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Ground-Water Levels and Water-Quality Data for Wells in the Crumpton Creek Area near Arnold Air Force Base, Tennessee, November 2001 to January 2002

Water-Resources Investigations Report 03-4175

U.S. Department of the Interior
U.S. Geological Survey

Cover photo: A private well in the Crumpton Creek area near Arnold Air Force Base, Tennessee.

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By SHANNON D. WILLIAMS

U.S. GEOLOGICAL SURVEY

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Nashville, Tennessee
2003

U.S. DEPARTMENT OF THE INTERIOR
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Denver, Colorado 80225

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CONVERSION FACTORS, DATUM, AND SITE-NUMBERING SYSTEM

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square kilometer (km^2)
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	0.06308	liter per second (L/s)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C), and temperature in °C to °F, as follows:

°F = 1.8 x °C + 32

°C = 5/9(°F – 32)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29); horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Site-numbering system for wells: In addition to the project number, the U.S. Geological Survey assigns each site listed in this report a station identification number. The station identification number is used as an identifier for site data stored in the national computer data base of the U.S. Geological Survey. The station identification number is a unique number for each site based on a latitude and longitude grid system. The number consists of 15 digits. The first six digits denote the degrees, minutes, and seconds of latitude; the next seven digits denote degrees, minutes, and seconds of longitude; and the last two digits (assigned sequentially) identify the wells within a 1-second grid.

Ground-Water Levels and Water-Quality Data for Wells in the Crumpton Creek Area near Arnold Air Force Base, Tennessee, November 2001 to January 2002

By Shannon D. Williams

Abstract

From November 2001 to January 2002, a study of the ground-water resources in the Crumpton Creek area of Middle Tennessee was conducted to determine whether volatile organic compounds (VOCs) from Arnold Air Force Base (AAFB) have affected local private water supplies and to advance understanding of the ground-water-flow system in this area. VOC samples were collected from private wells that were not included in previous sampling efforts conducted in the Crumpton Creek area near AAFB. Ground-water-flow directions were investigated by measuring water levels in wells and constructing a potentiometric-surface map of the Manchester aquifer in the study area. Data were collected from a total of 68 private wells, 82 monitoring wells, and 1 cave during the period of study. Ground-water levels were determined for 42 of the private wells and for all 82 monitoring wells. Of the 82 monitoring wells, 81 withdraw water from the Manchester aquifer and 1 well withdraws water from the overlying shallow aquifer. The Manchester aquifer wells range in depth from 20 to 150 feet. Water-level altitudes for the Manchester aquifer ranged from 956 to 1,064 feet above the National Geodetic Vertical Datum of 1929. Water levels ranged from approximately 6 feet above land surface to 94 feet below land surface. Water-quality samples were collected from all 68 private wells, 8 of the monitoring wells, and the 1 cave.

Of the 55 VOCs analyzed, 42 were not detected. Thirteen VOCs were detected; however, only tetrachloroethylene (PCE), methylene chloride, and toluene were detected at concentrations equal to or above reporting levels for the analytical method used. PCE was detected in water samples from 15 private wells and was the only VOC that exceeded drinking water maximum contaminant levels for public water systems. PCE concentrations in samples from five of the wells were below the reporting level and ranged from estimated concentrations of 0.46 to 0.80 microgram per liter (µg/L). Samples from 10 wells contained concentrations equal to or greater than the analytical reporting level of 1 µg/L for PCE. Samples from one of these wells contained PCE concentrations (12 µg/L and 11 µg/L) exceeding the drinking water maximum contaminant level of 5 µg/L for PCE. The spatial distribution of PCE detections and the relative concentrations of PCE and trichloroethylene suggest that the PCE detections are associated with a small and localized ground-water contamination plume unrelated to AAFB ground-water contamination.

INTRODUCTION

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. The primary mission of AAFB is to support the development of aerospace systems. This mission is accomplished in part through test facilities at Arnold Engineering Development Center (AEDC), which occupies about 4,000 acres in the center of AAFB (fig. 1). Numerous site-specific ground-water-contamination investigations have been conducted at designated solid waste management units (SWMUs) at

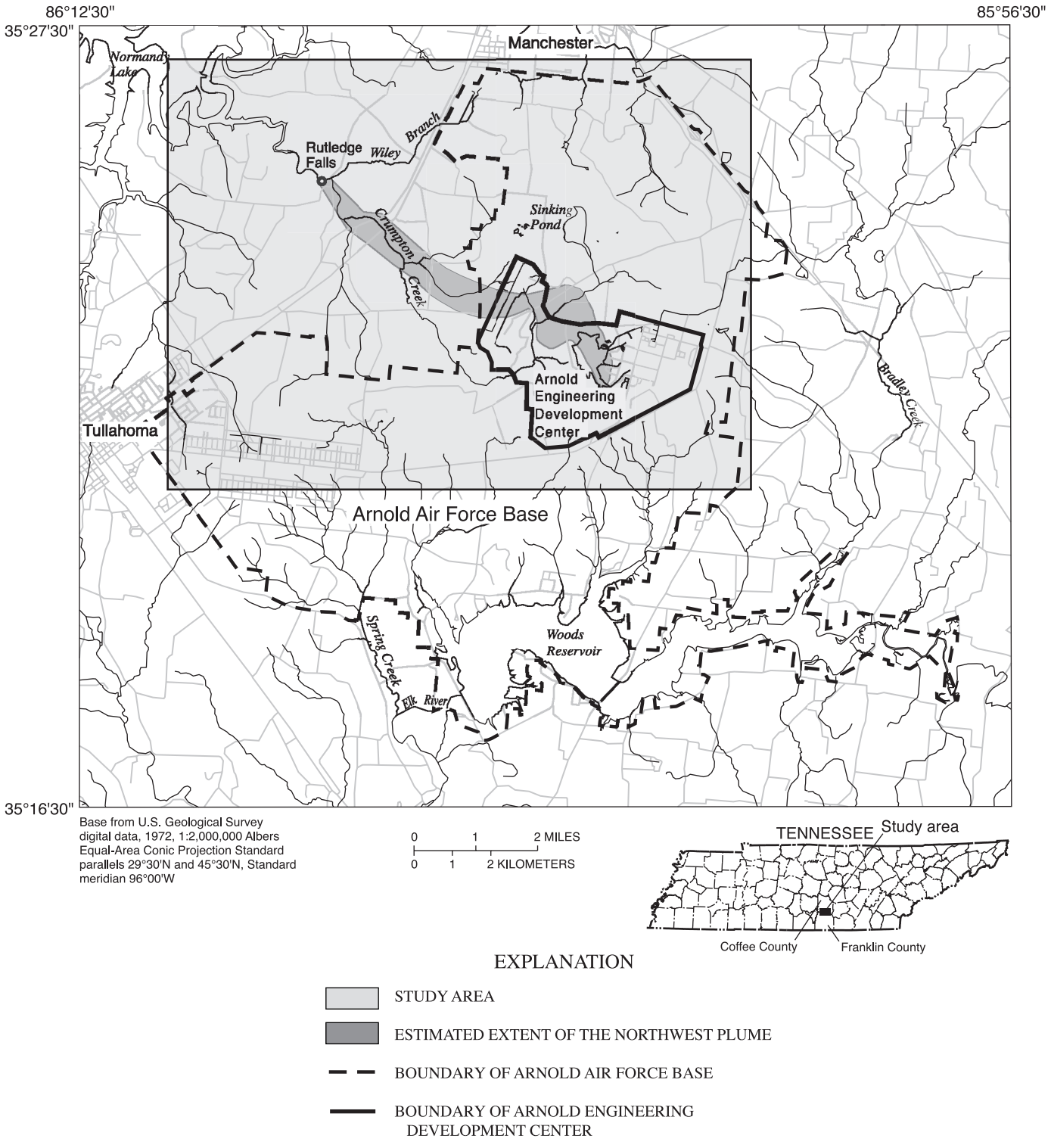


Figure 1. Location of the study area in Middle Tennessee.

AAFB. SWMU 74 has been designated as "undifferentiated ground-water contamination" and includes areas of ground-water contamination near AEDC that could not be attributed to a single source (CH2M HILL, 2001). One ground-water contamination plume managed as part of SWMU 74 is referred to as the "northwest plume." The northwest plume extends west-northwest from AEDC, through the Crumpton Creek area, and discharges to surface water at Rutledge Falls, approximately 3 miles outside of the AAFB boundary (fig. 1).

Several volatile organic compounds (VOCs) have been identified in the ground water at SWMU 74. Compounds detected include tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), 1,1,1-trichloroethane (1,1,1-TCA), and trichlorofluoromethane (TCFM) (CH2M HILL, 2001). PCE is used as a solvent in dry cleaning and to remove grease from metal parts (Lucius and others, 1992). TCE is used primarily as a solvent to remove grease from metal parts (Agency for Toxic Substances and Disease Registry, 1997b) and as a refrigerant at AAFB. TCE also can be formed during the biodegradation of PCE in soil and ground water (Wiedemeier and others, 1998). 1,1-DCE is used as a chemical intermediate in the production of plastics and adhesives (Lucius and others, 1992) and is also a product of the abiotic degradation of 1,1,1-TCA (Wiedemeier and others, 1998). TCFM is used as a refrigerant and in the manufacture of aerosol propellants (Lucius and others, 1992).

TCE and PCE are the VOCs detected at the greatest concentrations in the northwest plume. TCE is typically detected at concentrations approximately three times greater than PCE concentrations. CH2M HILL (2001) reported concentrations of TCE ranging from 4 to 10 micrograms per liter (μg/L) and concentrations of PCE ranging from 1 to 2.5 μg/L in water samples collected from two private wells and one monitoring well located between the AAFB boundary and Rutledge Falls. TCE and PCE concentrations of approximately 5 and 1 μg/L, respectively, have been detected in water samples collected from springs near Rutledge Falls (CH2M HILL, 2001; Farmer and Williams, 2001).

Purpose and Scope

The U.S. Geological Survey (USGS), in cooperation with the U.S. Air Force, Arnold Air Force Base, conducted a study of the ground-water resources in the Crumpton Creek area from November 2001 to January 2002. The objectives of the study were (1) to advance understanding of the ground-water-flow system in the Crumpton Creek area, and (2) to determine whether VOCs in ground water from AAFB have affected private water supplies in the Crumpton Creek area. This report documents (1) water-level measurements made in 42 private wells and 82 existing monitoring wells and (2) water-quality analyses of samples collected from 68 private wells, 8 monitoring wells, and 1 cave located in the Crumpton Creek area. This study focused on sampling wells that were not included in previous sampling efforts conducted in the Crumpton Creek area near AAFB. The data will help to refine the potentiometric-surface map developed during a study of the regional ground-water-flow system by Mahoney and Robinson (1993). Results from the study may aid in the development of corrective measures and long-term monitoring plans for AAFB.

Study Area

The AAFB area lies on the Eastern Highland Rim physiographic section of Tennessee (Miller, 1974) and is characterized by poorly drained, flat uplands and valley-dissected, sloping escarpments. The study area extends from AEDC to Rutledge Falls (fig. 1). The headwaters of Crumpton Creek are near Sinking Pond; Crumpton Creek flows through AEDC, merges with Wiley Branch just upstream from Rutledge Falls and discharges into Normandy Lake, which is an impoundment on the Duck River. Land-surface altitudes range from approximately 1,100 feet above NGVD 29 in the northwestern part of the study area to approximately 920 feet above NGVD 29 at Rutledge Falls.

Hydrogeologic Setting

The AAFB area is located in a fractured carbonate terrane covered by regolith derived from the in-situ weathering of carbonate rocks of Mississippian age. Geologic units in the study area are (in descending order) the St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formation (fig. 2; Wilson, 1976; Haugh and Mahoney, 1994). Regolith in the AAFB area is typically 10 to 100 feet thick and consists primarily of clay and clay-size chert with some silt, sand, and gravel. Typically, the regolith grades

Stratigraphy	Thickness, in feet	Lithology	Hydrogeologic unit	AEDC unit designation
Regolith derived from in-situ weathering of the St. Louis Limestone, Warsaw Limestone, or Fort Payne Formation	10-100	Clay, silt, and sand with some chert and rock fragments.	Shallow aquifer	Shallow aquifer
		Rock fragments, chert gravel, and rubble with some clay.	Manchester aquifer, upper part	Intermediate aquifer
Fort Payne Formation	20-230	Fractured and dissolutioned cherty limestone and siltstone.	Manchester aquifer, lower part	Deep aquifer
		Dark gray siltstone; dense, cherty limestone; and bedded chert. Few fractures.	Fort Payne aquifer	
Chattanooga Shale	20-30	Dark grayish black, carbonaceous shale.	Chattanooga confining unit	Chattanooga confining unit

Figure 2. Stratigraphy, lithology, and hydrogeologic units for the Arnold Air Force Base area, Tennessee. (Modified from Haugh and Mahoney, 1994.)

upward from gravel-size chert rubble at the top of bedrock to clay-size chert particles with silt, sand, and clay at land surface (Burchett, 1977). The Fort Payne Formation, an indurated siliceous limestone containing many chert nodules and platy chert stringers, underlies the regolith. Bedrock in the Fort Payne Formation is generally 20 to 230 feet thick in the AAFB area and 10 to 40 feet thick near AEDC. The upper part of the bedrock contains many fractures and solution openings. Underlying the Fort Payne Formation is the Chattanooga Shale, which consists of 20 to 30 feet of fissile, black, carbonaceous shale. The Chattanooga Shale is considered to be the base of the fresh ground-water system in the study area (Haugh and Mahoney, 1994; Haugh, 1996).

The ground-water system above the Chattanooga Shale can be divided into three different zones or aquifers (Haugh and Mahoney, 1994): the shallow aquifer, the Manchester aquifer, and the Fort Payne aquifer (fig. 2). Hydrogeologic investigations by AEDC have designated the aquifers as shallow, intermediate, and deep (CH2M Hill, 2001). The aquifers differ from one another in degree of weathering, amount of chert, and type of weathering product. The aquifers are not separated by confining units of any substantial lateral extent; therefore, water is able to flow between these zones at most locations. The shallow aquifer, as designated by the USGS and AEDC, is described as consisting of alluvium, residual silt, clay, sand, and clay-size chert particles of the upper part of the regolith; is not continuous throughout the AAFB area; and is perched at some locations (Haugh and Mahoney, 1994). The Manchester aquifer, the primary source of drinking water in the area, consists of chert gravels at the base of the regolith and solution openings in the upper part of the bedrock (Burchett and Hollyday, 1974). The upper part of the Manchester aquifer, the chert gravels at the base of the regolith, is designated as the intermediate aquifer by AEDC. The lower part of the Manchester aquifer, the solution openings in the top of bedrock, are included in the deep aquifer as designated by AEDC (fig. 2). The Fort Payne aquifer corresponds to the lower part of the Fort Payne Formation where solution openings are less developed. The Fort Payne aquifer also is included in the deep aquifer as designated by AEDC (fig. 2). The base of the Fort Payne aquifer is the Chattanooga Shale (Haugh and Mahoney, 1994; Haugh, 1996).

GROUND-WATER LEVELS

Ground-water altitudes and flow directions were determined by measuring water levels in wells and

constructing a potentiometric-surface map of the Manchester aquifer. In the study area, 68 private wells, 82 monitoring wells, and 1 cave were available for water-quality and water-level data collection (fig. 3). Of the 82 monitoring wells, 81 withdraw water from the Manchester aquifer and 1 well withdraws water from the shallow aquifer. Ground-water levels were determined for 42 of the private wells and for all 82 monitoring wells. Well depths and water-level data are presented in table 1 (at the end of report). Because of various types of well construction, water levels and well depths could not be measured for all of the private wells. Well depths that could not be measured were obtained from well owners. Land-surface altitudes for the private wells were determined by plotting the well locations from global-positioning-system-determined coordinates on 7.5-minute (1:24,000) USGS topographic maps. Land-surface altitudes were interpolated from the topographic contours. Well-location coordinates are estimated to be accurate to +/-30 feet, and land-surface altitudes are estimated to be accurate to +/-5 feet. Land-surface altitudes and well depths for the monitoring wells were obtained from AEDC.

Water levels ranged from approximately 6 feet above land surface to 94 feet below land surface (table 1). Water-level altitudes for the Manchester aquifer ranged from 956 to 1,064 feet above NGVD 29. The potentiometric-surface map of the Manchester aquifer (fig. 4) indicates a prominent ground-water trough that parallels Crumpton Creek between AAFB and Rutledge Falls. This trough (the most likely flow path for the northwest plume) is slightly offset from the previously estimated extent of the northwest plume (fig. 4). The potentiometric-surface map also indicates that the general direction of ground-water flow in the Manchester aquifer near Bryan Boulevard (Blvd.) is toward the west (fig. 4).

GROUND-WATER QUALITY

Water-quality samples collected from 68 private wells, 8 monitoring wells, and 1 cave in the Crumpton Creek area were analyzed for physical properties (appendix 1) and for VOCs (table 2). VOC samples were analyzed by Severn Trent Laboratories in Denver, Colorado, using U.S. Environmental Protection Agency (EPA) Method 8260b. Method detection limits (table 2) are less than 1 µg/L for all VOCs identified as contaminants of concern for AAFB (primarily chlorinated solvents).

Sampling procedures followed those outlined in Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (U.S. Environmental Protection Agency, 1997). Private wells were purged and sampled from a spigot located close to the well head, preferably between the well head and any storage/pressure tanks. Monitoring wells were purged and sampled using a submersible pump. Water samples were collected after specific conductance, pH, dissolved oxygen, and temperature stabilized. For most wells, field measurements stabilized within 30 minutes. Samples from the few wells in which field measurements did not stabilize were collected after the wells were purged at least 30 minutes. Water samples were collected from the cave using a disposable bailer. Water samples were treated and shipped in accordance with current EPA (1997) sampling protocols.

Specific conductance, pH, dissolved oxygen, and temperature of ground-water samples (appendix 1) were measured in the field at the time of sample collection. Specific conductance for water samples ranged from 12 to 282 microsiemens per centimeter (µS/cm). The median value for specific conductance is 100 µS/cm (table 3). The range and median value for pH in sampled water are 4.6 to 7.8, and 6.3, respectively (table 3).

Volatile Organic Compounds

Forty-two of the 55 VOCs in the analyte list (table 2) were not detected, and concentrations of 10 of the 13 compounds detected were less than reporting levels. Acetone, bromomethane, 2-butanone, carbon disulfide, carbon tetrachloride, chloroform, dichlorodifluoromethane, cis-1,2-dichloroethylene (DCE), 4-methyl-2-pentanone, and TCE were detected at concentrations less than their respective reporting levels (table 2 and appendix 2). VOC concentrations less than reporting levels are considered estimates and are indicated by the symbol “J” in appendix 2. Acetone and 2-butanone are common laboratory contaminants (U.S. Environmental Protection Agency, 1999a). Bromomethane is used primarily as an insect fumigant but is also used as a refrigerant, an herbicide, and a fire extinguishing agent (Lucius and others, 1992). Carbon disulfide occurs naturally but also is used as a pesticide intermediate and in manufacturing processes (Lucius and others, 1992). Carbon tetrachloride occurs

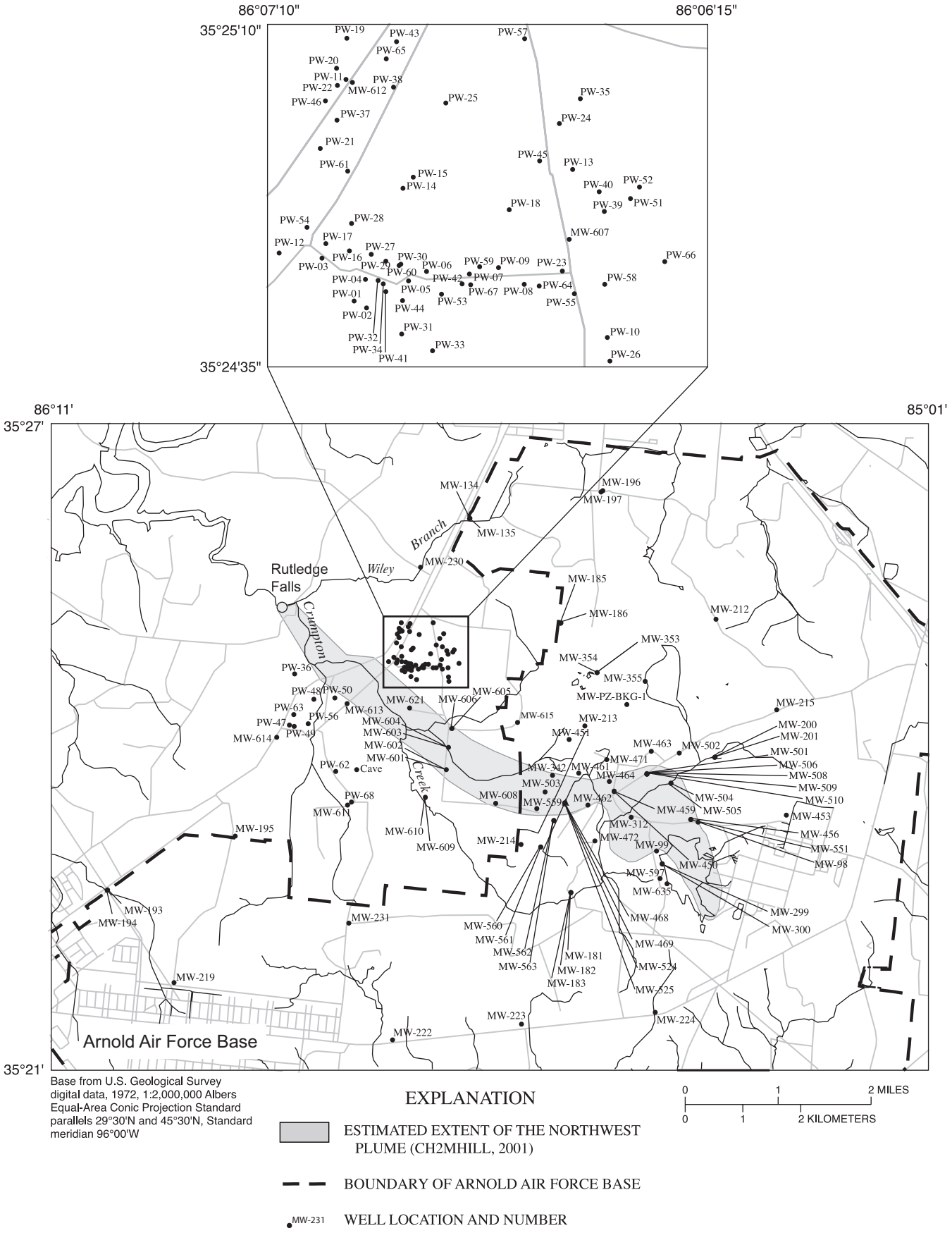


Figure 3. Private and monitoring wells at which water-level and water-quality data were collected in the Crumpton Creek area near Arnold Air Force Base, Tennessee.

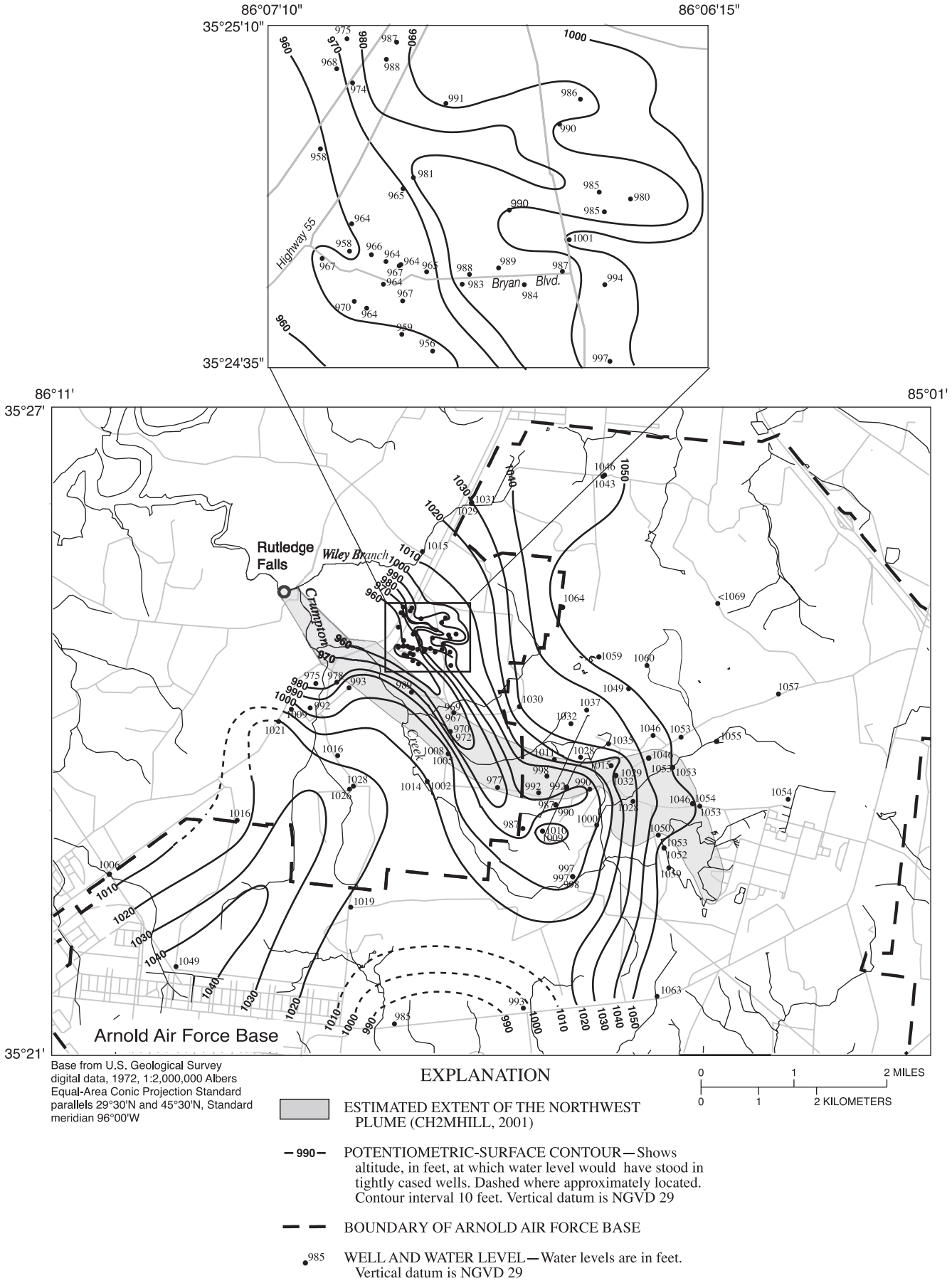


Figure 4. Altitude of the potentiometric surface of the Manchester aquifer in the Crumpton Creek area near Arnold Air Force Base, Tennessee, November 2001 to January 2002.

Table 2. Volatile organic compound analytes, reporting levels, and method detection limits

Analyte	Reporting level, in micrograms per liter	Method detection limit, in micrograms per liter
Acetone	10	1.9
Acetonitrile	20	2.6
Acrolein	20	4.7
Acrylonitrile	20	2.4
Benzene	1.0	0.21
Bromodichloromethane	1.0	0.22
Bromoform	1.0	0.32
Bromomethane	2.0	0.30
2-Butanone (MEK)	5.0	0.93
Carbon disulfide	1.0	0.19
Carbon tetrachloride	1.0	0.19
Chlorobenzene	1.0	0.30
Chloroprene	1.0	0.22
Dibromochloromethane	1.0	0.38
Chloroethane	2.0	0.25
Chloroform	1.0	0.23
Chloromethane	2.0	0.30
Allyl chloride	2.0	0.20
1,2-Dibromo-3-chloropropane (DBCP)	2.0	0.25
1,2-Dibromoethane (EDB)	1.0	0.36
Dibromomethane	1.0	0.44
trans-1,4-Dichloro-2-butene	1.0	0.60
Dichlorodifluoromethane	2.0	0.23
1,1-Dichloroethane	1.0	0.17
1,2-Dichloroethane	1.0	0.28
1,1-Dichloroethylene	1.0	0.20
cis-1,2-Dichloroethylene	1.0	0.26
trans-1,2-Dichloroethylene	0.5	0.27
1,2-Dichloropropane	1.0	0.21
cis-1,3-Dichloropropene	1.0	0.28
trans-1,3-Dichloropropene	1.0	0.42
1,4-Dioxane	200	17
Ethylbenzene	1.0	0.28
Ethyl methacrylate	1.0	0.25
2-Hexanone	5.0	0.70
Iodomethane	1.0	0.23
Isobutyl alcohol	50	11
Methacrylonitrile	10	1.6
Methylene chloride	1.0	0.89
Methyl methacrylate	1.0	0.30
4-Methyl-2-pentanone	5.0	0.79
Propionitrile	5.0	2.2
Styrene	1.0	0.27
1,1,1,2-Tetrachloroethane	1.0	0.22
1,1,2,2-Tetrachloroethane	1.0	0.31
Tetrachloroethylene	1.0	0.36
Toluene	1.0	0.29
1,1,1-Trichloroethane	1.0	0.26
1,1,2-Trichloroethane	1.0	0.39
Trichloroethylene	1.0	0.22
Trichlorofluoromethane	2.0	0.28
1,2,3-Trichloropropane	1.0	0.29
Vinyl acetate	2.0	0.31
Vinyl chloride	2.0	0.21
Xylenes (total)	1.0	0.95

Table 3. Ranges and median values of selected physical properties of water samples from wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter]

Physical property	Minimum	Maximum	Median
Specific conductance (µS/cm)	12	282	100
pH (standard units)	4.6	7.8	6.3
Dissolved oxygen (mg/L)	0.1	11	7.6
Temperature (°C)	12.0	18.5	15.5

naturally but is also used in the manufacturing of refrigerants and aerosol propellants. In the past, carbon tetrachloride also was widely used as a degreasing agent, a cleaning fluid, a pesticide, and a fire extinguishing agent (Agency for Toxic Substances and Disease Registry, 1994). Chloroform is a disinfectant byproduct of the chlorination of water containing naturally occurring organic matter (Agency for Toxic Substances and Disease Registry, 1997a). Dichlorodifluoromethane is used as a refrigerant and aerosol. The VOC 4-methyl-2-pentanone is used in the manufacturing of methyl amyl alcohol and as a solvent in paints and varnishes (Lucius and others, 1992). The VOC 1,2-DCE is used primarily as a chemical intermediate in the production of other chlorinated solvents (Agency for Toxic Substances and Disease Registry, 1996), and cis-1,2-DCE is also a biodegradation byproduct of PCE (Wiedemeier and others, 1998).

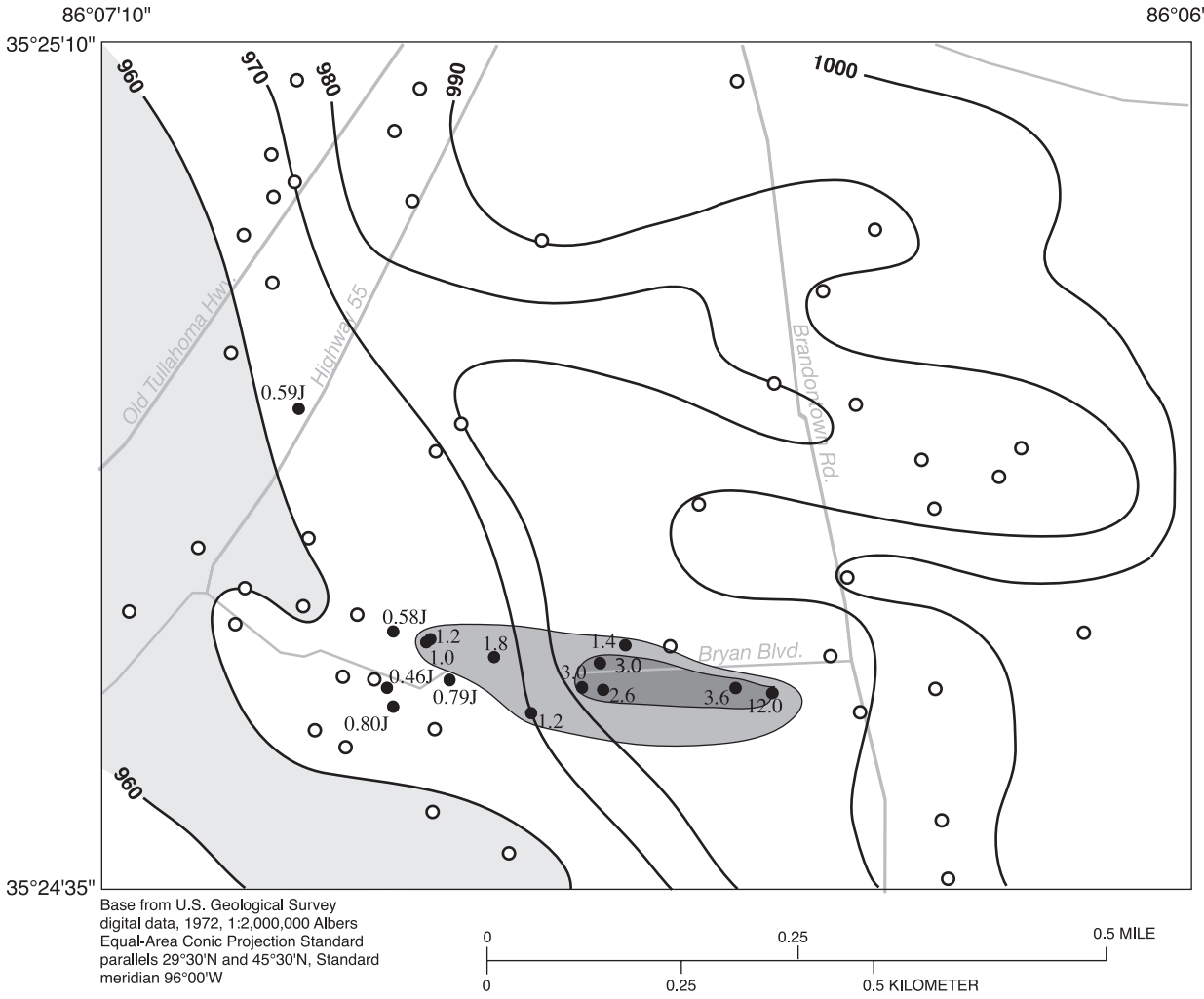
Three VOCs (PCE, methylene chloride, and toluene) were detected at concentrations greater than their respective reporting levels (table 2, appendix 2). PCE was the only VOC detected at a concentration exceeding a drinking water maximum contaminant level (MCL). Methylene chloride is a common laboratory contaminant (U.S. Environmental Protection Agency, 1999a). Toluene is in gasoline and is used as a solvent in paints, coatings, adhesives, inks, and cleaning agents (Agency for Toxic Substances and Disease Registry, 2000). Toluene also occurs naturally in association with petroleum deposits and shales, and has been previously detected in water samples from the Fort Payne aquifer (Haugh and others, 1992).

PCE was detected in water samples from 15 private wells (fig. 5; appendix 2). PCE concentrations detected in samples from five of the wells were below the reporting level for the analytical method used and ranged from estimated concentrations of 0.46 to 0.80 µg/L. Samples from 10 wells contained concentrations equal to or greater than the analytical reporting level of 1 µg/L for PCE. Samples from one well contained PCE concentrations exceeding the drinking water MCL of 5 µg/L for PCE (U.S. Environmental Protection Agency, 2001). A PCE concentration of 12 µg/L was detected in a water sample from well PW-64, and a PCE concentration of 11 µg/L was detected in a second (duplicate) sample also collected from well PW-64.

All but one of the PCE detections were at wells located along Bryan Blvd. PCE concentrations decreased in the downgradient direction from 12 µg/L (well PW-64) to less than 1 µg/L within 0.3 mile of PW-64 (fig. 5). PCE was not detected in three private wells (PW-23, PW-55, and PW-58), which are upgradient from well PW-64 (fig. 3, fig. 5). PCE also was not detected in several wells located between Bryan Blvd. and the ground-water trough (fig. 5) extending between AAFB and Rutledge Falls. The spatial distribution of the PCE detections suggests that these detections are associated with a small localized ground-water contamination plume unrelated to AAFB ground-water contamination. PCE biodegradation products, TCE and cis-1,2-DCE were detected at estimated concentrations below the analytical reporting level in samples collected from well PW-64. The relative concentrations of PCE and TCE detected near Bryan Blvd. also suggest that these detections are part of a local plume and are unrelated to contaminants detected in the northwest plume. In water samples collected from monitoring wells associated with the northwest plume, TCE is the primary contaminant and the ratio of TCE to PCE is about 3 to 1 (fig. 6) (CH2M Hill, 2001). In contrast, PCE was the primary contaminant detected in water samples collected from private wells near Bryan Blvd. (fig. 6), and the ratio of TCE to PCE was 1 to 14 (appendix 2). TCFM, which is usually detected in samples from the northwest plume (fig. 6), was not detected in samples from private wells near Bryan Blvd.

Quality-Assurance/Quality-Control Samples

Field quality-assurance/quality-control (QA/QC) samples included duplicate samples, equipment blanks, trip blanks, and replicate samples for matrix spikes. One duplicate sample was collected and



EXPLANATION

ESTIMATED EXTENT OF PCE CONCENTRATIONS GREATER THAN 1.0 MICROGRAM PER LITER

ESTIMATED EXTENT OF PCE CONCENTRATIONS GREATER THAT 3.0 MICROGRAMS PER LITER

PROMINENT GROUND-WATER TROUGH IN THE CRUMPTON CREEK AREA

960 — POTENTIOMETRIC-SURFACE CONTOUR—Shows altitude, in feet, at which water level would have stood in tightly cased wells. Contour interval 10 feet. Vertical datum is NGVD 29

1.2 ● WELL AND TETRACHLOROETHYLENE (PCE) CONCENTRATION—Concentrations are in micrograms per liter. J indicates estimated concentration below the reporting limit of 1.0 microgram per liter

○ WELL WHERE PCE WAS NOT DETECTED—Method detection limit was 0.36 microgram per liter

Figure 5. Tetrachloroethylene (PCE) concentrations detected in water samples collected from wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee.

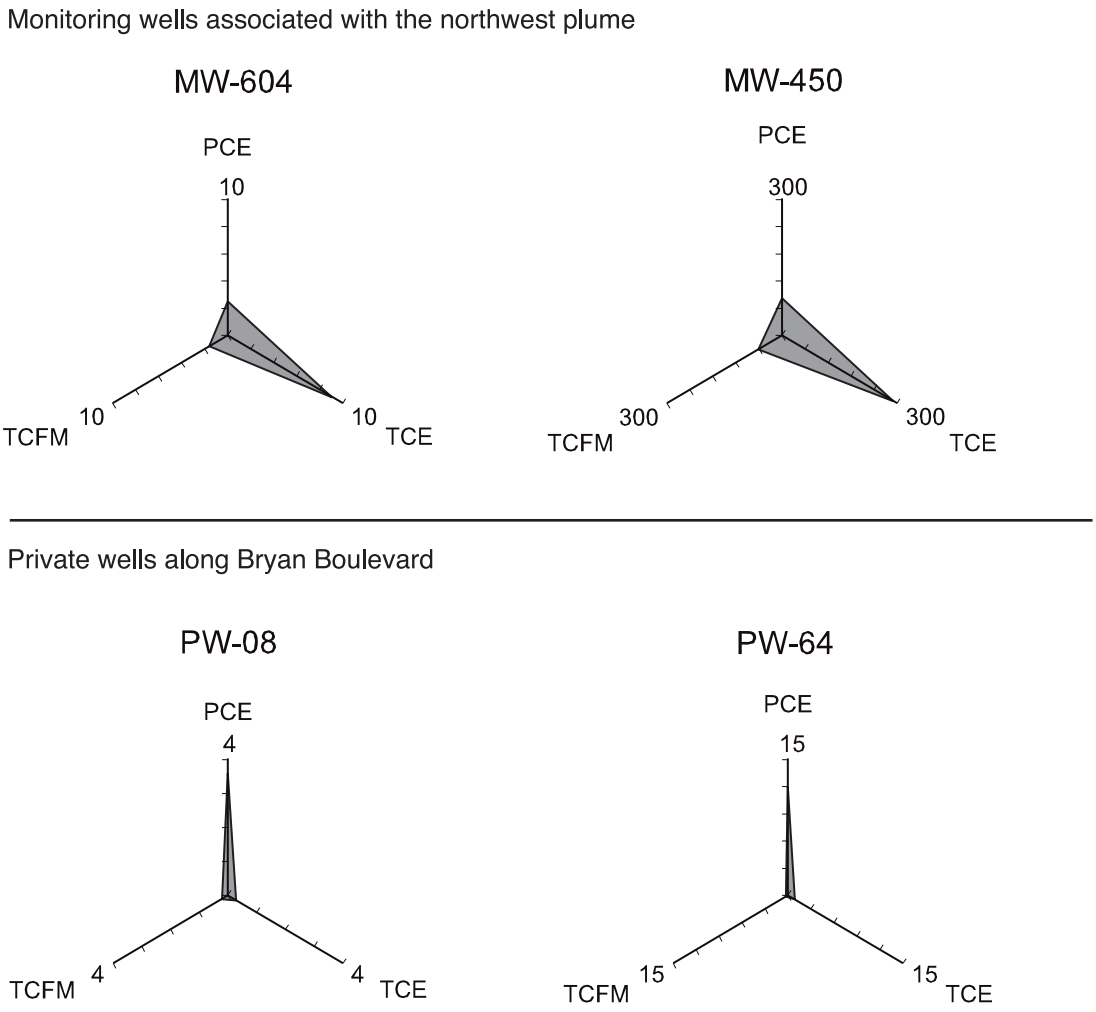


Figure 6. Concentrations of volatile organic compounds detected in selected monitoring and private wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee. (PCE, tetrachloroethylene; TCE, trichloroethylene; TCFM, trichlorofluoromethane; all concentrations are in micrograms per liter; monitoring well data from CH2M HILL, 2001.)

analyzed for every 10 VOC samples collected. Duplicate VOC samples were collected from wells PW-03, PW-15, PW-25, PW-35, PW-45, PW-58, and PW-64 (appendix 2). No significant difference was identified in any of the duplicate analyses. Equipment blanks and matrix spike samples were collected and analyzed for every 20 samples collected. A trip blank accompanied each sample shipment. Analytical results for detected compounds in equipment blanks and trip blanks are presented in appendix 3. Acetone was detected in two equipment blanks at estimated concentrations, and carbon disulfide was detected in one equipment blank at an estimated concentration below the reporting level. Acetone was detected in four trip blanks at estimated concentrations below the analytical reporting level (appendix 3). Acetone has been identified as a common laboratory contaminant (U.S. Environmental Protection Agency, 1999a).

Severn Trent Laboratories followed standard analytical QA/QC practices for all VOC analyses. These practices include laboratory blanks, quality-control standards, surrogate spikes, matrix spikes, and duplicate analyses (Severn Trent Laboratories, 2000). All VOC sample results were validated (EPA Level 2 review) by Quality by Design, Hilo, Hawaii. The validation was based on the EPA national guidelines for organic data review (U.S. Environmental Protection Agency, 1999b) and consisted of a review of sample

and quality-control results and the accompanying raw data. The purpose of data validation is to assess the effect of the overall analytical process on the quality of the data.

The data validation determined that some of the quality-control data associated with instrument calibration did not meet criteria listed in the EPA national functional guidelines for organic data review. Several of the nondetections for acetone, acrolein, acrylonitrile, 2-butanone, 1,4-dioxane, acetonitrile, propionitrile, methacrylonitrile, and isobutyl alcohol were unreliable (Lorraine Davis, Quality by Design, written commun., 2002; Thomas Davis, Quality by Design, written commun., 2002). These results are indicated by the symbol "R" (appendix 2). The validation also determined that the reporting levels listed in some of the analytical reports may be inaccurate for the following compounds: acetone, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chloromethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, dibromomethane, dichlorodifluoromethane, 1,2-dichloroethane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 2-hexanone, iodomethane, methyl methacrylate, 4-methyl-2-pentanone, 1,1,1-TCA, 1,1,2-trichloroethane, TCFM, 1,2,3-trichloropropane, and vinyl acetate (Lorraine Davis, Quality by Design, written commun., 2002; Thomas Davis, Quality by Design, written commun., 2002). These results are indicated by the symbol "UJ" in appendixes 2 and 3.

SUMMARY

Volatile organic compounds (VOCs), primarily chlorinated solvents, have been identified in the ground water that flows west-northwest from AEDC (the northwest plume) in the Crumpton Creek area near Arnold Air Force Base (AAFB). From November 2001 to January 2002, a study of the ground-water resources in the Crumpton Creek area was conducted to determine whether VOCs from AAFB have affected local private water supplies and to advance understanding of the ground-water-flow system in this area. The study focused on collecting VOC samples from private wells that were not included in previous sampling efforts conducted in the Crumpton Creek area near AAFB.

Data were collected from a total of 68 private wells, 82 monitoring wells, and 1 cave. Ground-water-flow directions were investigated by measuring water levels in wells and constructing a potentiometric-surface map of the Manchester aquifer in the study area. Depths to ground water were determined for 42 of the private wells and for all 82 monitoring wells. Of these 82 monitoring wells, 81 withdraw water from the Manchester aquifer, and one withdraws water from the overlying shallow aquifer. The Manchester aquifer wells ranged in depth from 20 to 150 feet. Water-level altitudes ranged in the Manchester aquifer from 956 to 1,064 feet above NGVD 29. Water levels ranged from approximately 6 feet above land surface to 94 feet below land surface. Water-quality samples were collected from all 68 private wells, the cave, and from 8 of the monitoring wells.

Forty-two of the 55 VOCs analyzed were not detected. Thirteen VOCs were detected; however, most of these detections were at concentrations less than reporting levels and are considered estimated concentrations. Tetrachloroethylene (PCE), methylene chloride, and toluene were detected at concentrations equal to or above reporting levels for the analytical method used. PCE was the only VOC detected at a concentration exceeding drinking water maximum contaminant levels for public water systems.

PCE was detected in water samples from 15 private wells. Concentrations detected in samples from five of the wells were below the reporting level for the analytical method used and ranged from estimated concentrations of 0.46 to 0.80 µg/L. Samples from 10 wells contained concentrations equal to or above the analytical reporting level of 1 µg/L for PCE. Samples from one of these wells contained PCE concentrations (11 to 12 µg/L), which exceeded the drinking water maximum contaminant level of 5 µg/L for PCE. The spatial distribution of the PCE detections and the relative concentrations of PCE and TCE suggest that the PCE detections are associated with a small, localized ground-water contamination plume unrelated to AAFB ground-water contamination.

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Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee

[°, degrees; ′, minutes; ″, seconds; UM, the upper part of the Manchester aquifer; LM, the lower part of the Manchester aquifer; --, no data; -, indicates water levels above land surface; <, less than; >, greater than; vertical datum is NGVD 29]

Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
PW-01	35°24'42"	86°06'59"	11/06/01	970	1030	60	99	Measurement	UM-regolith		Private
PW-02	35°24'42"	86°06'57"	11/06/01	964	1035	71	89	Measurement	UM-regolith		Private
PW-03	35°24'47"	86°07'03"	11/06/01	967	1013	46	66	Measurement	--		Private
PW-04	35°24'44"	86°06'58"	--	--	1020	--	--	--	LM-bedrock		Private
PW-05	35°24'44"	86°06'52"	--	--	1051	--	123	Owner	LM-bedrock		Private
PW-06	35°24'45"	86°06'50"	11/07/01	965	1052	87	99	Measurement	--		Private
PW-07	35°24'45"	86°06'45"	11/07/01	988	1063	75	105	Measurement	LM-bedrock		Private
PW-08	35°24'44"	86°06'38"	11/07/01	984	1065	81	99	Measurement	--		Private
PW-09	35°24'46"	86°06'41"	11/07/01	989	1069	80	118	Measurement	UM-regolith		Private
PW-10	35°24'38"	86°06'27"	--	--	1071	--	123	Owner	UM-regolith		Private
PW-11	35°25'05"	86°07'00"	--	--	1035	--	97	Owner	UM-regolith		Private
PW-12	35°24'47"	86°07'08"	--	--	990	--	--	--	LM-bedrock		Private
PW-13	35°24'56"	86°06'32"	--	--	1063	--	105	Owner	UM-regolith		Private
PW-14	35°24'55"	86°06'53"	11/08/01	965	1054	89	107	Measurement	UM-regolith		Private
PW-15	35°24'54"	86°06'52"	11/08/01	981	1060	79	102	Measurement	UM-regolith		Private
PW-16	35°24'47"	86°06'00"	11/08/01	958	1016	58	90	Measurement	UM-regolith		Private
PW-17	35°24'48"	86°07'03"	--	--	1014	--	--	--	--		Private
PW-18	35°24'52"	86°06'40"	11/08/01	990	1072	82	107	Measurement	UM-regolith		Private
PW-19	35°2509"	86°07'00"	11/14/01	975	1042	67	111	Measurement	UM-regolith		Private
PW-20	35°25'06"	86°07'01"	11/14/01	968	1049	81	102	Measurement	UM-regolith		Private
PW-21	35°24'58"	86°07'03"	11/14/01	958	1011	53	67	Measurement	LM-bedrock		Private
PW-22	35°25'04"	86°07'01"	--	--	1037	--	100	Owner	UM-regolith		Private
PW-23	35°24'45"	86°06'33"	11/15/01	987	1075	88	114	Measurement	UM-regolith		Private
PW-24	35°25'00"	86°06'33"	11/15/01	990	1062	72	103	Measurement	UM-regolith		Private
PW-25	35°25'03"	86°06'48"	11/15/01	991	1061	70	140	Owner	UM-regolith		Private

Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

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Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
PW-26	35°24'36"	86°06'27"	11/15/01	997	1072	75	106	Measurement	UM-regolith		Private
PW-27	35°24'47"	86°06'57"	11/15/01	966	1022	56	96	Measurement	UM-regolith		Private
PW-28	35°24'50"	86°06'59"	11/15/01	964	1030	66	93	Measurement	LM-bedrock		Private
PW-29	35°24'46"	86°06'55"	11/28/01	964	1038	74	86	Measurement	UM-regolith		Private
PW-30	35°24'46"	86°06'53"	11/28/01	964	1051	86	95	Measurement	LM-bedrock		Private
PW-31	35°24'39"	86°06'53"	11/28/01	959	1049	90	117	Measurement	LM-bedrock		Private
PW-32	35°24'44"	86°06'56"	--	--	1037	--	--	--	UM-regolith		Private
PW-33	35°24'37"	86°06'49"	11/28/01	956	1050	94	107	Measurement	LM-bedrock		Private
PW-34	35°24'44"	86°06'55"	11/28/01	964	1041	77	85	Measurement	UM-regolith		Private
PW-34	35°24'44"	86°06'55"	12/19/01	965	1041	76	85	Measurement	UM-regolith		Private
PW-35	35°25'03"	86°06'31"	11/28/01	986	1057	71	96	Measurement	UM-regolith		Private
PW-36	35°24'40"	86°08'13"	--	--	1018	--	80	Owner	LM-bedrock		Private
PW-37	35°25'00"	86°07'01"	--	--	1020	--	110	Owner	LM-bedrock		Private
PW-38	35°25'04"	86°06'54"	--	--	1037	--	80	Owner	UM-regolith		Private
PW-39	35°24'51"	86°06'28"	12/03/01	985	1066	81	100	Owner	LM-bedrock		Private
PW-40	35°2453"	86°06'29"	12/03/01	985	1066	81	123	Measurement	LM-bedrock		Private
PW-41	35°24'43"	86°06'55"	--	--	1046	--	105	Owner	LM-bedrock		Private
PW-42	35°24'44"	86°06'46"	12/06/01	983	1060	77	119	Measurement	LM-bedrock		Private
PW-43	35°25'09"	86°06'54"	12/06/01	987	1041	54	90	Measurement	UM-regolith		Private
PW-44	35°24'42"	86°06'53"	12/06/01	967	1050	83	--	--	--		Private
PW-45	35°24'57"	86°06'36"	--	--	1058	--	98	Owner	UM-regolith		Private
PW-46	35°25'03"	86°07'03"	--	--	1033	--	--	--	LM-bedrock		Private
PW-47	35°24'11"	86°08'17"	12/06/01	1009	1051	42	--	--	LM-bedrock		Private
PW-48	35°24'26"	86°08'00"	12/06/01	975	1052	77	120	Owner	LM-bedrock		Private
PW-49	35°24'11"	86°08'13"	--	--	1051	--	--	--	UM-regolith		Private

Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

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Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
PW-50	35°24'27"	86°07'45"	12/06/01	978	1012	34	70	Owner	LM-bedrock		Private
PW-51	35°24'53"	86°06'24"	12/11/01	980	1071	91	145	Measurement	--		Private
PW-52	35°24'54"	86°06'23"	--	--	1063	--	--	--	LM-bedrock		Private
PW-53	35°24'42"	86°06'48"	--	--	1058	--	96	Owner	UM-regolith		Private
PW-54	35°24'50"	86°07'05"	12/11/01	991	999	8	92	Measurement	--		Private
PW-55	35°24'42"	86°06'32"	--	--	1074	--	125	Owner	UM-regolith		Private
PW-56	35°24'12"	86°08'04"	12/11/01	992	1025	33	47	Measurement	UM-regolith		Private
PW-57	35°25'09"	86°06'38"	--	--	1061	--	150	Owner	--		Private
PW-58	35°24'44"	86°06'28"	12/14/01	994	1083	89	112	Measurement	UM-regolith		Private
PW-59	35°24'46"	86°06'43"	--	--	1065	--	--	--	--		Private
PW-60	35°24'45"	86°05'54"	12/14/01	967	1050	83	108	Measurement	--		Private
PW-61	35°24'56"	86°07'00"	--	--	1009	--	81	Owner	UM-regolith		Private
PW-62	35°23'45"	86°07'45"	12/14/01	1016	1035	19	64	Measurement	UM-regolith		Private
PW-63	35°24'17"	86°08'14"	--	--	1051	--	--	--	LM-bedrock		Private
PW-64	35°24'44"	86°06'36"	--	--	1070	--	--	--	UM-regolith		Private
PW-65	35°25'07"	86°06'55"	12/18/01	988	1029	41	68	Measurement	UM-regolith		Private
PW-66	35°24'46"	86°06'20"	--	--	1084	--	--	--	LM-bedrock		Private
PW-67	35°24'44"	86°06'44"	--	--	1061	--	--	--	--		Private
PW-68	35°23'28"	86°07'34"	01/14/02	1028	1032	4	--	--	LM-bedrock		Private
MW-98	35°23'17"	86°03'36"	12/11/01	1054	1086	32	63	CH2M Hill, 2001		Intermediate	Monitoring
MW-99	35°23'01"	86°04'04"	12/11/01	1050	1073	22	72	CH2M Hill, 2001		Intermediate	Monitoring
MW-134	35°26'08"	86°06'13"	12/19/01	1031	1048	17	33	CH2M Hill, 2001		Intermediate	Monitoring
MW-135	35°26'08"	86°06'13"	12/19/01	1029	1050	21	55	CH2M Hill, 2001		Deep	Monitoring
MW-181	35°22'37"	86°05'03"	12/19/01	997	1029	32	95	CH2M Hill, 2001		Deep	Monitoring
MW-182	35°22'37"	86°05'03"	12/19/01	997	1029	32	73	CH2M Hill, 2001		Intermediate	Monitoring

Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

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Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
MW-183	35°22'37"	86°05'03"	12/19/01	998	1029	31	43	CH2M Hill, 2001		Intermediate	Monitoring
MW-185	35°25'09"	86°05'10"	12/12/01	1064	1105	41	60	CH2M Hill, 2001		Deep	Monitoring
MW-186	35°25'09"	86°05'10"	12/12/01	1087	1102	15	27	CH2M Hill, 2001		Shallow	Monitoring
MW-193	35°22'38"	86°10'22"	12/19/01	958	1038	80	109	CH2M Hill, 2001		Deep	Monitoring
MW-194	35°22'38"	86°10'22"	12/19/01	1006	1039	33	43	CH2M Hill, 2001		Intermediate	Monitoring
MW-195	35°23'08"	86°08'54"	12/19/01	1016	1047	31	58	CH2M Hill, 2001		Intermediate	Monitoring
MW-196	35°26'23"	86°04'41"	12/12/01	1046	1081	35	108	CH2M Hill, 2001		Deep	Monitoring
MW-197	35°26'23"	86°04'42"	12/12/01	1043	1083	40	42	CH2M Hill, 2001		Intermediate	Monitoring
MW-200	35°23'53"	86°03'24"	12/12/01	1055	1067	12	84	CH2M Hill, 2001		Deep	Monitoring
MW-201	35°23''53	86°03'24"	12/12/01	1055	1067	12	51	CH2M Hill, 2001		Intermediate	Monitoring
MW-212	35°25'11"	86°03'23"	12/12/01	<1069	1096	>27	27	CH2M Hill, 2001		Intermediate	Monitoring
MW-213	35°24'11"	86°04'53"	12/11/01	1037	1071	34	59	CH2M Hill, 2001		Intermediate	Monitoring
MW-214	35°23'04"	86°05'37"	12/11/01	987	1060	73	79	CH2M Hill, 2001		Intermediate	Monitoring
MW-215	35°24'20"	86°02'42"	12/12/01	1057	1076	19	58	CH2M Hill, 2001		Intermediate	Monitoring
MW-219	35°21'46"	86°09'36"	12/19/01	1049	1070	21	73	CH2M Hill, 2001		Intermediate	Monitoring
MW-222	35°21'14"	86°07'06"	12/19/01	985	1047	62	93	CH2M Hill, 2001		Intermediate	Monitoring
MW-223	35°21'23"	86°05'37"	12/19/01	993	1047	54	68	CH2M Hill, 2001		Intermediate	Monitoring
MW-224	35°21'30"	86°04'05"	12/19/01	1063	1080	17	83	CH2M Hill, 2001		Intermediate	Monitoring
MW-230	35°25'40"	86°06'47"	12/19/01	1015	1021	6	20	CH2M Hill, 2001		Intermediate	Monitoring
MW-231	35°22'20"	86°07'36"	12/19/01	1019	1047	28	71	CH2M Hill, 2001		Intermediate	Monitoring
MW-299	35°22'53"	86°04'00"	12/11/01	1053	1073	20	81	CH2M Hill, 2001		Intermediate	Monitoring
MW-300	35°22'53"	86°04'00"	12/11/01	1052	1073	21	113	CH2M Hill, 2001		Deep	Monitoring
MW-312	35°23'19"	86°04'22"	12/11/01	1028	1064	36	90	CH2M Hill, 2001		Intermediate	Monitoring
MW-342	35°23'43"	86°05'16"	12/11/01	1011	1077	66	74	CH2M Hill, 2001		Intermediate	Monitoring
MW-353	35°24'41"	86°04'45"	12/12/01	1059	1068	9	95	CH2M Hill, 2001		Deep	Monitoring

Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[°, degrees; ′, minutes; ″, seconds; UM, the upper part of the Manchester aquifer; LM, the lower part of the Manchester aquifer; --, no data; -, indicates water levels above land surface; <, less than; >, greater than; vertical datum is NGVD 29]

Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
MW-354	35°24'41"	86°04'45"	12/12/01	1059	1067	8	23	CH2M Hill, 2001		Intermediate	Monitoring
MW-355	35°24'36"	86°04'12"	12/12/01	1060	1071	11	31	CH2M Hill, 2001		Intermediate	Monitoring
MW-450	35°23'34"	86°04'33"	12/11/01	1032	1063	31	101	CH2M Hill, 2001		Intermediate	Monitoring
MW-451	35°24'03"	86°05'04"	12/11/01	1032	1065	33	69	CH2M Hill, 2001		Intermediate	Monitoring
MW-453	35°23'18"	86°03'41"	12/11/01	1054	1082	28	65	CH2M Hill, 2001		Intermediate	Monitoring
MW-456	35°22'46"	86°04'02"	12/11/01	1046	1045	-1	78	CH2M Hill, 2001		Intermediate	Monitoring
MW-459	35°23'34"	86°04'33"	12/11/01	1029	1063	34	118	CH2M Hill, 2001		Deep	Monitoring
MW-461	35°23'44"	86°04'58"	12/11/01	1028	1055	27	82	CH2M Hill, 2001		Intermediate	Monitoring
MW-462	35°23'26"	86°04'51"	12/11/01	990	1056	66	92	CH2M Hill, 2001		Intermediate	Monitoring
MW-463	35°23'57"	86°04'08"	12/12/01	1046	1069	23	84	CH2M Hill, 2001		Intermediate	Monitoring
MW-464	35°23'40"	86°04'37"	12/11/01	1015	1064	49	92	CH2M Hill, 2001		Intermediate	Monitoring
MW-468	35°23'28"	86°05'07"	12/11/01	992	1062	70	120	CH2M Hill, 2001		Deep	Monitoring
MW-469	35°23'28"	86°05'07"	12/11/01	992	1062	70	106	CH2M Hill, 2001		Intermediate	Monitoring
MW-471	35°23'52"	86°04'38"	12/11/01	1035	1066	31	62	CH2M Hill, 2001		Intermediate	Monitoring
MW-472	35°2'306"	86°04'46"	12/11/01	1000	1049	49	64	CH2M Hill, 2001		Intermediate	Monitoring
MW-501	35°23'44"	86°04'11"	12/12/01	1046	1069	23	75	CH2M Hill, 2001		Intermediate	Monitoring
MW-502	35°23'56"	86°03'49"	12/12/01	1053	1067	14	80	CH2M Hill, 2001		Intermediate	Monitoring
MW-503	35°23'34"	86°05'21"	12/11/01	998	1072	74	106	CH2M Hill, 2001		Intermediate	Monitoring
MW-504	35°23'39"	86°03'54"	12/12/01	1053	1056	3	33	CH2M Hill, 2001		Intermediate	Monitoring
MW-505	35°23'39"	86°03'54"	12/12/01	1053	1056	3	80	CH2M Hill, 2001		Deep	Monitoring
MW-506	35°23'44"	86°04'11"	12/12/01	1046	1069	23	76	CH2M Hill, 2001		Intermediate	Monitoring
MW-508	35°23'44"	86°04'11"	12/12/01	1046	1067	21	76	CH2M Hill, 2001		Intermediate	Monitoring
MW-509	35°23'44"	86°04'11"	12/12/01	1046	1067	21	69	CH2M Hill, 2001		Intermediate	Monitoring
MW-510	35°23'44"	86°04'11"	12/12/01	1046	1067	21	63	CH2M Hill, 2001		Intermediate	Monitoring
MW-524	35°23'27"	86°05'07"	12/11/01	992	1063	71	108	CH2M Hill, 2001		Intermediate	Monitoring

Table 1. Well depths and water-level data for private and monitoring wells in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[°, degrees; ′, minutes; ″, seconds; UM, the upper part of the Manchester aquifer; LM, the lower part of the Manchester aquifer; --, no data; -, indicates water levels above land surface; <, less than; >, greater than; vertical datum is NGVD 29]

Well number	Latitude	Longitude	Date of water level mesure-ment	Water level altitude, in feet above NGVD 29	Land sur-face alti-tude, in feet above NGVD 29	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Inferred hydrogeologic unit (where applicable)	Hydrogeologic unit - AEDC designation (where applicable)	Well type
MW-525	35°23'27"	86°05'07"	12/11/01	992	1063	71	92	CH2M Hill, 2001		Intermediate	Monitoring
MW-551	35°23'18"	86°03'40"	12/11/01	1053	1083	30	93	CH2M Hill, 2001		Deep	Monitoring
MW-559A	35°23'24"	86°05'26"	12/11/01	992	1065	73	105	CH2M Hill, 2001		Intermediate	Monitoring
MW-560	35°23'03"	86°05'24"	12/11/01	1009	1064	55	113	CH2M Hill, 2001		Deep	Monitoring
MW-561	35°23'03"	86°05'24"	12/11/01	1010	1065	55	68	CH2M Hill, 2001		Intermediate	Monitoring
MW-562	35°23'18"	86°05'15"	12/11/01	987	1064	77	112	CH2M Hill, 2001		Deep	Monitoring
MW-563	35°23'18"	86°05'15"	12/11/01	990	1064	74	75	CH2M Hill, 2001		Intermediate	Monitoring
MW-597	35°22'45"	86°04'02"	12/11/01	1049	1046	-3	97	CH2M Hill, 2001		Deep	Monitoring
MW-601	35°23'46"	86°06'29"	12/19/01	1005	1055	50	134	CH2M Hill, 2001		Deep	Monitoring
MW-602	35°23'46"	86°06'29"	12/19/01	1008	1055	47	65	CH2M Hill, 2001		Intermediate	Monitoring
MW-603	35°23'59"	86°06'27"	12/19/01	972	1014	42	103	CH2M Hill, 2001		Deep	Monitoring
MW-604	35°23'59"	86°06'27"	12/19/01	970	1014	44	84	CH2M Hill, 2001		Intermediate	Monitoring
MW-605	35°24'09"	86°06'25"	12/19/01	967	1048	81	133	CH2M Hill, 2001		Deep	Monitoring
MW-606	35°24'09"	86°06'25"	12/19/01	969	1048	79	121	CH2M Hill, 2001		Intermediate	Monitoring
MW-607	35°24'48"	86°06'32"	12/19/01	1001	1071	70	101	CH2M Hill, 2001		Intermediate	Monitoring
MW-608	35°23'27"	86°05'55"	12/19/01	977	1056	79	120	CH2M Hill, 2001		Intermediate	Monitoring
MW-609	35°23'31"	86°06'43"	12/19/01	1014	1008	-6	105	CH2M Hill, 2001		Deep	Monitoring
MW-610	35°23'31"	86°06'43"	12/19/01	1002	1008	6	20	CH2M Hill, 2001		Intermediate	Monitoring
MW-611	35°23'26"	86°07'37"	12/19/01	1026	1026	0	41	CH2M Hill, 2001		Intermediate	Monitoring
MW-612	35°25'04"	86°06'59"	12/19/01	974	1036	62	135	CH2M Hill, 2001		Intermediate	Monitoring
MW-613	35°24'23"	86°07'37"	12/19/01	993	1025	32	66	CH2M Hill, 2001		Intermediate	Monitoring
MW-614	35°24'04"	86°08'25"	12/19/01	1021	1035	14	48	CH2M Hill, 2001		Intermediate	Monitoring
MW-615	35°24'13"	86°05'40"	12/19/01	1030	1066	36	75	CH2M Hill, 2001		Intermediate	Monitoring
MW-621	35°24'21"	86°06'54"	12/19/01	989	1001	12	31	CH2M Hill, 2001		Intermediate	Monitoring
MW-635	35°22'42"	86°03'57"	12/11/01	1059	1071	12	45	CH2M Hill, 2001		Intermediate	Monitoring
PZ-BKG-1	35°24'23"	86°04'25"	12/12/01	1049	1084	35	48	CH2M Hill, 2001		Intermediate	Monitoring

Appendixes

Appendix 1. Physical properties of water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; °C, degrees Celsius; --, no data]

Well number	USGS station number	Date	Time	Specific conductance (µS/cm)	pH (standard units)	Dissolved oxygen (mg/L)	Temperature (°C)
PW-01	352442086065901	11/06/01	1145	22	4.7	8.3	16.0
PW-02	352441086065801	11/06/01	1340	28	4.9	8.3	17.0
PW-03	352446086070301	11/06/01	1500	183	6.0	6.0	17.0
PW-04	352444086065801	11/06/01	1545	--	--	--	--
PW-05	352444086065201	11/07/01	1000	155	7.8	9.9	15.5
PW-06	352445086065001	11/07/01	1120	149	6.9	8.0	15.5
PW-07	352445086064501	11/07/01	1340	204	7.4	9.5	16.0
PW-08	352444086063801	11/07/01	1500	94	6.6	8.0	15.5
PW-09	352445086064101	11/07/01	1600	42	6.0	8.2	15.5
PW-10	352438086062801	11/07/01	1700	32	6.1	9.1	15.5
PW-11	352505086070001	11/08/01	0950	29	5.1	5.5	16.0
PW-12	352447086070901	11/08/01	1120	261	7.3	3.8	16.0
PW-13	352455086063201	11/08/01	1245	60	5.6	8.7	16.0
PW-14	352453086065301	11/08/01	1000	17	4.9	9.0	15.0
PW-15	352454086065201	11/08/01	1115	15	4.7	8.5	15.0
PW-16	352447086066001	11/08/01	1315	71	5.0	6.0	15.0
PW-17	352448086070301	11/08/01	1420	226	6.1	5.1	16.5
PW-18	352451086064001	11/08/01	1530	24	4.6	7.5	15.0
PW-19	352509086070001	11/14/01	1025	15	4.9	7.4	15.5
PW-20	352506086070101	11/14/01	1150	26	5.1	6.7	15.5
PW-21	352457086070301	11/14/01	1345	234	6.9	6.9	15.5
PW-22	352504086070201	11/14/01	1505	69	5.9	6.4	15.5
PW-23	352445086063301	11/15/01	0915	56	6.0	7.6	15.5
PW-24	352460086063401	11/15/01	1035	28	4.8	8.0	16.0
PW-25	352503086064801	11/15/01	1135	12	5.0	8.1	16.0
PW-26	352436086062701	11/15/01	1240	27	5.2	9.4	16.0
PW-27	352447086065701	11/15/01	1350	25	5.2	8.3	15.0
PW-28	352450086065901	11/15/01	1445	192	7.0	7.5	15.5
PW-29	352446086065501	11/28/01	0930	74	6.3	9.3	15.0
PW-30	352445086065301	11/28/01	1030	152	6.7	9.0	15.0
PW-31	352438086065301	11/28/01	1135	187	6.9	6.0	15.5
PW-32	352444086065601	11/28/01	1150	35	5.6	--	--
PW-33	352437086064901	11/28/01	1310	179	6.7	4.6	15.5
PW-34	352443086065501	11/28/01	1355	53	6.0	9.0	15.5
PW-35	352502086063101	11/28/01	1505	53	6.1	8.2	15.5
PW-36	352440086081301	12/03/01	0940	239	7.1	11.0	15.0
PW-37	352460086070101	12/03/01	1047	210	6.9	9.7	15.0
PW-38	352504086065401	12/03/01	1135	69	5.6	9.0	15.5
PW-39	352451086062801	12/03/01	1256	156	6.8	9.7	15.5
PW-40	352453086062801	12/03/01	1337	163	6.8	9.5	15.5

Appendix 1. Physical properties of water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; °C, degrees Celsius; --, no data]

Well number	USGS station number	Date	Time	Specific conductance (µS/cm)	pH (standard units)	Dissolved oxygen (mg/L)	Temperature (°C)
PW-41	352443086065501	12/03/01	1425	216	6.7	--	--
PW-42	352443086064601	12/06/01	0850	167	6.6	7.1	16.0
PW-43	352508086065401	12/06/01	0945	26	4.8	6.3	16.0
PW-44	352442086065301	12/06/01	1045	113	6.9	8.4	15.5
PW-45	352456086063601	12/06/01	1155	25	4.7	8.4	15.5
PW-46	352502086070301	12/06/01	1300	196	7.0	7.6	15.5
PW-47	352411086081701	12/06/01	1405	195	6.5	6.1	18.5
PW-48	352426086080001	12/06/01	1500	240	7.8	3.9	16.0
PW-49	352410086081301	12/06/01	1540	83	4.8	7.0	15.5
PW-50	352426086074601	12/06/01	1640	280	6.7	4.9	14.5
PW-51	352452086062501	12/11/01	0905	105	6.5	7.4	14.0
PW-52	352454086062301	12/11/01	1010	203	6.8	5.4	15.0
PW-53	352442086064801	12/11/01	1055	91	6.4	8.3	12.0
PW-54	352449086070501	12/11/01	1240	167	5.4	1.7	15.0
PW-55	352443086063201	12/11/01	1325	73	6.1	8.2	15.5
PW-56	352412086080401	12/11/01	1350	61	5.7	--	--
PW-57	352509086063801	12/11/01	1430	154	6.4	4.0	15.0
PW-58	352443086062801	12/14/01	0905	23	5.1	8.7	15.5
PW-59	352445086064301	12/14/01	1000	131	6.6	9.0	15.5
PW-60	352445086055301	12/14/01	1040	128	6.5	9.0	15.0
PW-61	352455086070001	12/14/01	1120	76	5.8	8.1	15.5
PW-62	352345086074501	12/14/01	1215	31	5.6	7.6	16.0
PW-63	352417086081401	12/14/01	1350	236	7.7	0.6	15.5
PW-64	352443086063601	12/18/01	0930	77	6.3	9.2	15.0
PW-65	352507086065501	12/18/01	1010	23	4.8	6.4	15.0
PW-66	352446086062001	12/19/01	1100	176	7.0	7.8	15.0
PW-67	352443086064501	12/19/01	1225	120	6.5	8.4	15.0
PW-68	352328086074001	01/14/02	1030	256	7.2	3.4	15.5
Cave	352346086073101	12/18/01	1115	124	6.5	6.9	13.5
PZ-BKG-1	352423086042501	01/09/02	0930	14	4.8	2.8	13.0
MW-185	352509086051001	01/08/02	1200	282	7.4	0.8	15.0
MW-186	352509086051002	01/08/02	1255	265	6.9	2.6	12.5
MW-353	352441086044401	01/09/02	1230	94	6.5	0.1	14.5
MW-354	352441086044402	01/09/02	1125	155	6.1	1.8	14.5
MW-355	352434086041401	01/09/02	1440	56	5.6	0.2	15.5
MW-607	352448086063201	01/10/01	0950	256	7.2	5.4	16.5
MW-615	352413086054001	01/10/02	1105	216	6.8	4.4	14.5

Appendix 2. Volatile organic compounds detected in water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee

[µg/L, micrograms per liter; <, the analyte was not detected above the reporting limit; R, data validation indicated that the results are unreliable, the analyte may or may not be present; J, the analyte was not detected above the reporting limit, detections below reporting limits are presented as estimated concentrations; UJ, the analyte was not detected above the reporting limit, data validation indicated that the reporting limit is approximate and may be inaccurate, detections below the reporting limit are presented as estimated concentrations. Analytes where no samples showed detections are not listed. Samples were analyzed for compounds listed in table 2]

Well number	Date	Time	Acetone (µg/L)	Bromo-methane (µg/L)	2-Butanone (µg/L)	Carbon disulfide (µg/L)	Carbon tetrachlo-ride (µg/L)	Chloroform (µg/L)	Dichloro-difluoro-methane (µg/L)	*cis*-1,2-Dichloro-ethylene (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Tetrachloro-ethylene (µg/L)	Toluene (µg/L)	Trichloro-ethylene (µg/L)
PW-01	11/06/01	1145	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-02	11/06/01	1340	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-03	11/06/01	1500	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-03	11/06/01	1501	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-04	11/06/01	1545	3.6 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-05	11/07/01	1000	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	0.79 J	<1.0	<1.0
PW-06	11/07/01	1120	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	1.8	<1.0	<1.0
PW-07	11/07/01	1340	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	3.0	<1.0	<1.0
PW-08	11/07/01	1500	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	1.4	<5.0	3.6	<1.0	<1.0
PW-09	11/07/01	1600	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-10	11/07/01	1700	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-11	11/08/01	0950	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-12	11/08/01	1120	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-13	11/08/01	1245	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	3.6 J	<1.0	<1.0	<1.0
PW-14	11/08/01	1000	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-15	11/08/01	1115	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-15	11/08/01	1116	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-16	11/08/01	1315	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-17	11/08/01	1420	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
PW-18	11/08/01	1530	5.2 J	<2.0	1.7 J	<1.0	<1.0 UJ	0.55 J	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	9.9	<1.0
PW-19	11/14/01	1025	0.10 UJ	<2.0	<5.0 R	0.36J	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-20	11/14/01	1150	2.5 UJ	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-21	11/14/01	1345	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-22	11/14/01	1505	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-23	11/15/01	0915	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0

Appendix 2. Volatile organic compounds detected in water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[µg/L, micrograms per liter; <, the analyte was not detected above the reporting limit; R, data validation indicated that the results are unreliable, the analyte may or may not be present; J, the analyte was not detected above the reporting limit, detections below reporting limits are presented as estimated concentrations; UJ, the analyte was not detected above the reporting limit, data validation indicated that the reporting limit is approximate and may be inaccurate, detections below the reporting limit are presented as estimated concentrations. Analytes where no samples showed detections are not listed. Samples were analyzed for compounds listed in table 2]

Well number	Date	Time	Acetone (µg/L)	Bromo-methane (µg/L)	2-Butanone (µg/L)	Carbon disulfide (µg/L)	Carbon tetrachlo-ride (µg/L)	Chloroform (µg/L)	Dichloro-difluoro-methane (µg/L)	*cis*-1,2-Dichloro-ethylene (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Tetrachloro-ethylene (µg/L)	Toluene (µg/L)	Trichloro-ethylene (µg/L)
PW-24	11/15/01	1035	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-25	11/15/01	1135	<10 R	<2.0	<5.0 R	<1.0	<1.0	0.41 J	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-25	11/15/01	1140	<10 R	<2.0	<5.0 R	<1.0	<1.0	0.40 J	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-26	11/15/01	1240	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-27	11/15/01	1350	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-28	11/15/01	1445	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-29	11/28/01	0930	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	0.58 J	<1.0	<1.0
PW-30	11/28/01	1030	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	1.2	<1.0	<1.0
PW-31	11/28/01	1135	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-32	11/28/01	1150	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-33	11/28/01	1310	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-34	11/28/01	1355	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	0.46 J	<1.0	<1.0
PW-35	11/28/01	1505	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-35	11/28/01	1510	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-36	12/03/01	0940	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-37	12/03/01	1047	2.5 UJ	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	1.4	<1.0
PW-38	12/03/01	1135	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	0.39J	<1.0
PW-39	12/03/01	1256	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-40	12/03/01	1337	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-41	12/03/01	1425	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	0.93 J	<1.0	<1.0	<5.0	0.80 J	<1.0	<1.0
PW-42	12/06/01	0850	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	3.0	<1.0	<1.0
PW-43	12/06/01	0945	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-44	12/06/01	1045	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-45	12/06/01	1155	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-45	12/06/01	1200	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0

Appendix 2. Volatile organic compounds detected in water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[µg/L, micrograms per liter; <, the analyte was not detected above the reporting limit; R, data validation indicated that the results are unreliable, the analyte may or may not be present; J, the analyte was not detected above the reporting limit, detections below reporting limits are presented as estimated concentrations; UJ, the analyte was not detected above the reporting limit, data validation indicated that the reporting limit is approximate and may be inaccurate, detections below the reporting limit are presented as estimated concentrations. Analytes where no samples showed detections are not listed. Samples were analyzed for compounds listed in table 2]

Well number	Date	Time	Acetone (µg/L)	Bromo-methane (µg/L)	2-Butanone (µg/L)	Carbon disulfide (µg/L)	Carbon tetrachlo-ride (µg/L)	Chloroform (µg/L)	Dichloro-difluoro-methane (µg/L)	*cis*-1,2-Dichloro-ethylene (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Tetrachloro-ethylene (µg/L)	Toluene (µg/L)	Trichloro-ethylene (µg/L)
PW-46	12/06/01	1300	<10 R	<2.0	<5.0 R	<1.0	0.65 J	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-47	12/06/01	1405	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-48	12/06/01	1500	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-49	12/06/01	1540	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-50	12/06/01	1640	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-51	12/11/01	0905	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-52	12/11/01	1010	<10 R	0.33 J	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-53	12/11/01	1055	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	1.2	<1.0	<1.0
PW-54	12/11/01	1240	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-55	12/11/01	1325	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-56	12/11/01	1350	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-57	12/11/01	1430	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-58	12/14/01	0905	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-58	12/14/01	0910	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-59	12/14/01	1000	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	1.4	<1.0	<1.0
PW-60	12/14/01	1040	6.5 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	1.0	<1.0	<1.0
PW-61	12/14/01	1120	2.5 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	0.59 J	<1.0	<1.0
PW-62	12/14/01	1215	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-63	12/14/01	1350	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-64	12/18/01	0930	<10 R	<2.0	<5.0 R	0.29 J	<1.0	<1.0	<2.0	0.36 J	<1.0	<5.0	12	<1.0	0.85 J
PW-64	12/18/01	0935	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	0.37 J	<1.0	<5.0	11	<1.0	0.83 J
PW-65	12/18/01	1010	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-66	12/19/01	1100	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PW-67	12/19/01	1225	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	2.6	<1.0	<1.0
PW-68	01/14/02	1030	<10 R	<2.0	<5.0 R	<1.0 UJ	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0

Appendix 2. Volatile organic compounds detected in water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee—Continued

[µg/L, micrograms per liter; <, the analyte was not detected above the reporting limit; R, data validation indicated that the results are unreliable, the analyte may or may not be present; J, the analyte was not detected above the reporting limit, detections below reporting limits are presented as estimated concentrations; UJ, the analyte was not detected above the reporting limit, data validation indicated that the reporting limit is approximate and may be inaccurate, detections below the reporting limit are presented as estimated concentrations. Analytes where no samples showed detections are not listed. Samples were analyzed for compounds listed in table 2]

Well number	Date	Time	Acetone (µg/L)		Bromo-methane (µg/L)	2-Butanone (µg/L)		Carbon disulfide (µg/L)	Carbon tetrachlo-ride (µg/L)	Chloroform (µg/L)	Dichloro-difluoro-methane (µg/L)	*cis*-1,2-Dichloro-ethylene (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Tetrachloro-ethylene (µg/L)	Toluene (µg/L)	Trichloro-ethylene (µg/L)
Cave	12/18/01	1115	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
PZ-BKG-1	01/09/02	0930	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-185	01/08/02	1200	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-186	01/08/02	1255	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-353	01/09/02	1230	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-354	01/09/02	1125	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-355	01/09/02	1440	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-607	01/10/01	0950	<10	R	<2.0	<5.0	R	<1.0	<1.0	0.72 J	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-615	01/10/02	1105	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
MW-615	01/10/02	1110	<10	R	<2.0	<5.0	R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0

Appendix 3. Trip-blank and equipment-blank data for volatile organic compounds detected in water from wells sampled in the Crumpton Creek area near Arnold Air Force Base, Tennessee

[µg/L, micrograms per liter; <, the analyte was not detected above the reporting limit; R, data validation indicated that the results are unreliable, the analyte may or may not be present; J, the analyte was not detected above the reporting limit, detections below reporting limits are presented as estimated concentrations; UJ, the analyte was not detected above the reporting limit, data validation indicated that the reporting limit is approximate and may be inaccurate, detections below the reporting limit are presented as estimated concentrations. Analytes where no samples showed detections are not listed. Samples were analyzed for compounds listed in table 2]

Blank sample identifier	Date	Time	Acetone (µg/L)	Bromo-methane (µg/L)	2-Butanone (µg/L)	Carbon disulfide (µg/L)	Carbon tetrachlo-ride (µg/L)	Chloroform (µg/L)	Dichloro-dif-luoro-meth-ane (µg/L)	*cis*-1,2-Dichloroet-hylene (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Tetrachloro-ethylene (µg/L)	Toluene (µg/L)	Trichloroet-hylene (µg/L)
TB-01	11/07/01	1630	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-02	11/08/01	1600	<10 R	<2.0	<5.0 R	<1.0	<1.0 UJ	<1.0	<2.0	<1.0	<1.0	<5.0 UJ	<1.0	<1.0	<1.0
TB-03	11/15/01	1500	2.5 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	0.93 J	<5.0	<1.0	<1.0	<1.0
TB-04	11/28/01	1600	2.8 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-05	12/03/01	1530	2.3 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-06	12/06/01	1730	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-07	12/12/01	1400	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-08	12/14/01	1430	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-09	12/19/01	1500	1.9 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-10	01/09/02	1600	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-11	01/10/02	1445	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
TB-12	01/15/02	1200	<10 R	<2.0	<5.0 R	<1.0 UJ	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-01	11/07/01	1122	1.9 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-02	11/15/01	0920	2.2 J	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-03	11/15/01	1245	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-04	11/28/01	1450	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0 UJ	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-05	12/06/01	1305	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-06	12/14/01	1005	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-07	12/18/01	1025	<10 R	<2.0	<5.0 R	0.26 J	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-08	01/08/02	1000	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0
EB-09	01/10/02	1120	<10 R	<2.0	<5.0 R	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0