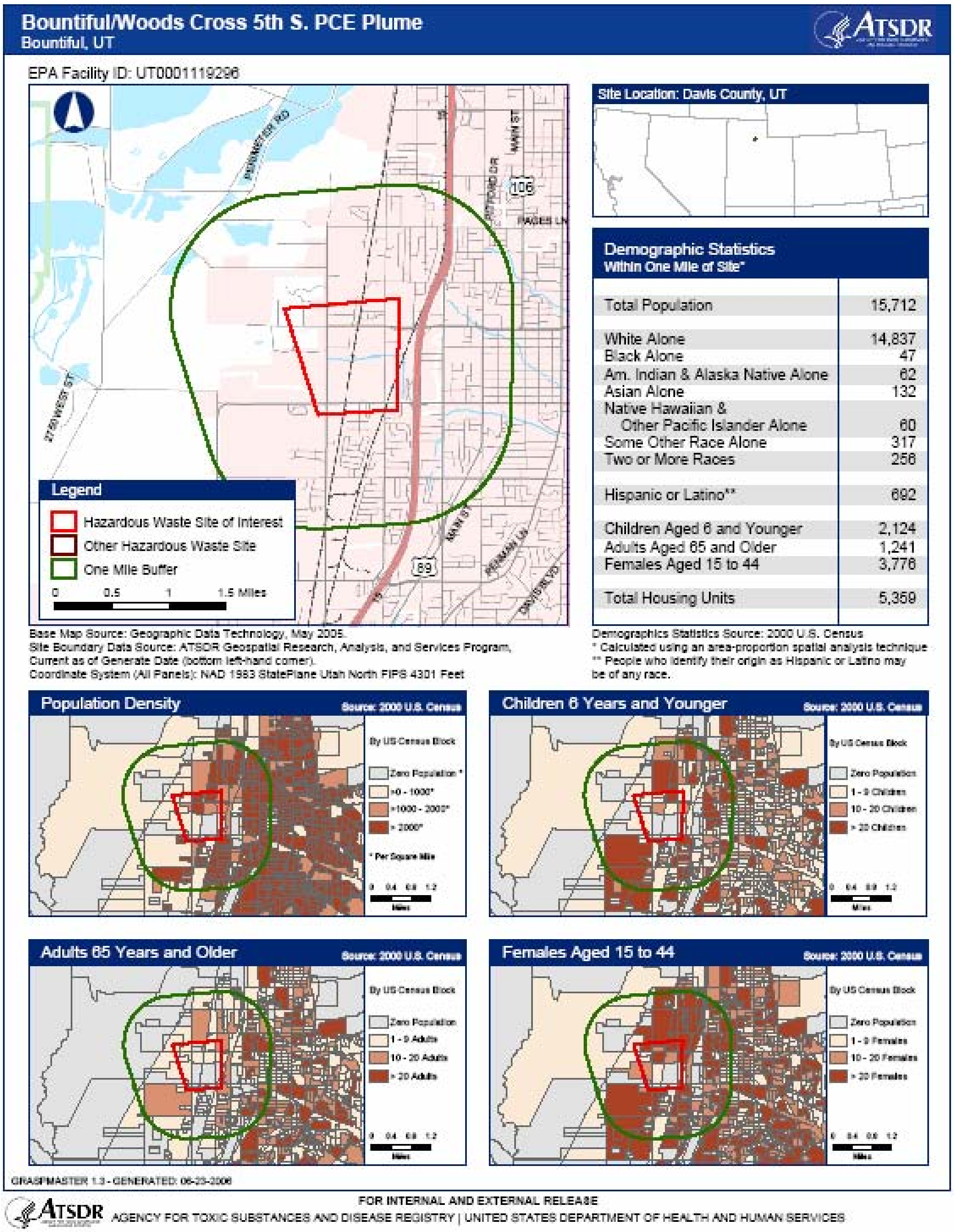

Figure 4. Map of Residential Wells On or Near Plume

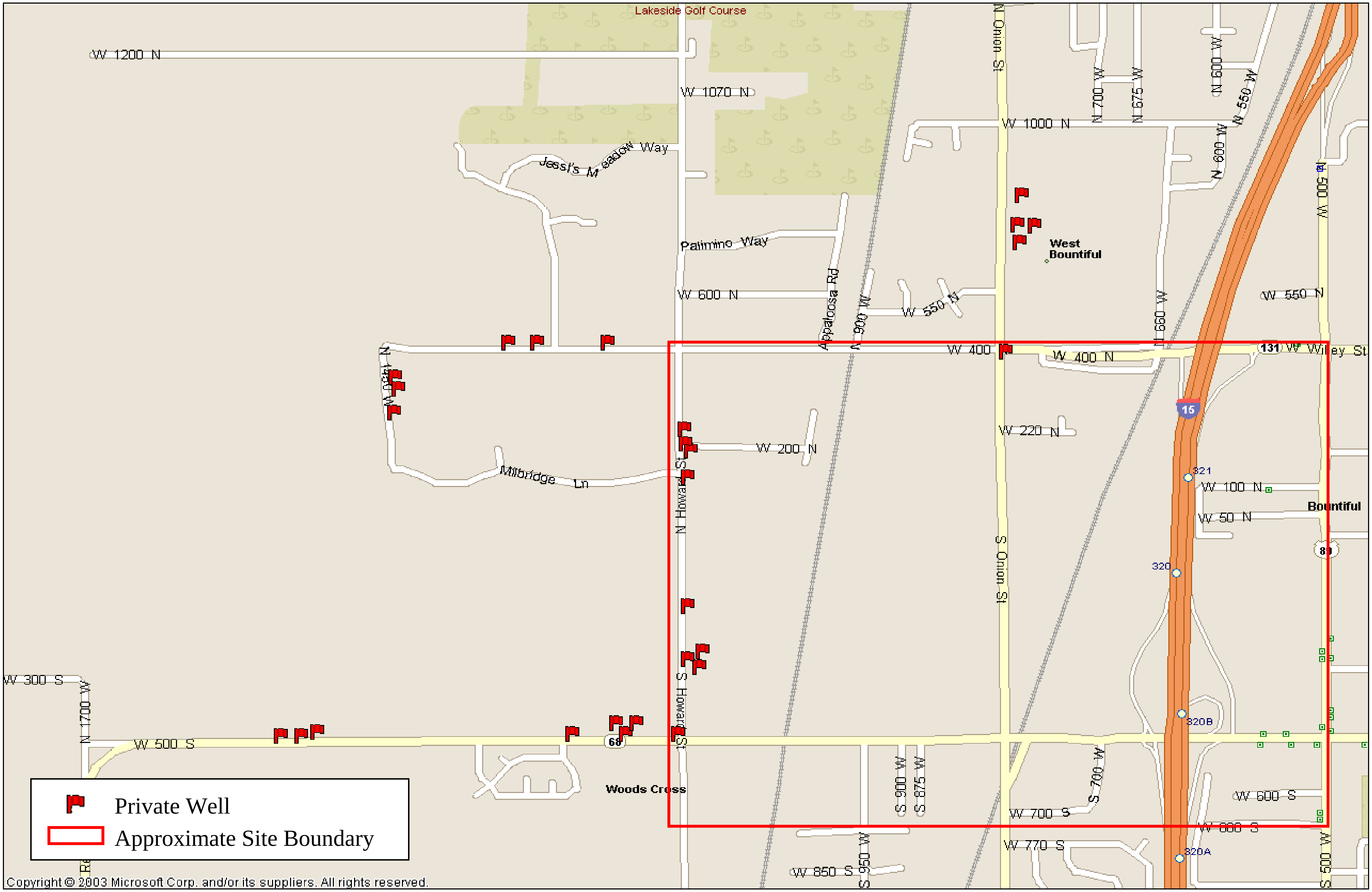

Table 1. Tetrachloroethene (PCE) Concentrations in Residential Wells near the Plume, 1996 Sampling

Well	Well Depth (feet)	Concentration of PCE (ppb) February, 1996	Concentration of PCE (ppb) March, 1996	Concentration of PCE (ppb) June, 1996	Comparison Value for PCE (MCL)	Current Well Status
R2	140’	**30**	**28**	**22**	5	Abandoned
R3	111’	**24**	**22**	**19**	5	Abandoned
114 North 1100 West	111’	N/S	**8**	**10**	5	Abandoned
324 North 1100 West	Approximately 174’	N/S	**24**	**22**	5	Used for irrigation

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
MCL: Maximum Contaminant Level, an enforceable standard calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water.
N/S: Not Sampled
Source: UDEQ 1996.

Table 2. Summary of Domestic Well Groundwater Data: Operable Unit 2, EPA/START, 1996

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1-Dichloroethene	2	26	8%	1	2	300	90	EMEG-c	NA	SU
Tetrachloroethene	18	26	69%	2	47	400	100	RMEG	NA	UR
Trichloroethene	**2**	**26**	**8%**	**1**	**6**	**5**		**MCL**	**NA**	**B2**

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: URS 1996a, URS 1996b, URS 1996c, URS 1997.

Table 3. Summary of Monitoring Well Groundwater Data: Operable Unit 2, Phillips Refinery, Golder Associates, 1987

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
Tetrachloroethene	3	4	75%	11	28	400	100	RMEG	NA	UR
Trichloroethene	3	4	75%	1	3	5		MCL	NA	B2

ppb: parts per billion
NA: not available
* See Appendix B.
Sources: Golder Associates 1987.

Table 4. Summary of Monitoring Well Groundwater Data: Operable Unit 2, Phillips Refinery, UDEQ-DERR, 1986-1998

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
Benzene	**1**	**16**	**6%**	**2**	**2**	**100**	**40**	**RMEG**	**0.6**	**A**
Carbon Disulfide	1	16	6%	11	11	4,000	1,000	RMEG	NA	3
Tetrachloroethene	15	16	94%	2	85	400	100	RMEG	NA	UR
Trichloroethene	**8**	**16**	**50%**	**1**	**7.09**	**5**		**MCL**	**NA**	**B2**

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: UDEQ 1999.

Table 5. Summary of Monitoring Well Groundwater Data: Operable Unit 2, EPA/START, 1996

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1-Dichloroethane	3	29	10%	6	11	900		RBC	NA	C
1,1-Dichloroethene	4	29	14%	1	11	300	90	EMEG-c	NA	SU
1,1,1-Trichloroethane	1	29	3%	9	9	700,000	200,000	EMEG-i	NA	D
cis-1,2-Dichloroethene (cis-1,2-DCE)	9	29	31%	6	750	10,000	3,000	EMEG-i	NA	D
Tetrachloroethene	19	29	66%	1	49	400	100	RMEG	NA	UR
trans-1,2-Dichloroethene (trans-1,2-DCE)	3	29	10%	8	19	7,000	2,000	EMEG-i	NA	D
Trichloroethene	**17**	**29**	**59%**	**1**	**980**	**5**		**MCL**	**NA**	**B2**
Vinyl Chloride	**4**	**29**	**14%**	**5**	**110**	**100**	**30**	**EMEG-c**	**0.03**	**A**

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: URS 1996a, URS 1996b, URS 1996c, URS 1997.

Table 6. Summary of Domestic Well Groundwater Data: CDM, 2002 - 2005

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class†
1,1,1-Trichloroethane	15	84	18%	0.054	3.7	700,000	200,000	EMEG-i	NA	D
1,1,2,-Trichloro-1,2,2-triflouroethane	4	70	6%	0.16	0.2	1,000,000	300,000	RMEG	NA	3
1,1-Dichloroethane	2	84	2%	0.1	0.18	900		RBC	NA	C
1,1-Dichloroethene	4	84	5%	1.0	5.5	300	90	EMEG-c	NA	SU
2-Hexanone	2	70	3%	0.82	1.4	NA	NA	NA	NA	NA
Acetone	19	70	27%	2.0	9.2	70,000	20,000	EMEG-i	NA	IN
Carbon disulfide	3	70	4%	0.029	0.037	4,000	1,000	RMEG	NA	3
Carbon tetrachloride	7	84	8%	0.043	0.11	700	200	EMEG-i	0.3	B2
Chloroform	27	84	32%	0.038	0.34	400	100	EMEG-c	NA	LI
Chloromethane	1	70	1%	0.48	0.48	3		LTHA	NA	D
cis-1,2-Dichloroethene (cis-1,2-DCE)	3	84	4%	0.057	0.2	10,000	3,000	EMEG-i	NA	D
Dichlorodifluoromethane	1	70	1%	0.038	0.038	7,000	2,000	RMEG	NA	D
Ethylbenzene	12	84	14%	0.037	0.5	4,000	1,000	RMEG	NA	D
Methylene Chloride	2	84	2%	0.17	0.24	2,000	600	EMEG-c	5	B2
Tetrachloroethene	67	84	80%	0.036	59.8	400	100	RMEG	NA	UR
Toluene	1	84	1%	0.27	0.27	700	200	EMEG-i	NA	D
Trichloroethene	30	84	36%	0.044	2	5		MCL	NA	B2
Trichlorofluoromethane	2	70	3%	0.062	0.069	10,000	3,000	RMEG	NA	D
Xylenes (total)	1	84	1%	0.36	0.36	7,000	2,000	EMEG-i	NA	IN

ppb: parts per billion
NA: not available.
† See Appendix B.
Sources: CDM 2002, CDM 2005a.

Table 7. Summary of Monitoring Well Groundwater Data: Operable Unit 2, CDM, 2002-2005

Contaminant	**Number of Detections**	**Total Number of Samples**	**Detection Frequency**	**Minimum Detected Conc. (ppb)**	**Maximum Detected Conc. (ppb)**	**Drinking Water Comparison Values (CV)**				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1,1-Trichloroethane	10	185	5%	0.042	0.44	700,000	200,000	EMEG-i	NA	D
1,1,2-Trichloroethane	3	185	2%	0.12	0.17	1,000	400	EMEG-i	0.6	C
1,1,2-Trichloro-1,2,2-trifluoroethane	3	127	2%	0.1	0.17	1,000,000	300,000	RMEG	NA	3
1,1-Dichloroethane	20	185	11%	0.24	5.7	900		RBC	NA	C
1,1-Dichloroethene	5	185	3%	0.32	1.5	300	90	EMEG-c	NA	SU
1,2-Dichloroethane	1	58	2%	2.2	2.2	100,000	10,000	EMEG-i	8	B2
Acetone	15	127	12%	2.4	100	70,000	20,000	EMEG-i	NA	IN
Benzene	**26**	**185**	**14%**	**0.019**	**4**	**100**	**40**	**RMEG**	**0.6**	**A**
Bromochloromethane	1	127	1%	0.15	0.15	90		LTHA	NA	D
Bromodichloromethane	1	127	1%	0.12	0.12	700	200	EMEG-c	0.6	B2
Bromoform	1	127	1%	0.061	0.061	7,000	2,000	EMEG-c	4	B2
Carbon Disulfide	45	127	35%	0.028	1.7	4,000	1,000	RMEG	NA	3
Carbon Tetrachloride	6	185	3%	0.058	0.13	700	200	EMEG-i	0.3	B2
Chlorobenzene	1	185	1%	0.055	0.055	10,000	4,000	EMEG-i	NA	D
Chloroethane	1	127	1%	0.77	0.77	3.6		RBC	NA	3
Chloroform	36	185	19%	0.049	13.8	400	100	EMEG-c	NA	LI
Chloromethane	2	127	2%	0.067	0.56	3		LTHA	NA	D
cis-1,2-Dichloroethene (cis-1,2-DCE)	48	185	26%	0.04	1,100	10,000	3,000	EMEG-i	NA	D
Cyclohexane	6	127	5%	0.055	1.7	12,000		RBC	NA	IN
Dichlorodifluoromethane	3	127	2%	0.06	0.17	7,000	2,000	RMEG	NA	D
Ethylbenzene	34	185	18%	0.031	4.2	4,000	1,000	RMEG	NA	D

Table 7 continued

Isopropylbenzene	1	127	1%	0.049	0.049	NA	NA	NA	NA	NA
Methyl Acetate	1	127	1%	5.3	5.3	6,100		RBC	NA	NA
Methylcyclohexane	1	127	1%	0.17	0.17	6,300		RBC	NA	NA
Methylene Chloride	**9**	**185**	**5%**	**0.19**	**10**	**2,000**	**600**	**EMEG-c**	**5**	**B2**
Naphthalene	2	58	3%	2.7	7.3	20,000	6,000	EMEG-i	NA	C
tert-Butyl Methyl Ether	**14**	**127**	**11%**	**0.046**	**13,000**	**10,000**	**3,000**	**EMEG-i**	**NA**	**3**
Tetrachloroethene	**119**	**185**	**64%**	**0.035**	**264**	**400**	**100**	**RMEG**	**NA**	**UR**
Toluene	21	185	11%	0.054	7.9	700	200	EMEG-i	NA	D
trans-1,2-Dichloroethene (trans-1,2-DCE)	26	185	14%	0.059	23	7,000	2,000	EMEG-i	NA	D
Trichloroethene	**68**	**185**	**37%**	**0.032**	**410**	**5**		**MCL**	**NA**	**B2**
Trichlorofluoromethane	4	127	3%	0.035	0.2	10,000	3,000	RMEG	NA	D
Stryrene	1	127	1%	0.041	0.041	7,000	2,000	EMEG-i	NA	C
Vinyl Chloride	**22**	**185**	**12%**	**1.3**	**84**	**100**	**30**	**EMEG-c**	**0.03**	**A**
Xylenes (total)	18	185	10%	0.033	22	7,000	2,000	EMEG-i	NA	IN

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: CDM 2002, CDM 2005a.

Table 8. Summary of Monitoring Well Groundwater Data: Operable Unit 1, TRT Tech, 1997

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1-Dichloroethane	5	13	38%	8	219	900		RBC	NA	C
1,1-Dichloroethene	1	13	8%	71	71	300	90	EMEG-c	NA	SU
Benzene	**2**	**13**	**15%**	**8**	**23**	**100**	**40**	**RMEG**	**0.6**	**A**
cis-1,2-Dichloroethene (cis-1,2-DCE)	**9**	**13**	**69%**	**3**	**3,720**	**10,000**	**3,000**	**EMEG-i**	**NA**	**D**
Ethylbenzene	3	13	23%	4	751	4,000	1,000	RMEG	NA	D
Naphthalene	4	13	31%	4	796	20,000	6,000	EMEG-i	NA	C
Tetrachloroethene	3	13	23%	3	66	400	100	RMEG	NA	UR
Toluene	1	13	8%	65	65	700	200	EMEG-i	NA	D
trans-1,2-Dichloroethene (trans-1,2-DCE)	2	13	15%	4	59	7,000	2,000	EMEG-i	NA	D
Trichloroethene	**7**	**13**	**54%**	**4**	**1,380**	**5**		**MCL**	**NA**	**B2**
Vinyl Chloride	**10**	**13**	**77%**	**16**	**1,560**	**100**	**30**	**EMEG-c**	**0.03**	**A**
Xylenes	3	13	23%	8	835	7,000	2,000	EMEG-i	NA	IN

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: UDEQ 1998.

Table 9. Summary of Monitoring Well Groundwater Data: Operable Unit 1, HDR Engineering, 2003

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1,1-Trichloroethane	6	19	32%	0.25	5.3	700,000	200,000	EMEG-i	NA	D
1,1-Dichloroethene	7	19	37%	0.4	1.52	300	90	EMEG-c	NA	SU
1,2,4-Trimethylbenzene	3	18	17%	0.35	4.49	12		PRG	NA	NA
4-Isopropyltoluene	1	18	6%	0.21	0.21	NA	NA	NA	NA	NA
Benzene	**11**	**19**	**58%**	**0.21**	**4.03**	**100**	**40**	**RMEG**	**0.6**	**A**
n-Butylbenzene	1	18	6%	0.35	0.35	240		PRG	NA	NA
Chloroethane	**3**	**19**	**16%**	**0.65**	**3.65**	**3.6**		**RBC**	**NA**	**3**
Chloromethane	5	19	26%	0.59	1.22	3		LTHA	NA	D
cis-1,2-Dichloroethene (cis-1,2-DCE)	16	19	84%	1.38	2,739	10,000	3,000	EMEG-i	NA	D
Ethylbenzene	5	19	26%	0.21	0.64	4,000	1,000	RMEG	NA	D
Isopropylbenzene	4	19	21%	0.21	0.78	NA	NA	NA	NA	NA
Naphthalene	6	19	32%	0.52	13.1	20,000	6,000	EMEG-i	NA	C
tert-Butyl Methyl Ether	2	19	11%	4.18	407	10,000	3,000	EMEG-i	NA	3
n-Propylbenzene	4	18	22%	0.34	0.56	240		PRG	NA	NA
Tetrachloroethene	16	19	84%	0.28	45.8	400	100	RMEG	NA	UR
Toluene	8	19	42%	0.31	0.81	700	200	EMEG-i	NA	D
trans-1,2-Dichloroethene (trans-1,2-DCE)	12	19	63%	0.57	34.3	7,000	2,000	EMEG-i	NA	D
Trichloroethene	**18**	**19**	**95%**	**0.95**	**1,346**	**5**		**MCL**	**NA**	**B2**
Vinyl Chloride	**14**	**19**	**74%**	**1.23**	**467**	**100**	**30**	**EMEG-c**	**0.03**	**A**
m,p-Xylene†	3	19	16%	0.73	1.32	7,000	2,000	EMEG-i	NA	IN
o-Xylene‡	3	19	16%	0.55	0.87	7,000	2,000	EMEG-i	NA	IN

Table 9 continued

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
† Comparison values for Xylenes, Total.
Sources: HDR Engineering, Inc. 2003.

Table 10. Summary of Monitoring Well Groundwater Data: Operable Unit 1, CDM, 2005

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppb)	Maximum Detected Conc. (ppb)	Drinking Water Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppb)	CV for child (ppb)	CV Source	CREG (ppb)	Cancer Class*
1,1,1-Trichloroethane	11	15	73%	0.32	540	700,000	200,000	EMEG-i	NA	D
1,1,2,2-Tetrachloroethane	**10**	**15**	**67%**	**0.11**	**33**	**1,000**	**400**	**EMEG-c**	**0.2**	**C**
1,1-Dichloroethane	8	15	53%	0.17	15	900		RBC	NA	C
2-Butanone	14	15	93%	0.17	280	20,000	6,000	RMEG	NA	IN
Benzene	**9**	**15**	**60%**	**0.2**	**150**	**100**	**40**	**RMEG**	**0.6**	**A**
Chloroethane	6	15	40%	0.21	2.8	3.6		RBC	NA	3
Chloroform	1	15	7%	0.33	0.33	400	100	EMEG-c	NA	LI
cis-1,2-Dichloroethene (cis-1,2-DCE)	5	15	33%	0.23	1.1	10,000	3,000	EMEG-i	NA	D
Cyclohexane	1	15	7%	0.25	0.25	12,000		RBC	NA	IN
Ethylbenzene	7	15	47%	0.39	30	4,000	1,000	RMEG	NA	D
Isopropylbenzene	1	15	7%	10	10	NA	NA	NA	NA	NA
Methylcyclohexane	2	15	13%	0.34	3.5	6,300		RBC	NA	NA
tert-Butyl Methyl Ether	1	15	7%	1.8	1.8	10,000	3,000	EMEG-i	NA	3
Tetrachloroethene	2	15	13%	0.17	53	400	100	RMEG	NA	UR
trans-1,2-Dichloroethene (trans-1,2-DCE)	1	15	7%	0.45	0.45	7,000	2,000	EMEG-i	NA	D
Trichloroethene	**1**	**15**	**7%**	**46**	**46**	**5**		**MCL**	**NA**	**B2**
Vinyl Chloride	**3**	**15**	**20%**	**0.16**	**0.16**	**100**	**30**	**EMEG-c**	**0.03**	**A**

Entries in **bold** indicate contaminant concentrations that exceed comparison value.
ppb: parts per billion
NA: not available
* See Appendix B.
Sources: CDM 2005a.

Table 11. Summary of Surface Soils Data: Operable Unit 1, HDR Engineering, 2003

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppm)	Maximum Detected Conc. (ppm)	Soil Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppm)	CV for child (ppm)	CV Source	CREG (ppm)	Cancer Class*
Benzene	1	13	8%	0.00109	0.00109	3,000	200	RMEG	10	A
cis-1,2-Dichloroethene (cis-1,2-DCE)	1	13	8%	0.0112	0.0112	200,000	20,000	EMEG-i	NA	D
Tetrachloroethene	1	13	8%	0.00365	0.00365	7,000	500	RMEG	NA	UR
Toluene	1	13	8%	0.0119	0.0119	10,000	1,000	EMEG-i	NA	D
Trichloroethene	2	13	15%	0.00118	0.00211	NA		NA	1.6	B2

ppm: parts per million
NA: not available
* See Appendix B.
Sources: HDR Engineering, Inc. 2003.

Table 12. Summary of Subsurface Soils Data: Operable Unit 1, TRT Tech, 1997

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppm)	Maximum Detected Conc. (ppm)	Soil Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppm)	CV for child (ppm)	CV Source	CREG (ppm)	Cancer Class*
Chloroform	1	17	6%	84	84	7,000	500	EMEG-c	NA	LI
cis-1,2-Dichloroethene (cis-1,2-DCE)	4	17	24%	77	266	200,000	20,000	EMEG-i	NA	D
1,1-Dichloroethane	1	17	6%	7	7	200,000		RBC	NA	C
Ethylbenzene	4	17	24%	11	331	70,000	5,000	RMEG	NA	D
Naphthalene	8	17	47%	15	3,140	400,000	30,000	EMEG-i	NA	C
Tetrachloroethene	2	17	12%	7.2	17	7,000	500	RMEG	NA	UR
Toluene	4	17	24%	8	77	10,000	1,000	EMEG-i	NA	D
Trichloroethene	1	17	6%	5	5	7.2		RBC	NA	B2
Vinyl Chloride	**2**	**17**	**12%**	**9**	**11**	**2,000**	**200**	**EMEG-c**	**0.5**	**A**
Xylenes	4	17	24%	25	970	100,000	10,000	EMEG-i	NA	IN

ppm: parts per million
NA: not available
* See Appendix B.
Sources: UDEQ 1998.

Table 13. Summary of Subsurface Soils Data: Operable Unit 1, HDR Engineering, 2003

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppm)	Maximum Detected Conc. (ppm)	Soil Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppm)	CV for child (ppm)	CV Source	CREG (ppm)	Cancer Class*
sec-Butylbenzene	2	15	13%	11.471	161.832	220		PRG	NA	NA
tert-Butylbenzene	1	15	7%	13.017	13.017	390		PRG	NA	NA
cis-1,2-Dichloroethene (cis-1,2-DCE)	4	15	27%	0.00366	46.241	200,000	20,000	EMEG-i	NA	D
Ethylbenzene	5	15	33%	0.051	30.574	70,000	5,000	RMEG	NA	D
Isopropylbenzene	4	15	27%	0.256	89.833	NA		NA	NA	NA
4-Isopropyltoluene	3	15	20%	0.221	39.014	NA		NA	NA	NA
Naphthalene	5	15	33%	0.0365	53.364	400,000	30,000	EMEG-i	NA	C
n-Propylbenzene	5	15	33%	0.053	67.768	240		PRG	NA	NA
Tetrachloroethene	2	15	13%	0.93	18.721	7,000	500	RMEG	NA	UR
Toluene	2	15	13%	1.89	4.326	10,000	1,000	EMEG-i	NA	D
Trichloroethene	**5**	**15**	**33%**	**0.00164**	**90.956**	**7.2**		**RBC**	**NA**	**B2**
1,2,4-Trimethylbenzene	4	15	27%	0.583	33.602	170		PRG	NA	NA
1,3,5-Trimethylbenzene	**2**	**15**	**13%**	**15.343**	**74.713**	**70**		**PRG**	**NA**	**NA**
Vinyl Chloride	1	15	7%	0.00332	0.00332	2,000	200	EMEG-c	0.5	A

ppm: parts per million
NA: not available
* See Appendix B.
Sources: HDR Engineering, Inc. 2003.

Table 14. Summary of Subsurface Soils Data: Operable Unit 2, CDM, 2002-2005

Contaminant	Number of Detections	Total Number of Samples	Detection Frequency	Minimum Detected Conc. (ppm)	Maximum Detected Conc. (ppm)	Soil Comparison Values (CV)				
						Non-Cancer CV			*Cancer CV*	
						CV for adult (ppm)	CV for child (ppm)	CV Source	CREG (ppm)	Cancer Class*
1,1,2-Trichloroethane	1	41	2%	0.004	0.004	30,000	2,000	EMEG-i	10	C
2-Butanone	3	32	9%	0.008	0.022	400,000	30,000	RMEG	NA	IN
Acetone	16	32	50%	0.004	1.5	1,000,000	100,000	EMEG-i	NA	IN
Benzene	1	41	2%	0.0007	0.0007	3,000	200	RMEG	10	A
Carbon Disulfide	11	32	34%	0.0005	0.017	70,000	5,000	RMEG	NA	3
cis-1,2-Dichloroethene (cis-1,2-DCE)	20	41	49%	0.001	0.16	200,000	20,000	EMEG-i	NA	D
Cyclohexane	3	32	9%	0.0005	0.01	140		PRG	NA	IN
Ethylbenzene	1	41	2%	0.002	0.002	70,000	5,000	RMEG	NA	D
Methylcyclohexane	1	32	3%	0.012	0.012	2,600		PRG	NA	NA
Methylene Chloride	14	41	34%	0.001	0.017	40,000	3,000	EMEG-c	90	B2
Tetrachloroethene	8	41	20%	0.001	0.19	7,000	500	RMEG	NA	UR
Toluene	7	41	17%	0.0005	0.11	10,000	1,000	EMEG-i	NA	D
trans-1,2-Dichloroethene (trans-1,2-DCE)	5	41	12%	0.009	0.006	100,000	10,000	EMEG-i	NA	D
Trichloroethene	5	41	12%	0.0009	0.01	NA		NA	1.6	B2
Vinyl Chloride	4	41	10%	0.001	0.004	2,000	200	EMEG-c	0.5	A
m,p-Xylene†	2	9	22%	0.0003	0.0006	100,000	10,000	EMEG-i	NA	IN
o-Xylene†	1	9	11%	0.0004	0.0004	100,000	10,000	EMEG-i	NA	IN
Xylenes (total)	2	32	6%	0.003	0.003	100,000	10,000	EMEG-i	NA	IN

ppm: parts per million
NA: not available
* See Appendix B.
† CV for xylenes (total).
Sources: CDM 2002, CDM 2005a.

Table 15. Indoor Air and Sub-Slab Vapor – Operable Unit 2 – February 2005

Contaminant	Comparison Values (CV)		Results - Maximum Concentration (µg/m³)				
			Bountiful Family Cleaners		David Early Property	Retail Store Hallway	
	CV (µg/m³)	CV Source	Indoor Air	Sub-slab Air	Sub-slab Air	Indoor Air	Sub-slab Air
Tetrachloroethene (PCE)	678,000	PEL	19,000	120,000	900	13	430
Trichloroethene (TCE)	134,000	REL	ND	340	5.8 J	ND	1.9 J
1,1,1-trichloroethane	1,900,000	PEL	ND	ND	150	ND	ND
1,2,4-trimethylbenzene	125,000	REL	120	650	29	3.5 J	48
1,3,5-trimethylbenzene	125,000	REL	46 J	320	6.8 J	ND	11
Benzene	320	REL	ND	7.3	3.4 J	3.5	3.2
Ethylbenzene	435,000	REL	ND	16	34	4.3	16
Toluene	375,000	REL	45 J	100	110	320	96
o-Xylene	435,000	REL	46 J	71 J	32	3.8	24
m-, p-Xylene	435,000	REL	36 J	110	120	10	62

µg/m³ = Micrograms per cubic meter.
NA = Not available.
ND = Non-detect; J = Estimated concentration.
Entries in **bold** indicate contaminant concentrations that exceed comparison value.
Chemicals measured but not detected include: 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride.
Source: CDM 2005b.

Table 16. Completed Exposure Pathways

Pathway Name	**Exposure Pathway Elements**					**Time Frame**	**Chemical(s)**
	Source	*Environmental Medium*	*Point of Exposure*	*Route of Exposure*	*Receptor Populations*		
Residential wells	Hatchco and Holly Refining Properties	Drinking water from residential wells	Faucets in homes with residential wells	Ingestion, Skin Contact	Residents	Past, Present, Future	Tetrachloroethene Trichloroethene

Table 17. Potential Exposure Pathways

Pathway Name	Exposure Pathway Elements					Time Frame	Chemical(s)
	Source	*Environmental Medium*	*Point of Exposure*	*Route of Exposure*	*Receptor Populations*		
Groundwater	Hatchco and Holly Refining Properties	Groundwater	Municipal and/or residential wells	Ingestion, Inhalation, Skin Contact	Workers, Residents	Past, Present, Future	Benzene, Chloroethane cis-1,2-DCE, MTBE Methylene Chloride 1,1,2,2,-Tetrachloroethene Tetrachloroethene Trichloroethene Vinyl Chloride
Indoor Air	Bountiful Family Cleaners/ David Early Property	Ambient Air	Inhalation of ambient air contaminated by soil gas	Inhalation	Workers	Past, Present, Future	Benzene, Toluene, Tetrachloroethene 1,2,4-Trimethylbenzene 1,3,5-Trimethylbenzene
Subsurface Soil	Hatchco and Holly Refining Properties	Soil	Soil contact	Ingestion, Skin Contact	Workers, Residents	Past, Present, Future	Trichloroethene 1,3,5-Trimethylbenzene Vinyl Chloride

Table 18. Estimated Exposure Doses with Non-Cancer Guidelines for Residential Well Water and Groundwater Contaminants

Contaminant	Sample Media	Maximum Concentration* (ppb)	Estimated Exposure Dose (mg/kg/day)		Non-Cancer Health Guideline Comparison Value (mg/kg/day)	Source
			Child	Adult		
Benzene	Groundwater	150	**0.02**	0.004	0.004	EPA Chronic Oral RfD
Chloroethane	Groundwater	3.65	0.0004	0.0001	0.4	EPA Region 3 RfDo
cis-1,2-Dichloroethene	Groundwater	3,720	**0.4**	0.1	0.3	Oral MRL - intermediate
Methyl-T-Butyl Ether	Groundwater	13,000	**1.3**	**0.4**	0.3	Oral MRL - intermediate
Tetrachloroethene	Residential Well Water	30	0.003	0.0009	0.05	Oral MRL - acute
	Groundwater	264	0.03	0.008		
Trichloroethene	Residential Well Water	6	0.0006	0.0002	0.2	Oral MRL - acute
	Groundwater	1,380	0.1	0.04		
Vinyl Chloride	Groundwater	1,560	**0.2**	**0.04**	0.003	Oral MRL - chronic

Exposure Dose values in **bold** exceed the Health Guideline Comparison Values.
* Concentration of contaminant exceeds ATSDR Comparison Values. To adequately protect the population, the maximum concentration has been used for screening purposes. This concentration, however, may not be representative of current plume conditions.

Table 19. Estimated Exposure Doses with Cancer Guidelines for Groundwater Contaminants

Contaminant	Sample Media	Maximum Concentration* (ppb)	Receptor Population	Estimated Exposure Dose (mg/kg/day)	EPA Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Cancer Risk
1,1,2,2-Tetrachloroethane	Groundwater	33	Child	0.003	0.2	6×10^{-4}
			Adult	0.0009		2×10^{-4}
Benzene	Groundwater	150	Child	0.02	0.055	1×10^{-3}
			Adult	0.004		2×10^{-4}
Methylene Chloride	Groundwater	10	Child	0.001	0.0075	8×10^{-6}
			Adult	0.0003		2×10^{-6}
Vinyl Chloride	Groundwater	1,560	Child	0.2	1.4	3×10^{-1}
			Adult	0.04	0.72	8×10^{-3}

* Concentration of contaminant exceeds ATSDR Comparison Values. To adequately protect the population, the maximum concentration has been used for screening purposes. This concentration, however, may not be representative of current plume conditions.

APPENDICES

Appendix A: Calculations

Comparison Values
Comparison values (CVs) are used in public health assessments and serve as a screening tool to identify contaminants that will require further evaluation.

Comparison Value Calculations
Each year, ATSDR updates their list of Comparison Values for selected compounds in soil, air, and water. EMEGs, RMEGs, and CREGs are all examples of comparison values. When the compound of interest is not listed, comparison values can be calculated as follows:

for non-carcinogenic health effects:
EMEG = MRL x BW / IR

RMEG = R_fD x BW / IR

for carcinogenic health effects:
CREG = $10E^{-6}$ x BW / IR x OSF

Where:	EMEG	=	Environmental Media Evaluation Guide (ppm)
	MRL	=	Minimal Risk Level (mg/kg/day)
	RMEG	=	Reference Dose Media Evaluation Guide
	R_fD	=	Reference Dose
	CREG	=	Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk
	OSF	=	Oral Slope Factor
	BW	=	Body Weight (kg)
		=	70 kg for an adult
		=	10 kg for a child
	IR	=	Water Ingestion rate (liter/day)
		=	2 L/day for an adult
		=	1 L/day for a child

Exposure Dose
The comparison value calculations described above are derived using standardized exposure assumptions. At some sites, the existing conditions may result in exposures that differ from those used to derive Comparison Values such as the EMEG. In these situations, the health assessor can calculate site-specific exposures more accurately using an exposure dose. The exposure dose can then be compared to the appropriate toxicity values (MRL, RfC, RfD).

Calculating Exposure Dose (ED) for drinking water [ATSDR 2005]:

ED = {(C x IR x EF) / BW}

Where: C = Contaminant level (mg/liter)

IR = Water Ingestion rate (liter/day)
= 2 liters/day for an adult
= 1 liter/day for a child

EF = Exposure Factor; an exposure factor of "1" was used for this health assessment (1 represents daily exposure to the contaminant rather than intermittent exposure. This assumes that the person is using home water as the primary drinking source).

BW = Body Weight (kg)
= 70 kg for an adult
= 10 kg for a child

Calculating Exposure Dose (ED) for inhalation of air [ATSDR 2005]:

ED = {(C x IR x EF) / BW}

Where: C = Contaminant level (mg/m^3)

IR = Intake rate (m^3/day)
= 11.3 m^3/day for an adult female
= 15.2 m^3/day for an adult male

EF = Exposure Factor (unitless) of 0.22, as calculated below

BW = Body Weight (kg)
= 70 kg for an adult

Air Exposure Factor (EF):
Adults exposed at workplace for 40 hours/week, 50 weeks/year, for 30 years.

EF = (40 hrs/week)*(1 day/24 hrs)*(50 weeks/year)*(30 years) / (30 years)*(365 days/year)
= 0.22

Appendix B: Acronyms & Terms Defined

Background Level The amount of a chemical that occurs naturally in a specific environment.

Cancer Classes Each health organizations has a separate method of cancer classification:

Environmental Protection Agency (EPA) (Based on 1986 cancer assessment guidelines):

- A = Human Carcinogen.
- B1 = Probable Human Carcinogen (based on limited human and sufficient animal studies).
- B2 = Probable Human Carcinogen (based on inadequate human and sufficient animal studies).
- C = Possible Human Carcinogen (no human studies and limited animal studies).
- D = Unlikely to be a Human Carcinogen
- E = Evidence of noncarcinogenicity in humans

Environmental Protection Agency (EPA) (Based on 2003 cancer assessment guidelines):

- CA = Carcinogenic to humans
- LI = Likely human carcinogen (cancer potential established; but limited human data)
- SU = Suggestive evidence (human or animal data suggestive)
- IN = Inadequate (data inadequate to assess)
- NO = Robust data indicate no human carcinogen.

International Agency for Research on Cancer (IARC)

- 1 = Carcinogenic to Humans (sufficient human evidence).
- 2A = Probably Carcinogenic to Humans (limited human evidence; sufficient evidence in animals).
- 2B = Possibly Carcinogenic to Humans (limited human evidence; less than sufficient evidence in animals).
- 3 = Not Classifiable
- 4 = Probably Not Carcinogenic to Humans

National Toxicology Program (NTP)

- 1 = Known Human Carcinogen
- 2 = Reasonably anticipated to be a carcinogen
- 3 = Not Classified

Comparison Values CVs; Health-based and media-specific concentrations that are used to select environmental contaminants for further evaluation in public health assessments. These values are not valid for other types of media, nor do concentrations above these values indicate that a health risk actually exists (agency that developed the value is in parenthesis for the examples below):

Examples of Comparison Values for non-cancer health effects

EMEG-c	=	Environmental Media Evaluation Guide for chronic (more than 365 days) exposure (ATSDR).
EMEG-i	=	Environmental Media Evaluation Guide for intermediate exposure (ATSDR).
EMEG-u	=	Environmental Media Evaluation Guides that are unpublished are designated with an asterisk by the authors of this health assessment and used only in the absence of published comparison values and are calculated using equations outlined in Appendix A.
RMEG	=	Reference Dose Media Evaluation Guide (ATSDR).
NPDWR	=	National Primary Drinking Water Regulations (EPA) accessed on web at: www.epa.gov/safewater/mcl.html
LTHA	=	Lifetime health advisory for drinking water (EPA).

Example of a Comparison Value for cancer health effects

CREG	=	Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk (ATSDR).

Completed Exposure Pathway A way in which people can be exposed to a contaminant associated with a site. An exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A completed exposure pathway has all of the 5 following elements:

1) A source of contamination
2) Transport through environmental medium
3) A point of exposure
4) A route of human exposure
5) An exposed population

CREG **Cancer Risk Evaluation Guides** are based on a contaminant concentration estimated to increase the cancer risk in a population by one individual in one million people over a lifetime exposure.

EMEG **Environmental Media Evaluation Guides** are media-specific comparison values used to select contaminants of interest at hazardous waste sites. EMEGs are derived from Minimal Risk Levels (MRLs), developed by the Agency for Toxic Substances and Disease Registry (ATSDR), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e. children). MRLs are guidelines and are not used to predict adverse health affects. MRLs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.

Exposure Dose At some sites, the existing conditions may result in exposures that differ from those used to derive Comparison Values such as the EMEG. In these situations, the health assessor can calculate site-specific exposures more accurately using an exposure dose. The exposure dose can then be compared to the appropriate toxicity values (MRL, RfC, RfD).

Health-Based Comparison Values see "Comparison Value" entry.

ICP Inductively Coupled Plasma.

LOAEL The **Lowest Observable Adverse Effect Level** (LOAEL) is the lowest exposure level of a chemical that produces significant increases in frequency or severity of adverse effects.

LTHA **Lifetime Health Advisory** for drinking water from EPA.

MCL A **Maximum Contaminant Level** is an enforceable standard calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water.

MRL A **Minimal Risk Level** (MRL) is defined as an estimate of daily human exposure to a chemical that is likely to be without an appreciable risk of deleterious non-cancer health effects over a specified duration of exposure. Thus, MRLs provide a measure of the toxicity of a chemical.

PEL **Permissible Exposure Limit** for a hazardous substance or condition in the workplace as defined by the Occupational Safety and Health Administration (OSHA) General Industry Air Contaminants Standard (29 CFR 1910.1000).

NOAEL The **No Observable Adverse Effect Level** (NOAEL) is the exposure level of chemical that produces no significant increases in frequency or severity of adverse effects. Effects may be produced at this dose, but they are not considered to be adverse.

NPDWR **National Primary Drinking Water Regulations** are legally enforceable standards that apply to public water systems. Primary standards are available on the web at: http://www.epa.gov/safewater/mcl.html

NPL site The National Priorities List (NPL) is a list published by EPA ranking all the Superfund sites. Superfund is the common name for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a federal law enacted in 1980. This law was preauthorized in 1986 as the Superfund Amendments and Reauthorization Act. CERCLA enables EPA to respond to hazardous waste sites that threaten public health and the environment. A site must be added to the NPL site list before remediation can begin under Superfund.

Potential Exposure Pathway
A possible way in which people can be exposed to a contaminant associated with a site. An Exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A potential exposure pathway has 4 of the 5 following elements:
1) a source of contamination
2) transport through environmental medium
3) a point of exposure
4) a route of human exposure
5) an exposed population

PRG
Preliminary Remediation Goals. Used for EPA Planning Purposes only.

Public Health Hazard
The category ATSDR assigns to sites that pose a health hazard to the public as the result of long-term exposures to hazardous substances. See "Public Health Hazard Categories".

Public Health Hazard Categories
Categories defined by ATSDR and used in public health assessments that assess if people could be harmed by conditions present at a site. One of the following categories is assigned to each site:

Category A: Urgent Public Health Hazard
Category B: Public Health Hazard
Category C: Indeterminate Public Health Hazard
Category D: No Apparent Public Health Hazard
Category E: No Public Health Hazard

REL
Recommended Exposure Limit for a hazardous substance or condition in the workplace as defined by the National Institute for Occupational Safety and Health (NIOSH).

RMEG
Reference Dose Media Evaluation Guides are media-specific comparison values used to select contaminants of interest at hazardous waste sites. RMEGs are derived from reference doses (RfDs), developed by the U.S. Environmental Protection Agency (EPA), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e. children). RfDs are guidelines and are not used to predict adverse health affects. RfDs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.

EPA The **U.S. Environmental Protection Agency** is the federal agency that develops and enforces environmental laws to protect the environmental and public health.

Appendix C: Community Needs Assessment
Bountiful/Woods Cross 5th South PCE Plume

1. By December 2003, provide information on groundwater pollution to the residents of Bountiful, West Bountiful, and Woods Cross.

2. By December 2007, the residents who participated in the previous survey will have a follow up questionnaire to detect if there is a greater awareness of the groundwater pollution.

Social Assessment

The Bountiful/Woods Cross PCE Plume is located from approximately 750 South to 400 North, and from 400 West to 1100 West. The Bountiful/Woods Cross PCE Plume crosses over three cities in Davis County: Bountiful, West Bountiful, and Woods Cross. This site incorporates private residences, agricultural land, commercial properties, interstate highway, and railroad tracks.

The Bountiful/Woods Cross site consists of a contaminated groundwater plume. The contaminated groundwater covers approximately 245 acres. Tetrachloroethene (PCE) has been detected at 24 feet and as deep as 150 feet below ground level. Approximately 5,900 wells have been constructed in the East Shore Aquifer servicing a population of over 45,000 within a four-mile radius of the site.

The first detection of PCE and trichloroethene (TCE) was in 1986. An investigation in 1987 was conducted at the Phillips 66 Refinery in an attempt to identify the potential source of PCE. Elevated levels of PCE were detected both up-gradient and down-gradient of the refinery. The United States Environmental Protection Agency (EPA) sampled residential wells. Four of the residential wells were found to contain elevated levels of PCE. The residents were notified and supplied with bottled water.

Several potential sources were identified in 1996, these include dry cleaners, a waste oil refinery, automotive maintenance facilities, and an oil refinery. The main route of exposure is the groundwater.

Sampling in August 2000 down-gradient of the Phillips 66 Refinery indicated TCE and PCE at elevated levels in three monitoring wells. Samples analyzed in September 2000, from permanent monitoring and residential wells, confirmed the presence of PCE, TCE, vinyl chloride and other contaminants at elevated levels.

The Bountiful/Woods Cross plume is approximately 10 miles north of Salt Lake City. The total population for Davis County is 238,994. According to the 2000 U.S. Census Bureau[5], the median family income was $58,329. The public education system in Davis County consists of elementary schools, middle schools, high schools, and vocational schools. This is an urban area

[5] U.S. Census Bureau 2000. United States Census 2000, May 2003, http://factfinder.census.gov

that is growing rapidly. Thirty-nine percent of the population in Bountiful, Woods Cross, and West Bountiful are 19 years old or younger. Seventeen percent of the families in Davis County fell below poverty level. Ninety percent of the residents in Davis County are high school graduates or higher. Twenty-eight percent of the residents in Davis County have earned a bachelor’s degree or higher.

According to the 2000 U.S. Census Bureau for Davis County, the population consists of the following races: 92.3% of the population is White, 5.4% are Hispanic or Latino, 1.5% are Asian, 1.5% are Black or African American, 0.6% are American Indian or Alaska Native, 0.3% are Native Hawaiian and Other Pacific Islander, and 0.1% are some other race.

In March 2002, the Utah Department of Health (UDOH) worked with the Davis County Health Department (DCHD) to develop a survey for distribution to the residents of Bountiful West Bountiful and Woods Cross. The purpose of this survey was to evaluate the public’s knowledge concerning two National Priorities Listed (NPL) sites, the International Waste and Oil Refinery (IWOR) and Bountiful Woods Cross 5th South PCE Plume.

Behavioral and Environmental Assessment

One of the objectives of the March 2002 survey was to determine the awareness and insights of the community. Examples of questions asked were: what they knew about the sites, if they would like to know more, and what they do not know. With this information we will be able to educate the residents better. Residents will be able to make informed decisions concerning their health to reduce exposure. The DCHD and the UDOH analyzed the survey to know how to better meet the needs of the community.

Community Concerns

A survey was mailed out March 2002, to 1,000 residents of Bountiful, West Bountiful, and Woods Cross. Of the residents that responded to the survey, 33% of the residents have lived in the area from 1-10 years; 18% responded living in the area for 31-40 years; 16% have lived in the area for 11-20 years.

The top five environmental concerns were: air pollution, over development, drinking water, noise pollution, and water quality. The top five health concerns in their community were: cancer, drugs, allergies, adequate health care, and asthma. Sixty-six percent responded that they were concerned about environmental health risks in the area. Most of the residents are concerned with the decrease of property values. Over half the residents responded that they were very concerned about the health risk from shallow groundwater contamination. Almost 92% are not aware of the EPA cleanup process.

Most of the residents responded that they would be likely to attend a public information meeting. Almost all of the residents responded that they would be interested in learning more about the superfund process. Eighty-nine percent answered that they would like more information about the groundwater contamination, the superfund process, and the EPA cleanup process.

A few comments the residents wrote in the survey are recorded as:

- "The air sometimes outside smells terrible. My family has always lived in Davis County along with friends. They all seem to die of strange illnesses. I think refineries are causing serious health problems."
- "Some say the high percent of cancer in our area is from our age factor as we are in an aging area. I believe there are too many cases to attribute that explanation."
- "I would request that the public be well informed so that we all work together to resolve the problem and not create more problems with witch-hunt accusations."
- "What is the contaminate in these plumes? What is the likelihood of them getting into the drinking water?"
- "I have a concern about the smell of my tap water. Sometimes it smells like rotten eggs."
- "What areas are contaminated? What is the contaminate? What is the extent of contamination? What health problems etc., could these contaminants cause or currently be responsible for? What steps are currently in the process to eradicate this contaminate."
- "Where can I find out more about the "pollution plumes" in our area and the superfund clean up?"
- "Thank you for making me aware of this. We tried to find environmental information about my area but haven't succeeded. What is a good resource to know what is going on? What is a "Superfund site?""
- "What does it mean to be listed as Federal Super Fund Site? What exactly have I gotten in my drinking water and how much?"
- "I'm more concerned about air quality in my area. I'd like more information about refinery odor."
- "Air quality is a great concern. I may be more concerned about water quality if I learn more about contamination potentials."
- "We would like to know where the two pollution plumes are located and if these areas are near our home, etc."
- "Has any information been given to residents to Bountiful about their 2 sites before this survey, and if so where can I find that info?"
- "This seems to be another environmental scare tactic. Similar to the legacy highway problems with the sierra club, rocky Anderson, et al."
- "We are very concerned about the safety of our family and the protection of them and our property."
- "I would like to know how can I protect me and my family concerning water contamination, what about risks in my garden and what I harvest, are we at risk eating them?"

Educational and Organizational Assessment

According to the March 2002 survey, most of the residents had not heard about the 5th South PCE plume. We have informed residents by distributing a flyer and pamphlet explaining the sites. Information such as what the contamination is, location, and how to protect themselves and their families from coming in contact with the contaminants. An announcement for a public meeting was also included in the flyer, along with the local newspaper, the Davis County Clipper.

The public meeting was held in September 2002, to answer questions and discuss the specifics of the chemicals and necessary procedures. The residents were given information of the cleanup process, potential dangers, and how to protect themselves. The community meeting involved several agencies, including the UDOH, the DCHD, the Utah Department of Environmental Quality (UDEQ), and the EPA.

The information provided at the meeting was mailed to all of the residents that listed their address on the survey to receive more information about the site. After the meeting the community was encouraged to express their comments, concerns and mailing information a sheet of paper we provided. All of the addresses received from the surveys in March 2002, along with those collected at the community meeting, were put on a mailing list to receive additional information about the site.

Future community meetings will take place as new data is collected in order to update the residents of the current information and address any questions that may arise. A newsletter was provided following the community meetings to ensure that all of the residents had an opportunity to review the information discussed. Additional pamphlets were produced and will be distributed as needed.

Predisposing- knowledge, attitudes, beliefs, values
According to the survey, 80% of the residents were not aware of the EPA listing two pollution plumes in the area. Only 10.5% of the residents knew of specific areas with contaminated shallow groundwater or contaminated soil. The majority of residents in the area did not know of specific locations where groundwater contamination had been detected. One resident stated that this was just another scare tactic. Most of the residents are very concerned about their property values. Over half of the residents that responded said they would be somewhat likely to attend a community meeting.

Enabling- skills, resources, or barriers help hinder the desired behavior
Many residents are unaware of the chemicals that have been found in the shallow aquifer of the groundwater. With education provided by the EEP, community members will be able to protect themselves and make informed decisions. The residents will also have the resources to locate more information on the chemicals or the groundwater in their area. The source of contamination has not yet been pinpointed; this may lead some of the residents to speculate if it will be found and if it is a problem. With resources available, individuals will be informed and know if they need to be concerned about their property value.

Reinforcing- rewards received from others following the adoption of desired behavior
A majority of the residents own their homes in this community, which caused them to be very concerned about the property values. If the contamination is cleaned up, then this may result in an increase in their property values. By receiving educational material, the residents will know the health concerns or what the health risks are in their community. Having resources available, individuals will be better informed and have a better understanding if there is a concern considering property value.

Administrative and Policy Assessment
According to the March 2002 survey, the residents would prefer to receive information in the future via newspaper, 46%; word of mouth, 36.5%; newsletter, 23%; public meeting, 6.9%; direct contact, 5.2%; internet, 3.3%; and library 0.9%. As new information becomes available regarding the site, a press release will be sent to the Davis County Clipper. A newsletter will also be mailed to the surrounding residents to inform them of cleanup efforts, upcoming activities, and any additional information about the Bountiful/Woods Cross 5th South PCE Plume.

Implementation
In September 2002, a community meeting was held to discuss the issues surrounding the Bountiful/Woods Cross site, as well as another site of concern, the International Waste Oil Refinery. The UDOH, the EPA, and the UDEQ were invited to the meeting and each discussed how their agency was involved in the site. The agencies also answered questions that any of the residents may have had concerning the site and chemicals. The UDOH has developed a site-specific pamphlet for the residents that attended the community meeting. A comment card was given to the residents to fill out after attending the meeting.

A newsletter/pamphlet will be mailed to the residents when new information is available to keep the public informed about the site. Additional material will be mailed out as needed.

Process evaluation
At the community meeting a survey will be given to each person. This survey will ask if the information they received was in an effective manner; if it was the information they need; and if they would like to learn more, and how often.

Impact evaluation
In 2007, the EEP will send out another survey to the residents surrounding the site, similar to the initial survey. This survey will examine if the residents have an increased knowledge about the site, and if they feel that the education provided was efficient to the needs of the community.

Outcome evaluation
The outcome evaluation will be completed after completion of the goals and objectives.

References:
1. EPA. Bountiful/Woods Cross 5th South PCE Plume. www.epa.gov/region08/superfund/sites/intmtnref.html. January 2002.
2. EPA. State, Tribal and Site Identification Center NPL Site Narrative at Listing, www.epa.gov/superfund/sites/npl/nar1579.html. January 2002.
3. Utah Department of Health, Public Health Assessment. Bountiful/Woods Cross 5th South PCE Plume

Appendix D: An Investigation of Cancer Incidence in Bountiful/Woods Cross.

Health Consultation

AN INVESTIGATION OF CANCER INCIDENCE
IN CENSUS TRACTS 126901, 127002, 127003, AND 127004

BOUNTIFUL, WEST BOUNTIFUL, AND WOODS CROSS,
DAVIS COUNTY, UTAH

CERCLIS # UT0001119296

September 28, 2004

Utah Department of Health
Office of Epidemiology
Environmental Epidemiology Program
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Table of Contents

Summary

The Bountiful/Woods Cross 5th South PCE Plume is located approximately 11 miles north of Salt Lake City, in the Bountiful, West Bountiful, and Woods Cross areas of Davis County, Utah. The contaminated groundwater plume is approximately 245 acres in size. The U.S. Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (UDEQ) continue to study the extent of the contamination. The primary contaminants in the groundwater are tetrachloroethene (PCE) and associated volatile organic compounds (VOCs) such as trichloroethene (TCE), dichloroethene (DCE), vinyl chloride, methyl-tert-butyl-ether (MTBE) and benzene. The Agency for Toxic Substances and Disease Registry (ATSDR) has requested that the Environmental Epidemiology Program (EEP) of the Utah Department of Health conduct this public health consultation to identify health hazards posed by this plume. The site is classified as an indeterminate health hazard until more information is collected.

In 1996, EPA and UDEQ discovered PCE, TCE, DCE, vinyl chloride, and related chemicals in the groundwater in the Bountiful/Woods Cross area. PCE is a synthetic chemical used for dry cleaning fabrics and metal-degreasing, as well as other industrial uses. TCE, DCE, and vinyl chloride are breakdown products of PCE. In the Bountiful/Woods Cross area, exposure to PCE, TCE, 1,2-DCE, MTBE, vinyl chloride, and benzene is possible from drinking water from contaminated wells (monitoring and residential). Forty-five municipal wells are located within a four-mile radius of the site. The wells are public supply wells for the south Davis County area and are part of blended drinking water systems. Three of the wells are within 1/4 to one mile of the site. Only the Woods Cross Well #1, located at 300 West 1500 South in Bountiful, has been contaminated with PCE above the maximum contaminant level.

EPA and UDEQ continue to study the site to identify other possible sources of contamination. Additional sampling was conducted in June 2003. Results indicate that contaminant levels, with the exception of PCE, are below levels harmful to human health. Cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood. A plan of action has been designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment from the Bountiful/Woods Cross 5th South PCE Plume.

Concerned local residents requested the Environmental Epidemiology Program to evaluate the incidence of cancer in the Bountiful/Woods Cross 5th South PCE Plume area.

Cancer data for this investigation were obtained from the Utah Cancer Registry for the state of Utah (comparison population) and for census tracts 126901, 127002, 127003, and 127004, respectively. These tracts surround the Bountiful/Woods Cross 5th South PCE plume and include Bountiful, West Bountiful, and the Woods Cross area. The data were broken down into the following periods: 1978–1981 (4 years), 1982–1986 (5 years), 1987–1991 (5 years), 1992–1996 (5 years), 1997–2001 (5 years), and 1978–2001 (24 years). The year 2001 was the most recent year for which complete data were available.

Population demographics for the selected census tracts and the state of Utah were obtained from 1970, 1980, 1990, and 2000 U.S. Census data. The state of Utah was selected as the comparison population *minus* the population and the observed number of cases found in the census tracts.

Standardized incidence ratios were calculated for each period and used to determine if a greater or lower risk of developing cancer exists as compared with the comparison population. Confidence intervals (95%) were applied to determine if a statistically significant difference had occurred in the number of observed cases versus the number of expected cases. Incidence rates were also age-adjusted to the 2000 U.S. Standard population (per 100,000 person years) (a unit of incidence measurement)

The results of the investigation did not find any cancer type that was statistically significantly increasing at a greater frequency in the Bountiful, West Bountiful, and the Woods Cross area as compared to the state of Utah from 1978–2001. However, several cancers that were not significantly increased demonstrated incidence rates consistently higher than the state of Utah in at least five of the periods evaluated (includes the cumulative period of 1978–2001). Testicular cancer demonstrated high incidence rates in five of the periods, and cancer of the soft tissue demonstrated consistently higher rates in all the periods evaluated.

IEEP is recommending that the communities living near the Bountiful/Woods Cross 5th South PCE Plume be provided with cancer and site remediation information and a copy of this health consultation.

Background

Site Description

The Bountiful/Woods Cross 5th South PCE Plume (henceforth referred to as the Bountiful Plume) is located between 400 North to 750 South, and 200 West to 1100 West in the Bountiful/Woods Cross area of Davis County. This site is in north-central Utah, approximately 11 miles north of Salt Lake City and is sandwiched between the Wasatch Mountains to the west and the Great Salt Lake to the east (Appendix A). More specifically, "the site is bounded by private residences and agricultural lands on the west, commercial properties and residences to the south, industrial sites and residential properties to the north, and interstate highway 15, railroad tracks, and commercial properties progressively farther east" (1). (ATSDR needs to be consistent with reference citing protocols)

The extent of the contaminated groundwater is approximately 245 acres (1). The vertical depth of contamination is unknown but may be over 100 feet deep (1). The plume has not yet been completely defined, and the investigation is still underway. Multiple sources are likely in this area (2). The former W. S. Hatchco/J. B. Kelley Trucking facility located at 643 South 800 West has been identified as a responsible party for a portion of the site.

In the Bountiful Plume area, exposure to PCE, TCE, 1,2-DCE, MTBE, vinyl chloride, and benzene is possible from drinking water from contaminated wells. Water from municipal wells is considered safe to drink.

Possible sources for these types of contaminants include businesses that routinely use solvents, generally as cleaning agents. Dry cleaners, automotive and machinery shops, and facilities with waste oil tanks (often inappropriately used to containerize solvents) are among the most likely sources for this type of contamination. Migration routes for contaminants include spills, leaks from containers, and leaks from sewer lines.

EPA and UDEQ continue to study the site to identify other sources of contamination. Additional sampling was conducted in June 2003. Results indicate that contaminant levels, with the exception of PCE, are below levels harmful to human health. Cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood.

In response to the concerns of local residents regarding the level of cancer in the area of interest, the Environmental Epidemiology Program was requested to evaluate the incidence of cancer within the surrounding area of the Bountiful Plume that include census tracts 126901, 127002, 127003, and 127004.

Study Methods

Cancer Data

Data for this investigation were obtained directly from the Utah Cancer Registry. The Utah Cancer Registry receives reports on each newly diagnosed case of cancer in Utah from hospitals, radiation therapy facilities, pathology laboratories, nursing homes, and physicians. Each newly diagnosed case is assigned to the census tract of residence at the time of diagnosis.

The data from the Utah Cancer Registry was separated by cancer site/type, sex, age group, and year of diagnosis for the residents of the study area (2000 census tracts 126901, 127002, 127003, and 127004) and the state of Utah. Cases were grouped by year into periods. The following periods were used: 1978–1981 (4 years), 1982–1986 (5 years), 1987–1991 (5 years), 1992–1996 (5 years), 1997–2001 (5 years), and 1978–2001 (24 years). The year 2001 was the most recent year for which complete data was available, and 1978 was the first year in which census tract data was available.

Census Data

The population demographics for the study area (2000 census tracts 126901, 127002, 127003, and 127004) and for the state of Utah were obtained from the 1970, 1980, 1990, and 2000 U.S. Census data, provided electronically by Geolytics CensusCD products. The intercensal populations were estimated linearly from the 1970, 1980, 1990, and 2000 populations. The population estimates were based on the assumption of a constant rate of growth (Appendix B).

Geographic Data

The 2000 census tracts 126901, 127002, 127003, and 127004 were selected for this study because the tract boundaries closely correspond to the area of concern within Bountiful, West Bountiful, and Woods Cross, and for other data consistency considerations. Census tract 126901 has remained relatively constant throughout the study period. The 1980 census tract 127000 split into two tracts and became 127001 and 127002 in 1990. In the 2000 census, 127001 split again into two tracts and became 127003 and 127004 (Appendix C).

Comparison Population

A comparison population to the study population was selected to evaluate whether the observed cases in the study population are statistically different from that which would be expected if the population had not been at any special risk. The state of Utah, minus the population of the study area, was used as the comparison population for this investigation. From this point after, census tract 126901, 127002, 127003, and 127004 will be referred to as the *Bountiful/Woods Cross area* and the state of Utah will be referred to as *Utah*, unless otherwise specified.

Statistical Analysis

Standardized incidence ratios (SIR) were used for the quantitative analysis of cancer incidence in the evaluation areas and different time periods (3). A SIR was calculated for each period and used to determine if a greater or lower risk of acquiring a disease or condition exists among comparison populations. The SIR is calculated by dividing the crude observed count by the expected count (4). The ratio of observed to expected is then used to determine if a greater or lower risk exists between populations of acquiring a disease or condition. The expected count was calculated by multiplying the age-specific comparison rate (Utah) by the age-specific population of the study population (Bountiful/Woods Cross area) and summing the results. A SIR of 1.0 indicates rates are equal no increased risk exists. A SIR greater than 1.0 indicates an increased risk for the study group, while a SIR less than 1.0 indicates a decreased risk for the study group. Random fluctuations may account for some SIR deviations from 1.0 (Appendix D).

The statistical significance of deviations from SIR=1.0 was evaluated using a 95% confidence interval. The confidence interval for the SIR is the range within which the true SIR value has a specified probability of being included. The specified probability is called the confidence level, and the endpoints of the confidence interval are called the confidence limits. We calculated the confidence limits using the method of Frumkin and Kantrowitz (1987). By assessing the confidence interval, we obtained information about the variability of the data and the statistical significance of the SIR. The differences between the observed versus the expected (or SIRs >1.0) were considered significant (not a random occurrence or due to chance alone) if the confidence interval does not include 1.0. Statistical significance here does *not* mean causally associated. It does mean that the recognized association has stability and may need further evaluation.

The SIRs and associated confidence intervals were calculated using a Microsoft Excel 2002 spreadsheet. The statistical formula for the SIR confidence interval (95%) is presented in Appendix D.

Age-Adjusted Rates

Age-adjusted rates of morbidity (per 100,000 person-years) were calculated through direct standardization and adjusted to the 2000 U.S. Standard Population. This adjustment provides a basis for comparison across populations by reducing the effects of differences in the age distributions of the population being compared. It is computed by using the weighted age-specific rates in the population of interest and the proportions of the persons in the corresponding age groups within a standard population. From this point after, the age-adjusted rates will be referred to as *incidence rates* or *rates*, unless otherwise specified.

Literature Search

A literature search was conducted for associations between the cancers found to be elevated and the contaminants of concern in this investigation. This investigation used the National Library of Medicine's Medical Literature Analysis and Retrieval System (MEDLINE®). The computer files of the National Library of Medicine consist of more than 30 biomedical databases. MEDLINE® contains more than 20 years of bibliographic data from more than 3,600 major medical journals. Our search analysis included bibliographic data for the years 1970 through 2003.

Cancers of Concern

This investigation evaluated all the cancers reported to the cancer registry from 1978–2001 that occurred in the Bountiful/Woods Cross area. The following are the cancers that have a potential association to one or more of the contaminants of concern. The International Classifications of Diseases for Oncology codes are listed next to each of the cancers.

Brain (C71.9)	*Testis (C62.9)*	*Lung (C34.0)*
Liver (C22.0)	*Kidney (C64.9)*	*Myeloid leukemia (M-9860/3)*
Soft tissue (C49.9)	*Esophagus (C15.9)*	

Non-Hodgkin's lymphoma and chronic lymphocytic leukemia (M-9591/3)

Note: Chronic lymphocytic leukemia is now considered a non-Hodgkin's lymphoma (5). Therefore, despite being classified separately by the International Classifications of Diseases for Oncology, the cases for non-Hodgkin's lymphoma and chronic lymphocytic leukemia (NHL/CLL) were combined.

Results

The results of the investigation did not find any of the cancers evaluated to be statistically significantly increasing at a greater frequency in the Bountiful/Woods Cross area as compared to Utah from 1978–2001. This investigation did find two cancers (testis and soft tissue) for which most of the SIRs (and rates) were not statistically significant but were elevated in each of the periods evaluated. These cancers, along with cancer of the esophagus, brain, lung, liver, kidney, NHL/CLL, and myeloid leukemia, are presented below.

Interpretation of these results should be approached cautiously because of the small number of cases diagnosed in any of the periods evaluated.

Tables that present the incidence rates (per 100,000 person years) and the SIRs (with confidence intervals) for the cancers mentioned above are presented in Appendix E.

Cancer of the Testis

The incidence rates of cancer of the testis exceeded the rates of Utah in every period except for 1992–1996. The SIRs were also greater than 1.0 (highest SIR = 1.93) in every period but one (1987–1991). The cumulative SIR (1978–2001) was 1.47, and the cumulative rate also exceeded the rate of Utah (rates = 7.75 vs. 5.42). (See Table 1).

Soft Tissue Cancer

The incidence rates of cancer of the soft tissue exceeded the rates of Utah in every period evaluated, including the cumulative period from 1978–2001. However, these rates are based on periods with less than three cases from 1978–1996. The SIRs were also greater than one in all the periods evaluated. The highest SIR was observed in 1987–1991 (SIR = 1.56), and the highest incidence rate was observed during 1997–2001 (rate = 4.56). (See Table 2)

Brain Cancer

The incidence rate of brain cancer exceeded the rate of Utah in two periods: slightly in 1987–1991 (rates = 7.20 vs. 7.12) and more than doubled in 1997–2001 (rates = 15.70 vs. 6.73). Except for the period of 1997–2001 (SIR = 2.06), all SIRs were less than 1.0. During the period 1997 – 2001, the observed number of cases (n = 10) exceeded the expected number (n = 4.9) by two times the expected rate. Cumulatively, the rates were slightly higher than the rate of Utah, with a SIR just slightly over 1.0 (SIR = 1.08). (See Table 3)

Lung Cancer

The incidence rates and SIRs of lung cancer were higher in 1978–1981 (rate = 35.70, SIR = 1.13) and in 1997–2001 (rate = 41.69, SIR = 1.34) as compared to Utah. The rates (and SIRs) have been increasing since 1992–2001. (See Table 4)

Liver Cancer

Incidence rates of liver cancer exceeded the rates of Utah for two periods. During 1978–1981 the incidence rate for liver cancer was slightly higher than the rate of Utah (rates = 3.22 vs. 1.92). However, this rate is based on a period with less than three cases. During 1992–1996 the incidence rate was almost three times higher as compared to Utah (rates = 7.84 vs. 2.74). The SIR during this period was 2.53. (See Table 5)

Cancer of the Kidney

Only one period (1997–2001) was observed where the SIR (1.17) exceeded 1.0, where the observed number of cases exceeded the expected, and where the incidence rate exceeded the rate of Utah (rate = 11.27 vs. 9.28). The SIRs and the incidence rates of cancer of the kidney have increased steadily from 1978–2001. (See Table 6)

NHL/CLL

The observed number of cases of NHL/CLL have increased from 1987–2001. However, the observed number of cases did not exceed the expected number of cases in any period evaluated. During one period 1978–1981,the incidence rate exceeded the rate of Utah. The highest SIR was observed in period 1992–1996 (SIR = 1.07). The cumulative SIR was 0.89. (See Table 7)

Myeloid Leukemia

The incidence rates of myeloid leukemia have fluctuated from 1978–2001. The highest incidence rate was observed during 1982–1986 (rate = 8.17). The cumulative SIR (0.80) was less than 1.0, and the incidence rate (3.85) was below the rate of Utah (rate = 4.87). (See Table 8)

Esophagus

Cancer of the esophagus did not have enough cases to evaluate from 1978–2001.

Discussion

The Bountiful Plume is an indeterminate public health hazard. The site characterization is currently incomplete and still under evaluation by UDEQ and EPA. The site contains residential, commercial, and agricultural areas. A crude oil refinery, formerly owned by Phillips 66, is in the center of the site. (The Woods Cross refinery was acquired by Holly Corporation in June 2003.) This area has a contaminated groundwater plume that is approximately 245 acres in size. The contaminants of concern include PCE and associated chemicals, such as TCE and vinyl chloride. With the exception of Woods Cross Well #1, located at 300 West 1500 South in Bountiful, these chemicals have not affected the wells used for the municipal/city water system. The Woods Cross Well #1 has been contaminated with PCE above the maximum contaminant level[1]. Forty-five municipal wells are located within a four-mile radius of the site.

Possible sources for these types of contaminants include businesses that routinely use solvents, generally as cleaning agents. Dry cleaners, automotive and machinery shops, and facilities with waste oil tanks (often inappropriately used to containerize solvents) are among the most likely sources for this type of contamination. Migration routes for contaminants include spills, leaks from containers, and leaks from sewer lines.

In response to the concerns of local residents, the Environmental Epidemiology Program examined the issue of whether an excess of cancer is present in the Bountiful/Woods Cross area. The cancers identified by this investigation that have risk factors associated with chronic exposures to PCE, TCE, and vinyl chloride (primarily through occupational exposures), MTBE, and benzene include non-Hodgkin's lymphoma, renal cell carcinoma, esophageal adenocarcinoma (6), liver cancer (7), brain cancer, cancer of the soft tissue (8), and some cancers of the blood (9). This investigation did not find a statistically significant increase in non-Hodgkin's lymphoma, kidney (or kidney related), esophageal, liver, brain, soft tissue, lung, testicular, blood-related cancers, or any other cancer type in any of the periods evaluated. Of the cancers mentioned above, only cancer of the soft tissue exceeded the incidence rates of Utah in every period evaluated.

[1] A Maximum Contaminant Level (MCL) is calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water. MCLs are enforceable standards.

Some variation in cancer rates simply occurs by chance within a family, neighborhood, or community. During the period of 1997 – 2001 the number of brain cancers in the Bountiful/Woods Cross area exceeded the expected number by twice of what would be expected; however, this SIR was not significant. Scientifically, it is difficult to prove that an environmental pollutant caused a cancer increase in a community. Cancer increases identified in a community may not be the result of any single, external cause or hazard. Increases that have scientifically been attributed to a specific cause have been those with chronic occupational exposures. Workers (such as in a factory) are more likely to develop a particular type of cancer because of exposures to a chemical(s) they handle every day. Scientific evidence that links an environmental contaminant(s) to an increased occurrence of cancer is sparse.

Some evidence indicates that chemicals (such as arsenic and chlorination by-products) dissolved in drinking water may elevate the risk of gastrointestinal and urinary tract cancers (10, 11). No evidence has found that gastrointestinal cancers or urinary tract cancers were significantly elevated in the Bountiful/Woods Cross area.

Other cancers that were elevated, but were not statistically significant, were cancer of the testis, and prostate. No literature was found that associated human cancer of the testis and prostate with chronic occupational or environmental exposures to PCE, TCE, or vinyl chloride. One animal study did cite sperm and testicular damage (noncancerous) to animals with long-term exposure to vinyl chloride (9).

This investigation tried to determine if the residents were being exposed to the contaminants and from what source. At this time, no exposure pathway has been identified at this site. The EPA and UDEQ will continue to study the site and try to identify sources of contamination and any potential exposure pathways to the residents. Cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood.

Cancer Risk Factors

Cancer is a name applied to many diseases with many different causes. Cancers are very common. Nearly half of all men and one-third of all women in the U.S. population will develop cancer at some point in their lives (12). Statistically, it is normal for cancer rates to fluctuate in smaller communities. Some years the rates are higher, other years lower; the rates tend to balance out over time.

When a subset of the population is found to have an increased rate of cancer, no definitive tests exists to determine which risk factors caused the cancer. Individual cases may result from unique risk factors present in that population or from background risk factors or genetic factors present in the general population. For example, the expected rate of a particular cancer in the general population may be 100 cases, and a particular occupational group is found to have 120 cases. No test currently can determine which 20 individuals developed the disease due to the specific risks associated with their profession (or environmental exposures) and which 100 would have occurred anyway.

Characterizing types of cancers, cancer rates, and causal relationships to environmental exposures without exposure measurements or data is difficult. People live and work in many environments and are exposed to complex mixtures of toxic pollutants at home, at work, and in the ambient environment. In addition, only a relatively small percentage of cancers can be attributed to environmental factors. A breakdown of the proportion of cancer deaths, attributed to various behavioral and environmental factors, is listed in the following table (13).

Behavioral and environmental factors	*Percentage attributed to cancer mortality*
Diet	*35%*
Tobacco	*30%*
Infections	*10%*
Reproductive and sexual behavior	*7%*
Occupation	*4%*
Alcohol	*3%*
Geophysical	*3%*
Pollution	*2%*
Medicine and medical procedures	*1%*
Industrial products	*<1%*
Food additives	*<1%*
Unknown	*?%*

From the percentages noted above, we can conclude that of the total cancer mortality attributed to environmental factors, pollution and geophysical factors account for only 5% of the cancer mortality, whereas personal behavior/lifestyle accounts for approximately 75% of the cancer mortality.

The following are risk factors associated with the etiology of the following cancers: testis, prostate, soft tissue, brain, lung, liver, kidney, NHL/CLL, chronic and acute lymphocytic leukemia, and acute and chronic myeloid leukemia.

Testicular

Testicular cancer is relatively uncommon in the United States. It is more commonly diagnosed in men ages 20–44 years. Testicular cancer accounts for only 1% of all cancers in men, and is more commonly diagnosed in whites. (11). Risk factors include cryptorchidism (undescended testicles), family history, occupational exposures, and HIV infection, and being white. About 14% of cases of testicle cancer occur in men with a history of cryptorchidism, but up to 25% of cases occur in the normally descended testicle. Men with Klinefelter's syndrome (a sex chromosome disorder that may be characterized by low levels of male hormones, sterility, breast enlargement, and small testes) are at greater risk of developing testicular cancer (8). Occupational risks include workers exposed to metals, metal dust, and cutting oils, miners, oil and gas workers, leather workers, food and beverage processing workers, janitors, and utility workers (11). A study in which male rats were given high doses of methyl-*tertiary*-butyl ether reported a significant increase in testicular cancer (14).

Soft Tissue

Soft tissue cancer is a general category that includes cancer occurring in muscle, heart, subcutaneous, and other related tissues. Because this category includes a number of different types of cancer, it is difficult to define the etiology associated with all cancers of the soft tissue. In addition, we do not yet know all of the risk factors that may lead to the development of soft tissue cancer. Soft tissue (and bone) malignant tumors are common tumors in children. It is also referred to as musculoskeletal sarcoma, which means a cancer of mesenchymal tissues, such as the bone, soft tissues, and connective tissue. This type of cancer is highly malignant and harmful to children (15).

Workers who were exposed to phenoxyacetic acid in herbicides and chlorophenols in wood preservatives, as well as workers exposed to vinyl chloride, may have an increased risk. High doses of radiation have caused soft tissue sarcomas in some patients. Patients with AIDS (acquired immune deficiency syndrome) often develop Kaposi's sarcoma, which has different characteristics and is treated differently than typical soft tissue cancer. Certain inherited diseases, such as Li-Fraumeni syndrome and von Recklinghausens's disease, are associated with an increased risk for soft tissue cancer (8).

Brain

In the United States, 17,000 new primary cancers of the nervous system are diagnosed each year. These are among the most (rapidly) fatal of all cancers, and only about half (52%) of patients are still alive 1 year after diagnosis. Brain cancer is the 10th most common type of death from cancer. The etiology of the majority of nervous system tumors remains unknown. Environmental agents, such as ionizing radiation, have been clearly implicated in the etiology of brain tumors. Other physical, chemical, and infectious agents suspected of being risk factors have not yet been established as etiologically relevant. Factors associated/suspected in the etiology of childhood and adult brain cancer include N-nitroso compounds, exposure to low frequency electromagnetic fields, pesticides, insecticides, radiation exposure, infections, alcohol consumption, lead, hair dye and spray, barbiturates, chemotherapy (in utero), medications, familial history, and race (11). Brain cancer may also be connected with breathing vinyl chloride over long periods (16).

Lung and Bronchus

Smoking is by far the leading risk factor of lung cancer. Passive smoking is also a risk factor. Exposure to radon and asbestos are additional factors leading to lung cancer. Smoking plus these exposures greatly increases the cancer causing effects of asbestos and radon. Cancers of the lung increase after radiotherapy for Hodgkin's disease. Excess lung cancers of all types have been reported from military exposures to atomic and thermonuclear weapons. Smoking and radiation exposure also appear to have an additive effect on lung cancer. Occupational lung cancer may result from exposure to inorganic arsenic compounds from insecticides and pesticides and during smelting or tin mining. The risk of lung cancer, mesothelioma, and asbestosis is increased in various asbestos industries. Those include mining, milling, and shipbuilding; textile, gas mask, friction products, and insulation manufacturing; and among cement workers. A high risk of lung cancer was reported in workers exposed to bis(chloromethyl)ether (BCME). Risk appears to decrease after exposure stops, suggesting that the chemical may affect late as well as early stages of carcinogenesis. (11). An excess of lung cancer has been reported among persons with high dietary intake of foods rich in fat and cholesterol. Other risk factors implicated in lung and bronchus cancer are exposure to asbestos, coal gas, nickel, polycyclic hydrocarbons, chromium, arsenic (11), chlormethyl ethers (17), radon (18), and arsenic, asbestos and coal (19, 20, 21). Tuberculosis has also been identified as a risk factor for lung and bronchus cancer (22). More than 2% of the population in Utah will be affected with lung and bronchus cancer in their lifetime (23). Lung cancer may also be connected with breathing vinyl chloride over long periods of time (16). In a study of workers exposed to dry cleaning solvents (carbon tetrachloride, TCE, and PCE) an excess of lung cancer was observed (24).

Liver

The greatest risk factor for cancer of the liver is persistent infection with the hepatitis B or C virus. This accounts for more than three quarters of the world's cases. The remaining cases are caused by exposures that damage the liver, such as excessive alcohol consumption, and exposures that may be directly genotoxic, such as dietary aflatoxin (primarily produced by two *Aspergillus* species of mold) and tobacco use. Exposure to diagnostic thorium dioxide has been strongly associated with an increased risk of liver cancer. Occupational exposure to inorganic arsenic, vinyl chloride, and the organic solvent TCE are also risk factors. Liver cancer is also associated with diabetes mellitus (5). In a study in which laboratory mice were exposed to 386 milligrams per kilograms per day (mg/kg/day) of PCE for at least 1 year, the mice developed liver cancer and kidney damage (7). Workers who have breathed vinyl chloride over many years indicated an increased risk of liver cancer (16). In a study of workers exposed to dry cleaning solvents (carbon tetrachloride, TCE, and PCE), a slight excess of liver cancer was observed (24).

Kidney and Renal Pelvis

In the United States, 2% of new cancers are from malignant tumors of the kidney, more in men (60%) than in women (40%). Since the 1970s, incidence rates for this type of cancer have been increasing. The five-year relative survival rate for patients with kidney and renal pelvis cancer is about 50% to 65%. Cigarette smoking is causally linked to this type of cancer, even more so with cancer of the renal pelvis. Smoking accounts for a large percentage of these cancers in both men and women. The best way to prevent most of these cancers is to avoid tobacco use. Abuse of prescription analgesics is another risk factor and has been causally linked to this type of cancer. Regular use of prescription diuretics may increase risk. Consistently, obesity has been found to be a risk factor for renal cell cancer. Coffee, tea, alcoholic drinks, and possibly increased meat consumption, are important risk factors. In some studies, asbestos-exposed workers and coke-oven workers in steel plants have an elevated risk of kidney cancer mortality (25). Workers exposed to TCE also have a high risk of developing renal cell carcinoma (6).

Non-Hodgkin's Lymphoma

The cause of most of the cases of non-Hodgkin's lymphoma (NHL) remains unknown. The incidence rate of NHL is higher among males than females. There is also some evidence that a major proportion of the cases have a strong genetic basis. Individuals at increased risk for NHL include those with primary immunodeficiency diseases, acquired immunodeficiency diseases, and patients who are immunosuppressed subsequent to transplantation. Increased risk for NHL has been observed for patients with testicular cancer and Hodgkin's disease. Although the data are not entirely consistent, occupations dealing with chemicals and agriculture appear to be associated with NHL in studies of incident cases. Other industries with reported increased risks of NHL are woodworkers, meat workers, and metalworkers (11). Workers exposed to TCE also have a high risk of developing NHL (6).

Chronic Lymphocytic Leukemia

Chronic lymphocytic leukemia is a disease of later life, predominantly present in the elderly. It is more common in males than females, for unknown reasons. The etiology of chronic lymphocytic leukemia is almost entirely unknown (23). This disorder has not been convincingly linked to any myelotoxic agent, and sufficient data rule out an association with ionizing radiation. This condition does have a reported association with butadiene, ethylene oxide, nonionizing radiation, herbicides, and solvents (26). Risk factors such as radiation and chemical exposures commonly linked to other types of leukemia have not been shown to increase the risk of chronic lymphocytic leukemia (23). Some cancers of the blood may also be connected with breathing vinyl chloride over long periods (16) and long-term exposures to TCE and PCE (24).

Acute Lymphocytic Leukemia

Acute lymphocytic leukemia accounts for about 5% of the cancer in the 40 years and older age group. However, it is the most common type of childhood cancer in the nation. Environmental risk factors include occupational exposure to benzene, radiation, farming chemicals, paints, butadiene, styrene, and ethylene oxide. Such exposures have been implicated in the etiology of acute lymphocytic leukemia (11). Childhood leukemia has been associated with pregnancy-related diagnostic X-ray exposure. Children who have inherited certain genetic problems such as Down syndrome are at increased risk of developing acute lymphocytic leukemia, as are children who receive medical drugs to suppress their immune systems after organ transplants (28). Some cancers of the blood may also be connected with breathing vinyl chloride over long periods of time (16) and long-term exposures to TCE and PCE (24).

Acute Myeloid Leukemia

Acute myeloid leukemia accounts for 15%–25% of all childhood leukemia and 20%–40% in children 4 years of age and younger. The incidence of acute myeloid leukemia has increased among men 50 years of age and older. Environmental factors associated in the etiology of acute myeloid leukemia include nonionizing electric magnetic fields, benzene, and ethylene oxide and related chemicals. Occupations associated with acute myeloid leukemia include farmers, embalmers, anatomists, and pathologists (11). There are some cancers of the blood that may also be connected with breathing vinyl chloride over long periods (16) and long-term exposures to TCE and PCE (24).

Chronic Myeloid Leukemia

Chronic myeloid leukemia accounts for approximately 1% to 3% of all childhood leukemias. The incidence of chronic myeloid leukemia is higher among males than females. Unlike other leukemias, the incidence of chronic myeloid leukemia in the United States is higher among blacks than whites. This leukemia first becomes apparent in the early mid-teens, followed by an increased rise in early adulthood. The rates continue to rise throughout middle age and among the elderly. Environmental risk factors include exposure to benzene, radiation (nonionizing and ionizing), and butadiene. Occupations associated with chronic myeloid leukemia include farmers, welders, metal mill workers, male barbers and hairdressers, and dry cleaners (11). Some cancers of the blood may also be connected with breathing vinyl chloride over long periods of time (16) and long-term exposures to TCE and PCE (24).

Esophagus

Cancer of the esophagus is relatively uncommon and, most often, rapidly fatal, even where medical care meets the highest standards available (11). It is most often associated with tobacco use and alcohol abuse, which may explain the fact that the rates in Utah are only half the national rates (23). It is more prevalent among males than females. Other risk factors associated in the etiology of cancer of the esophagus include genetics, diet, ionizing radiation, silica, and lower socioeconomic status. Occupations at higher risk include plumbers, brass and bronze workers, chimney sweepers, vulcanization workers (11), and workers exposed to TCE (6).

Contaminants

1,2-Dichloroethene

1,2-Dichloroethene (also called 1,2-dichloroethylene) is a highly flammable, colorless liquid with a sharp odor that is noticeable in very small amounts, beginning at a level of about 17 parts per million (ppm). The chemical exists in two forms or as a mixture of both; one form is called cis-1,2-dichloroethene, and the other form is called trans-1,2-dichloroethene. The chemical is commonly released into the environment from industries involved in solvent production, pharmaceutical manufacturing, and rubber extraction. When 1,2-dichloroethene is released into air, it takes 5–12 days for half of any amount to break down. When it is released into groundwater, it takes 13–48 weeks for half of a given amount to break down because it has less opportunity to evaporate. Small amounts of 1,2-dichloroethene may break down into vinyl chloride, a more toxic chemical. Also, 1,2-dichloroethene is a breakdown product of other volatile compounds, such as TCE (29).

People can be exposed to 1,2-dichloroethene by breathing contaminated air, by drinking contaminated water, or bathing in contaminated water. Animal studies have shown that once 1,2-dichloroethene is in the body, it is absorbed by the blood and other tissues and is eventually broken down by the liver (29).

EPA has determined that the maximum contaminant level (MCL) for the cis- form is 70 ppb and for the trans- form is 100 ppb (30). The trans- form is approximately twice as potent as the cis-form in its ability to depress the central nervous system (30). On the basis of animal studies, ATSDR established an oral minimal risk level[2] (MRL) for intermediate exposures of 0.3 mg/kg/day and 0.2 mg/kg/day for the cis- and trans- forms, respectively.

Exposure doses of cis-1,2-DCE were estimated for children and adults because levels detected at the site exceeded ATSDR comparison values for drinking water. If children were to drink groundwater contaminated with the maximum level of cis-1,2-DCE detected on site, exposure would be estimated at 0.372 mg/kg/day, which slightly exceeds the MRL. Dose exposure for adults is much less (0.106 mg/kg/day). Using the most recent analytical data for cis-1,2-DCE (353 ppb), the estimated exposure dose for children would be 0.0353 mg/kg/day, which is below the MRL by a factor of ten; for adults, 0.01 mg/kg/day would be the estimated exposure.

Cis-1,2-dichloroethene does not cause cancer in humans; no studies have been conducted to assess whether trans-1,2-dichloroethene can cause cancer in humans (30).

Tetrachloroethylene (PCE)

PCE has many names. Among these are tetrachloroethylene, perchloroethylene, perc, perclene, and perchlor. PCE is a synthetic chemical that is widely used for dry cleaning of fabrics and metal-degreasing, as well as other industrial uses (9). Exposure to PCE can occur by using certain consumer products. Examples include spot removers, adhesives, wood cleaners, and water repellents.

Exposure to PCE occurred in the past when residents were drinking water from private wells with levels as high as 30 ppb. Exposure doses were calculated for both children and adults and compared to ATSDR's MRLs. The estimated drinking water exposure doses to PCE for children (0.003mg/kg/day) and adults (0.00086 mg/kg/day) are well below the MRL for this chemical (0.05mg/kg/day). Exposure dose estimates were also calculated for children and adults exposed to the maximum concentration of PCE detected in the groundwater in 2003. Again, these results were below the MRL, with adult exposure estimated at 0.0075mg/kg/day, and children at 0.0264 mg/kg/day.

The MRL for PCE, 0.05 mg/kg/day, is considered an estimate of the daily human oral exposure to PCE that is likely to be without appreciable risk of adverse non-cancer health effects. This number is derived from studies in which changes were observed in the behavior of laboratory mice given 5 mg/kg/day of PCE for 60 days (31).

Despite the identification of this MRL, the human health effects of drinking water or breathing in air with low levels of PCE are not definitively known. The effects on infants of consuming PCE in breast milk also are unknown. PCE has been used as a general anesthetic agent and at high concentrations can cause dizziness, amnesia, and loss of consciousness. PCE has also been used to treat hookworm and other intestinal worms (9). Laboratory mice exposed to 386 mg/kg/day for at least one year developed liver cancer and kidney damage (7). Laboratory rats exposed to

[2] Minimal risk level (MRL) is an estimate of daily exposure of a human being to a chemical that is likely to be without an appreciable risk of adverse non-cancer effects over a specified duration of exposure.

900 mg/kg/day for 14 days or less showed neurological, reproductive, and developmental abnormalities (32).

Exposure to PCE can occur through using certain consumer products. Examples include spot removers, adhesives, wood cleaners, and water repellents. Clothes that have been dry-cleaned may release small amounts of PCE into the air (9). In a study of workers exposed to dry cleaning solvents (carbon tetrachloride, TCE, and PCE), an increased risk of malignant neoplasms resulted primarily from an excess of lung cancer and a slight excesses of leukemia and liver cancer (24).

High concentrations of tetrachloroethylene (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death.

The EPA is currently reviewing the carcinogenicity of PCE. The International Agency for Research on Cancer has determined that, based on limited human evidence and sufficient evidence in animals, PCE probably causes cancer in humans. The National Toxicology Program identifies PCE as “reasonably anticipated to be a carcinogen” (33).

Trichloroethene (TCE)

TCE (trichloroethylene) is a non-flammable, colorless liquid with a sweet taste. It has a sweet odor that becomes noticeable at a level of about 100 ppm. The largest source of TCE in the environment is evaporation from factories that use TCE as a solvent to remove grease from metals. TCE can also be found in typewriter correction fluid, paint removers, and adhesives. When TCE is released into air, it takes 7 days for half of any amount to break down. When TCE is released into groundwater, it takes much longer to break down because it has less opportunity to evaporate (34).

People can be exposed to TCE by breathing contaminated air, by drinking contaminated water, or by bathing in contaminated water. When a person breathes air that contains TCE, the blood and other organs absorb about half the amount inhaled; the rest will be exhaled. If a person drinks water that contains TCE, most of the contaminant will be absorbed directly into the bloodstream. If TCE comes in contact with human skin, some of it will enter into the body, although not as much as from inhalation or ingestion. Once TCE is in the body, the liver changes it to other chemicals that are excreted in the urine within a day. If exposure continues, TCE and its breakdown products can build up in body fat (34).

Exposure doses for ingesting groundwater contaminated with TCE at the highest concentration detected (1,380 ppb) were estimated for children and adults. These doses were below the MRL of 0.2 mg/kg/day.

EPA established the MCL of TCE that is permissible in community water systems at 5 parts per billion (ppb). Some studies in humans exposed to TCE in drinking water reported impaired fetal development in pregnant women (34). A New Jersey survey suggested an association between TCE exposure at levels averaging about 55 ppb in water (level >10 ppb) to oral clefts, central nervous system defects, neural tube defects, and major cardiac defects (34). The small case numbers and exposure classification limited interpretation of the findings of that study.

People who breathe 38–172 ppm of TCE may experience headaches or dizziness. Those levels are about 100 to 1,000 times the amount found in monitoring well water at the Bountiful site. TCE is a mild irritant to the lungs and respiratory tract. However, phosgene and hydrogen chloride, TCE's breakdown products in air, are severe lung irritants (34).

Skin contact with TCE may lead to the development of rashes and skin irritations. However, dermal effects are usually due to direct skin contact with concentrated solutions of TCE. Because the concentration of TCE found in the on-site monitoring well is considered dilute at 650–855 ppb, this concentration is unlikely to cause dermal irritation (34).

The International Agency for Research on Cancer has determined that, on the basis of extensive animal research and limited human data, TCE likely causes cancer in humans (34). A subcohort study of highly exposed workers to TCE found elevated risks for NHL, renal cell carcinoma, and esophageal adenocarcinoma (6). A study of workers exposed to dry cleaning solvents (carbon tetrachloride, TCE, and PCE), found an increased risk of malignant neoplasms. Those resulted primarily from an excess of lung cancer and a slight excess of leukemia and liver cancer (24). Associations between TCE exposure and other cancers are less consistent. More studies are needed to establish the relationship between TCE exposure and cancer.

Vinyl Chloride

Vinyl chloride is a colorless gas at normal temperature. It is also known as chloroethene, chloroethylene, ethylene monochloride, or monochloroethylene. All vinyl chloride is manufactured or results from the breakdown of other manufactured substances, such as TCE and PCE. Most of the vinyl chloride produced in the United States is used to make polyvinyl chloride (PVC). PVC is used in the manufacturing of a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Other uses include furniture and automobile upholstery, wall coverings, housewares, and automotive parts (16).

Liquid vinyl chloride evaporates easily into the air. Vinyl chloride in water evaporates rapidly if it is near the surface. Vinyl chloride released into the air will break down within a few days. The breakdown of vinyl chloride in air often results in the formation of other harmful chemicals. A limited amount of vinyl chloride can dissolve in water. It can enter groundwater and can also be found in groundwater with other chemicals (16).

Breathing high levels (10,000 ppm) of vinyl chloride can cause a person to become dizzy or sleepy. Studies in animals show that extremely high levels of vinyl chloride can damage the liver, lungs, kidneys, and heart, and prevent blood clotting. It is unlikely that vinyl chloride will build up in plants or animals (16).

People who have breathed vinyl chloride for several years, especially at high levels, may experience changes in liver structure. People who have worked with vinyl chloride may suffer from nerve damage or may develop an immune reaction. The lowest levels of exposure that may result in liver damage, nerve damage, or an immune reaction in humans are not known. Certain occupations related to PVC production expose workers to very high levels of vinyl chloride. These workers may experience problems with blood flow, specifically in the hands. The fingers turn white and hurt when exposed to lower temperatures. In some of these people, the appearance of the skin of the hands and forearms has changed. Also, bones at the tips of the fingers have broken down. Studies suggest that some people may be more sensitive to these effects than others (16).

Some men who work with vinyl chloride have complained of lack of sex drive. Studies in animals showed that long-term exposure might damage the sperm and testes. Some women who work with vinyl chloride have reported irregular menstrual periods and/or high blood pressure during pregnancy. Studies of women who live near vinyl chloride manufacturing plants did not show that vinyl chloride causes birth defects. Studies using pregnant animals showed that breathing high levels of vinyl chloride might harm unborn offspring. Animal studies also show that vinyl chloride may cause increased numbers of miscarriages early in pregnancy. It may also cause decreased weight and delayed skeletal development in fetuses. The same very high levels of vinyl chloride that caused these fetal effects also caused adverse effects in the pregnant animals (16).

Results from several studies have suggested that breathing air or drinking water containing low levels of vinyl chloride may increase the risk of cancer. However, the levels used in these studies were much higher than those found in the ambient air and/or most drinking water supplies at the Bountiful site. Examination of workers who have breathed vinyl chloride over many years indicated an increased risk of liver cancer. Brain cancer, lung cancer, and some cancers of the blood also may be connected with breathing vinyl chloride over long periods. Studies of long-term exposure in animals showed that increases in cancer of the liver and mammary gland may occur at very low levels of vinyl chloride in the air (no range/levels provided). Analysis has shown that animals consuming low levels of vinyl chloride each day during their lifetime also had an increased risk of liver cancer (16).

Child and adult exposure doses for drinking water with the maximum level of vinyl chloride detected at the Bountiful Plume exceed ATSDR's MRL of 0.00002 mg/kg/day. These doses were estimated at 0.0467 mg/kg/day for children and 0.0133 mg/kg/day for adults.

The U.S. Department of Health and Human Services has determined that vinyl chloride is a known carcinogen. The International Agency for Research on Cancer has determined that vinyl chloride is carcinogenic to humans, and the EPA has determined that vinyl chloride is a human carcinogen (16).

Vinyl chloride is regulated in drinking water, food, and air. Because it is a hazardous substance, regulations on its disposal, packaging, and other forms of handling also exist. EPA requires that the amount of vinyl chloride in drinking water not exceed 0.002 milligrams per liter (mg/L) of water (0.002 ppm). Under the EPA's Ambient Water Quality Criteria for the protection of human health, a concentration of zero has been recommended for vinyl chloride in ambient water (16).

Methyl Tert-Butyl Ether (MTBE)

MTBE is the common name for a synthetic chemical called methyl tert-butyl ether. It is a flammable liquid made from combinations of chemicals like isobutylene and methanol. It has a distinctive odor that most people find disagreeable. It was first introduced as an additive for unleaded gasoline in the 1980s to enhance octane ratings. MTBE is an oxygenating agent that enables fuel to burn more efficiently during the winter months. When MTBE is mixed with gasoline, people can come in contact with it if exposed to automobile fuel vapors or exhausts. MTBE has other special uses as a laboratory chemical and in medicine to dissolve gallstones (14).

MTBE will evaporate quickly from open containers. In the open air, it will quickly break down into other chemical compounds, with half of it disappearing in about four hours. Like most ethers and alcohols, MTBE dissolves readily in water. If MTBE is spilled on the ground, rainwater can dissolve it and carry it through the soil into the groundwater. Spills or leaks from storage containers can seep into deeper soil layers and pollute groundwater, especially near manufacturing sites, pipelines, and shipping facilities. Leakage from underground storage tanks, such as tanks at gasoline filing stations, can also add MTBE to groundwater. MTBE is not expected to concentrate in fish or plants found in lakes, ponds, and rivers (14).

Exposure to MTBE can occur from auto exhaust when driving or from gasoline while fueling cars. People can also be exposed to MTBE if they drink polluted groundwater. Low levels of MTBE can be present in both indoor and outdoor air (mostly because MTBE is used as a gasoline additive.

More is known about how MTBE affects the health of animals than the health of humans. Evidence shows that MTBE can affect kidney function in male and female rats exposed at doses as low as 100 mg/kg/day (90 days, oral gavage). Evidence also shows that at higher doses and longer exposure duration (250 and 1000 mg/kg/day respectively, oral gavage for two years), MTBE caused lymphoma and leukemia in female rats and testicular Leydig cell tumors in male rats (35 as described in 14).

Exposure dose estimates for MTBE at the Bountiful/Woods Cross PCE Plume site are estimated at 1.3 mg/kg/day. This level exceeds the minimal risk level for MTBE, calculated at 0.3 mg/kg/day and based on the above-mentioned 100 mg/kg/day oral LOAEL (lowest-observed-adverse-effect-level) for MTBE (14)

Benzene

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities (36).

Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals that are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke (36).

Most people are exposed to a small amount of benzene on a daily basis. Exposure can occur in the outdoor environment, in the workplace, and in the home. Exposure of the general population to benzene is mainly through breathing air that contains benzene (36).

For most people, the level of exposure to benzene through food, beverages, or drinking water is not as high as through air. Typical drinking water contains less than 0.1 ppb benzene. Leakage from underground gasoline storage tanks or from landfills and hazardous waste sites containing benzene can result in benzene contamination of well water. People with benzene-contaminated tap water can be exposed from drinking the water or eating foods prepared with the water. In addition, exposure can result from breathing in benzene while showering, bathing, or cooking with contaminated water (36).

Benzene has been detected at the Bountiful Plume site at levels that exceed ATSDR's comparison value for drinking water. The EPA has set the maximum permissible level of benzene in drinking water at 5 ppb. The levels of benzene detected in groundwater at the Bountiful Plume site are as high as 301 ppb. Exposure doses have been calculated for children and adults drinking groundwater with benzene at this level. ATSDR has not determined an oral MRL for benzene; therefore, the estimated doses were compared to EPA's acute oral reference dose (RfD) of 0.004 mg/kg/day. The estimated exposure dose for children is 0.0301 mg/kg/day, and adults, 0.0086 mg/kg/day. Both doses exceed the RfD.

Although definitive scientific data are not available on oral absorption of benzene in humans, case studies of accidental or intentional poisoning indicate that benzene is absorbed by the oral route. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death (36).

The major effect of benzene from chronic (365 days or longer) exposure is on the blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection (36). Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men.

The EPA, International Agency for Research on Cancer, and the National Toxicology Program have determined that benzene is a known human carcinogen.

Child Health Considerations

ATSDR and EEP recognize the unique vulnerabilities of infants and children. Children are at a greater risk than adults from some environmental hazards. Children are more likely to be exposed to contaminants because they play outdoors, often bring food into contaminated areas, and are more likely to make contact with dust and soil. Because children's bodies are still developing, children can sustain permanent damage if toxic exposures to some contaminants occur during critical growth stages.

This investigation also examined the incidence of pediatric cancers in the Bountiful/Wood Cross area and found no excess of cancer among the age group of 0 to 18 years of age.

Limitations of Investigation

Factors that must be considered in the development and etiology of most cancers, but could not be evaluated in this investigation, include latency period, population migration, personal habits, diet, occupational exposures, and familial history. The latency, or induction period, for most adult cancers ranges from 10 to 30 years after initial exposure to a carcinogen. Therefore, ascertaining the place and time of exposure to a carcinogen is difficult. Migration of people into and out of the area presents a problematic issue relative to exposure and latency. Humans live and work in many environments and are exposed to complex mixtures of toxic pollutants at home and at work. Information was not available for individual occupational exposures. Lifestyle factors such as smoking and alcohol consumption could not be examined.

Factors such as latency or induction period, population migration, personal habits, race, diet, occupational exposures, and familial history make drawing a conclusion problematic. In most cancer cluster investigations, no exposure or potential cause is ever apparent or established (37).

The primary objective of a cancer cluster investigation is to identify whether the number of cases that have occurred is significantly greater than what would be expected to occur by chance in the study area. The goal also is to determine if a plausible carcinogenic association of increased cancer rates to the contaminants of concern exists. This investigation should not be viewed as a tool to definitively identify a source to the cancers that are associated or linked to any of the chemicals of concern.

Conclusion

No conclusive evidence was found to suggest that any of the cancers evaluated by this investigation were occurring at a significantly greater frequency in the Bountiful/Woods Cross area as compared to Utah from 1978–2001. This investigation could not identify an exposure pathway to the residents. EPA and UDEQ will continue to study the site and try to identify sources of contamination and potential exposure pathways to the residents. Cleanup plans will remain uncertain until the nature of the contamination and related sources are better understood.

Recommendations

The EEP will provide the communities living near the Bountiful/Woods Cross 5th South PCE Plume with cancer and site remediation information.

Provide the community with a copy of this health consultation.

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Certification

This Health Consultation, "An Investigation of Cancer Incidence in Census Tracts 126901, 127002, 127003, and 127004, Bountiful, West Bountiful, and Woods Cross, Davis County, Utah," was prepared by the Utah Department of Health, Environmental Epidemiology Program under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

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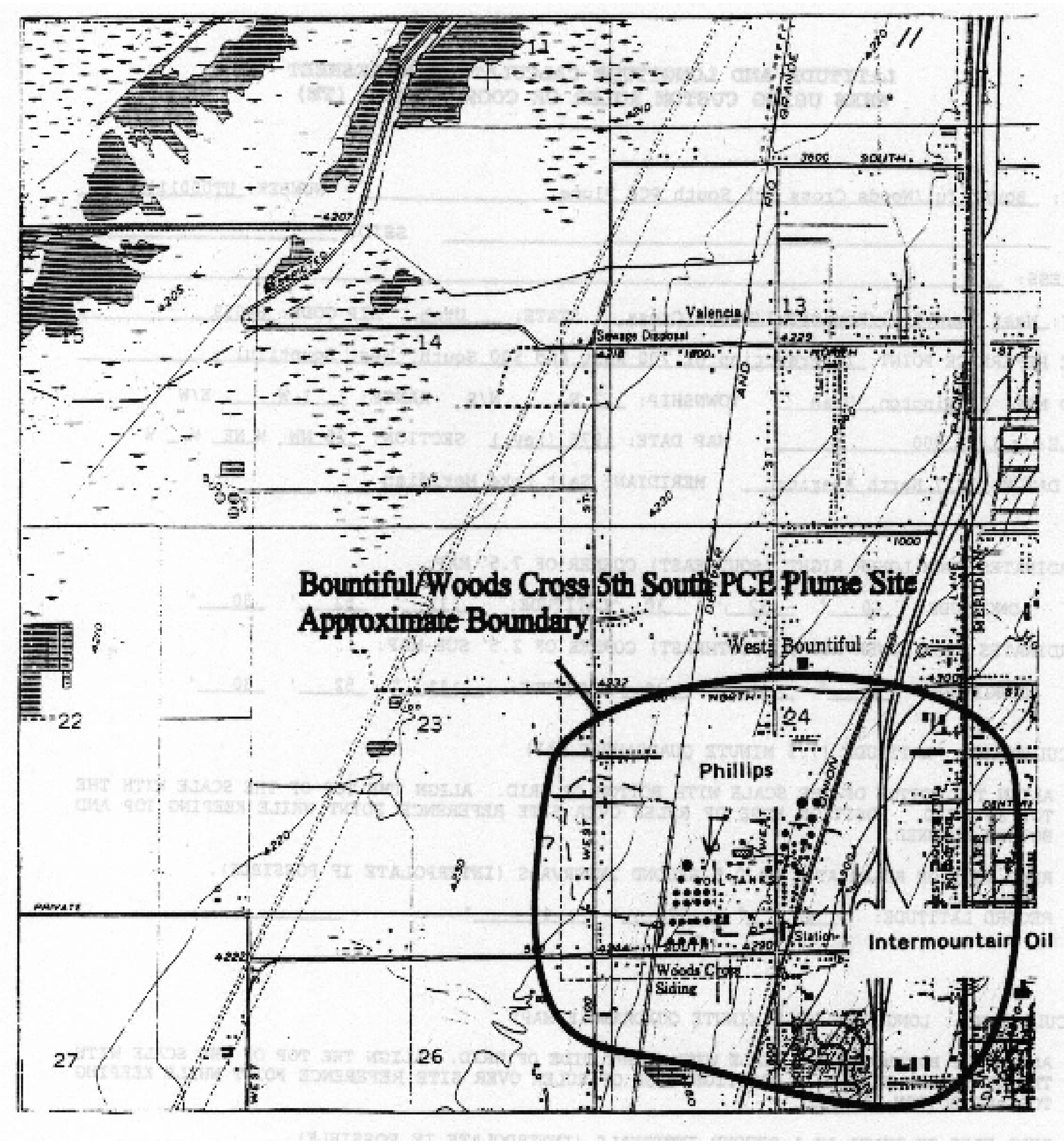
APPENDIX A – 2003 SITE BOUNDARIES of Bountiful/Woods Cross 5th PCE Plume.

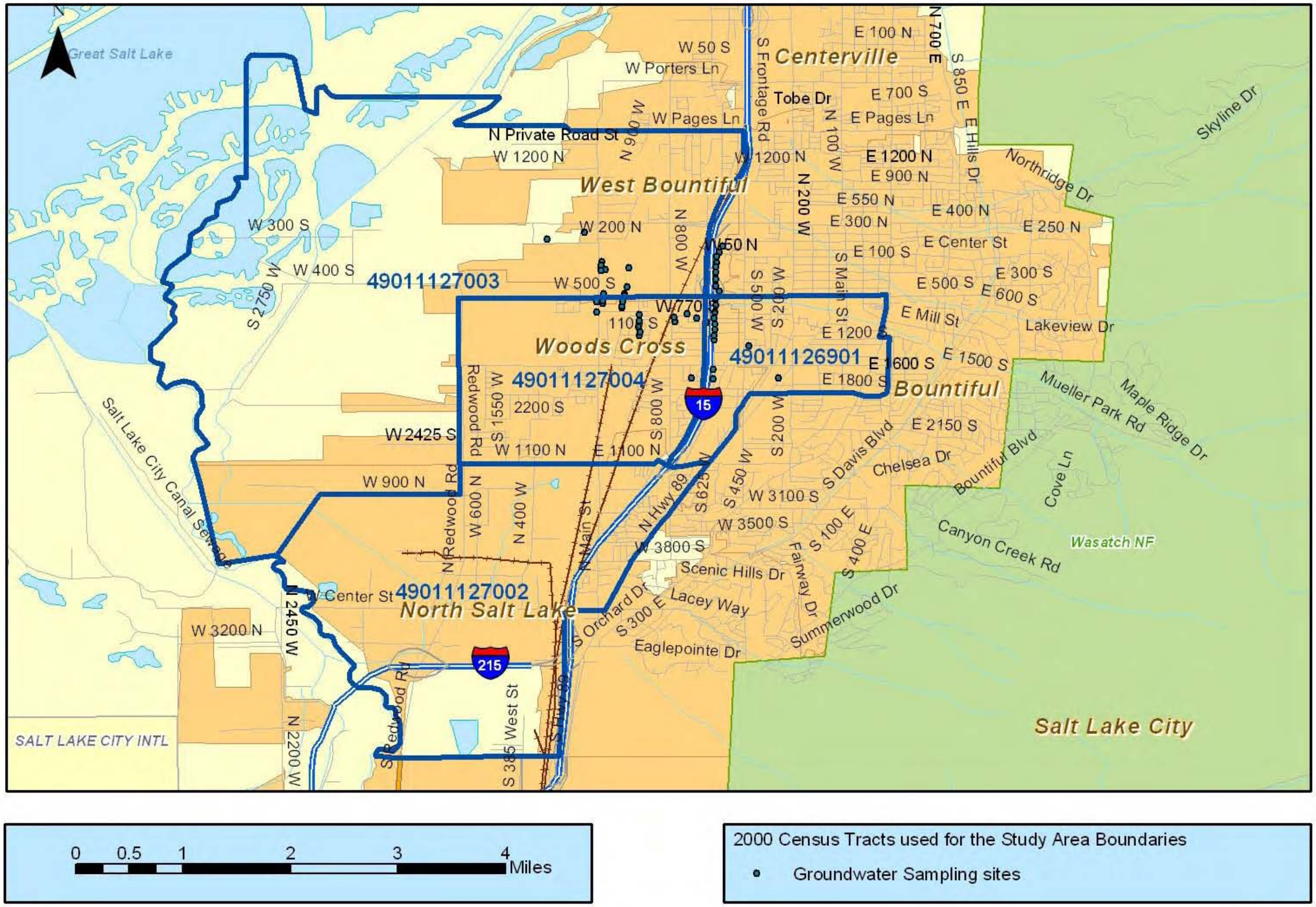


APPENDIX B - Population Estimates

The intercensal population estimates for the Bountiful/Woods Cross area for the years 1970 through 2001. Populations were estimated linearly using the 1970, 1980, 1990, and 2000 U.S. Census data provided by Geolytics CensusCD products. Study area: 2000 Census Tracts 126901, 127002, 127003, and 127004.

	Study Area Population			Utah Population		
Year	male	female	total	male	female	total
1970	5,301	5,229	10,530	523,107	536,166	1,059,273
1971	5,471	5,418	10,889	543,246	556,203	1,099,449
1972	5,642	5,606	11,248	563,386	576,240	1,139,626
1973	5,812	5,795	11,607	583,525	596,277	1,179,802
1974	5,983	5,983	11,966	603,665	616,314	1,219,979
1975	6,153	6,172	12,325	623,804	636,351	1,260,155
1976	6,323	6,360	12,683	643,943	656,388	1,300,331
1977	6,494	6,549	13,042	664,083	676,425	1,340,508
1978	6,664	6,737	13,401	684,222	696,462	1,380,684
1979	6,835	6,926	13,760	704,362	716,499	1,420,861
1980	7,005	7,114	14,119	724,501	736,536	1,461,037
1981	7,062	7,203	14,265	737,586	749,632	1,487,218
1982	7,120	7,291	14,411	750,671	762,728	1,513,400
1983	7,177	7,380	14,557	763,757	775,824	1,539,581
1984	7,235	7,469	14,703	776,842	788,920	1,565,762
1985	7,292	7,558	14,850	789,927	802,017	1,591,944
1986	7,349	7,646	14,996	803,012	815,113	1,618,125
1987	7,407	7,735	15,142	816,097	828,209	1,644,306
1988	7,464	7,824	15,288	829,183	841,305	1,670,487
1989	7,522	7,912	15,434	842,268	854,401	1,696,669
1990	7,579	8,001	15,580	855,353	867,497	1,722,850
1991	7,644	8,064	15,708	881,721	892,161	1,773,882
1992	7,709	8,127	15,836	908,089	916,825	1,824,914
1993	7,774	8,190	15,964	934,456	941,489	1,875,946
1994	7,839	8,253	16,092	960,824	966,153	1,926,978
1995	7,904	8,316	16,220	987,192	990,818	1,978,010
1996	7,969	8,379	16,348	1,013,560	1,015,482	2,029,041
1997	8,034	8,442	16,476	1,039,928	1,040,146	2,080,073
1998	8,099	8,505	16,604	1,066,295	1,064,810	2,131,105
1999	8,164	8,568	16,732	1,092,663	1,089,474	2,182,137
2000	8,229	8,631	16,860	1,119,031	1,114,138	2,233,169
2001	8,294	8,694	16,988	1,145,399	1,138,802	2,284,201

APPENDIX C – Census Tracts of the Bountiful/Woods Cross 5th PCE Plume, 2004.



APPENDIX D - Statistical Calculations

Age-Adjustment Method (Standardized Incidence Ratios)

Standardized incidence ratios (SIR) were calculated using a statistical method applicable to both the direct and indirect age-adjustment or standardization methods. This method uses the age distribution of each population group and the age-specific rates for the standard population (state of Utah) to calculate the expected number of cancer cases if the rates of disease were constant as in the standard population. The observed number of incidences is then compared (divided) with the expected number of incidences in the study population (census tract 126901, 127002, 127003, and 127004) and a ratio is derived, referred to as the SIR. The formula for this ratio = $\Sigma p_{ia} n_{ia} / \Sigma p_{is} n_{ia}$

Where: a = area chosen as the study area (census tracts 126901, 127002, 127003, and 127004)
s = area chosen as a reference standard (state of Utah)
n_{ia} = number of individuals in ith class [ith ???] of study area
n_{is} = number of individuals in ith class of reference standard area
x_{ia} = number of cases in ith age class of area a (similarly for s)
$p_{ia} = x_{ia}/n_{ia}$ = incidence rate in ith age class of area a (similarly for s)

(Harold A. Kahn and Christopher T. Sempos, "Statistical Methods in Epidemiology", Oxford University Press, 1989, pp 85-136.)

The confidence interval for the SIR is the range of values for a calculated SIR with a specified probability (95%) of including the true SIR value:

$$\frac{\left[\sqrt{n} \pm (1.96 \, X \, 0.5)\right]^2}{x}$$

Where *n* is the number observed.
x is the number expected.

(Frumkin H, Kantrowitz W. 1987. Cancer clusters in the workplace: an approach to investigation. J Occup Med 29(12):949–52.)

The confidence interval is used as a surrogate test of statistical significance (p-value). Both the p-value function and the spread of the function can be determined from the confidence interval. The difference between the observed versus the expected is considered significant if the confidence interval for the SIR does not include one (1.0) and if the SIR is greater than one (1.0).

(Rothman KJ. Greenland S, 1998. Modern Epidemiology. Lipincott-Raven Publishers. pp. 189-191)

APPENDIX E - Tables

Presented are the number of observed cases, expected number of cases, the Standardized Incidence Ratios, and 95% confidence intervals for cancer in the Bountiful/Woods Cross area, census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census) for each of the periods analyzed. The state of Utah was selected as the comparison population. Cancers presented are: *testis*, *soft tissue, brain, lung and bronchus, liver, kidney, NHL/CLL, and myeloid leukemia*.

The criteria established for determining significance involved two statistical methods:

1. A Standardized Incidence Ratio greater than 1.0.
2. A 95% confidence interval with limits that do not include 1.0.

The following terms and abbreviations are used as following:

- SIR means a Standardized Incidence Ratio.
- Study means the study population.
- Comp means the comparison population.

Table 1. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the Testis in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Testis \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	3	<3	3	4	<16
Expected	1.0	1.7	2.0	2.4	2.4	9.5
SIR	1.93	1.76	1.00	1.27	1.70	1.47
Upper Limit	5.53	4.30	2.87	3.13	3.77	2.35
Lower Limit	0.18	0.33	0.09	0.24	0.44	0.80
Study Rate	7.97	9.73	7.30	6.03	7.77	7.75
Comp Rate	4.19	4.94	5.42	6.18	5.65	5.42

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.

Table 2. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the **Soft Tissue** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Soft Tissue \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	<3	<3	<3	3	<15
Expected	0.8	1.4	1.3	1.9	2.3	7.7
SIR	1.24	1.43	1.56	1.06	1.30	1.30
Upper Limit	4.88	4.11	4.48	3.04	3.20	2.23
Lower Limit	0.00	0.14	0.15	0.10	0.25	0.62
Study Rate	3.22	4.01	3.61	3.34	4.56	3.81
Comp Rate	1.95	2.71	2.12	2.96	3.21	2.70

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.

Table 3. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the **Brain** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Brain \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	<3	4	3	10	<23
Expected	2.4	3.4	4.4	4.4	4.9	19.5
SIR	0.82	0.58	0.91	0.69	2.06	1.08
Upper Limit	2.36	1.66	2.02	1.68	3.53	1.59
Lower Limit	0.08	0.05	0.24	0.13	0.98	0.67
Study Rate	5.08	2.08	7.20	5.02	15.70	8.03
Comp Rate	5.99	5.96	7.12	6.43	6.73	6.50

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.

Table 4. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the **Lung and Bronchus** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Lung&Brn \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	10	11	11	15	26	73
Expected	8.9	14.1	16.1	18.5	19.4	76.6
SIR	1.13	0.78	0.68	0.81	1.34	0.95
Upper Limit	1.93	1.31	1.15	1.27	1.90	1.18
Lower Limit	0.54	0.39	0.34	0.45	0.87	0.75
Study Rate	35.70	26.38	21.44	27.32	41.69	30.48
Comp Rate	30.62	32.91	31.66	32.71	31.16	31.91

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Table 5. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the **Liver** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Liver \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	0	0	4	<3	<10
Expected	0.6	1.0	1.3	1.6	2.1	6.4
SIR	1.75	0.00	0.00	2.53	0.49	0.93
Upper Limit	6.87	0.0	0.0	5.62	1.91	1.83
Lower Limit	0.00	0.0	0.0	0.66	0.00	0.34
Study Rate	3.22	0.00	0.00	7.84	1.45	2.72
Comp Rate	1.92	2.04	2.62	2.74	3.22	2.63

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.

Table 6. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for cancer of the **Kidney** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

Kidney \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	<3	3	4	7	<20
Expected	2.1	3.2	4.1	4.6	6.0	20.0
SIR	0.47	0.62	0.74	0.87	1.17	0.85
Upper Limit	1.85	1.78	1.81	1.93	2.20	1.30
Lower Limit	0.00	0.06	0.14	0.23	0.46	0.49
Study Rate	3.22	5.62	6.32	7.03	11.27	7.01
Comp Rate	6.73	7.16	7.74	7.80	9.28	7.92

Data source: Utah Cancer Registry, 2001.

Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.

Table 7. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for **NHL/CLL** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

NHL&CLL \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	5	4	7	13	14	43
Expected	4.9	7.4	10.2	12.1	13.9	48.5
SIR	1.02	0.54	0.69	1.07	1.01	0.89
Upper Limit	2.11	1.19	1.29	1.73	1.61	1.17
Lower Limit	0.32	0.14	0.27	0.57	0.55	0.64
Study Rate	21.41	11.18	13.82	20.66	21.54	17.29
Comp Rate	16.90	17.20	19.78	20.88	21.64	19.70

Data source: Utah Cancer Registry, 2001.
Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Table 8. The number of observed and expected, Standardized Incidence Ratios (SIR) with upper and lower 95% confidence limits, and incidence rates (study and comparison) are presented for **Myeloid Leukemia** in census tracts 126901, 127002, 127003, and 127004, from 1978–2001 (2000 Census).

MyelLeuk \ Years	1978-81	1982-86	1987-91	1992-96	1997-2001	1978-2001
Observed	<3	3	0	3	<3	<12
Expected	1.5	2.2	2.4	3.0	3.4	12.5
SMR	1.33	1.35	0.00	1.00	0.59	0.80
Upper Limit	3.88	3.31	0.0	2.45	1.71	1.37
Lower Limit	0.13	0.25	0.0	0.19	0.06	0.38
Study Rate	2.59	8.17	0.00	5.37	3.11	3.85
Comp Rate	4.70	4.80	4.62	5.01	5.02	4.87

Data source: Utah Cancer Registry, 2001.
Incidence rates (study and comparison) are the number of cases per 100,000 person years and are age-adjusted to U.S. 2000 standard population.

Observed cases are presented as < 3 when cases are less than three to protect the confidentiality of the cases.