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Ground-Water Levels and Water-Quality Data for Wells in the Spring Creek Area near Arnold Air Force Base, Tennessee, April and May 2000

Open-File Report 01-150

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

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By SHANNON D. WILLIAMS and ROBERT A. AYCOCK

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Nashville, Tennessee
2001

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

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

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)

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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 6 digits denote the degrees, minutes, and seconds of latitude; the next 7 digits denote degrees, minutes, and seconds of longitude; and the last 2 digits (assigned sequentially) identify the wells within a 1-second grid.

Ground-Water Levels and Water-Quality Data for Wells in the Spring Creek Area near Arnold Air Force Base,Tennessee, April and May 2000

By Shannon D. Williams *and* Robert A. Aycock

EXECUTIVE SUMMARY

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. Numerous site-specific ground-water contamination investigations have been conducted at designated solid waste management units (SWMU's) at AAFB. Several synthetic volatile organic compounds (VOC's), primarily chlorinated solvents, have been identified in ground-water samples collected from monitoring wells near SWMU 8 in the Spring Creek area.

During April and May 2000, a study of the ground-water resources in the Spring Creek area was conducted to determine if VOC's 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 sampling private wells located within the Spring Creek area that are used as a source of drinking water. Ground-water-flow directions were determined 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 35 private wells and 22 monitoring wells during the period of study. Depths to ground water were determined for 22 of the private wells and all 22 of the monitoring wells. The wells ranged in depth from 21 to 105 feet. Water-level altitudes ranged from 930 to 1,062 feet above sea level. Depths to water ranged from 8 to 83 feet below land surface. Water-quality samples were collected from 29 private wells which draw water from either gravel zones in the upper part of the Manchester aquifer, fractured bedrock in the lower part of the Manchester aquifer, or a combination of these two zones.

Concentrations of 50 of the 55 VOC's analyzed for were less than method detection limits. Chloroform, acetone, chloromethane, 2-butanone, and tetrachloroethylene were detected in concentrations exceeding the method detection limits. Only chloroform and acetone were detected in concentrations equal to or exceeding reporting limits. Chloroform was detected in a sample from one well at a concentration of 1.2 micrograms per liter (µg/L). Acetone was detected in a sample from another well at a concentration of 10 µg/L. Acetone also was detected in a duplicate sample from the same well at an estimated concentration of 7.2 µg/L, which is less than the reporting limit for acetone. The only contaminant of concern detected was tetrachloroethylene. Tetrachloroethylene was detected in only one sample, and this detection was at an estimated concentration below the reporting limit. None of the VOC concentrations exceeded drinking water maximum contaminant levels for public water systems.

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).

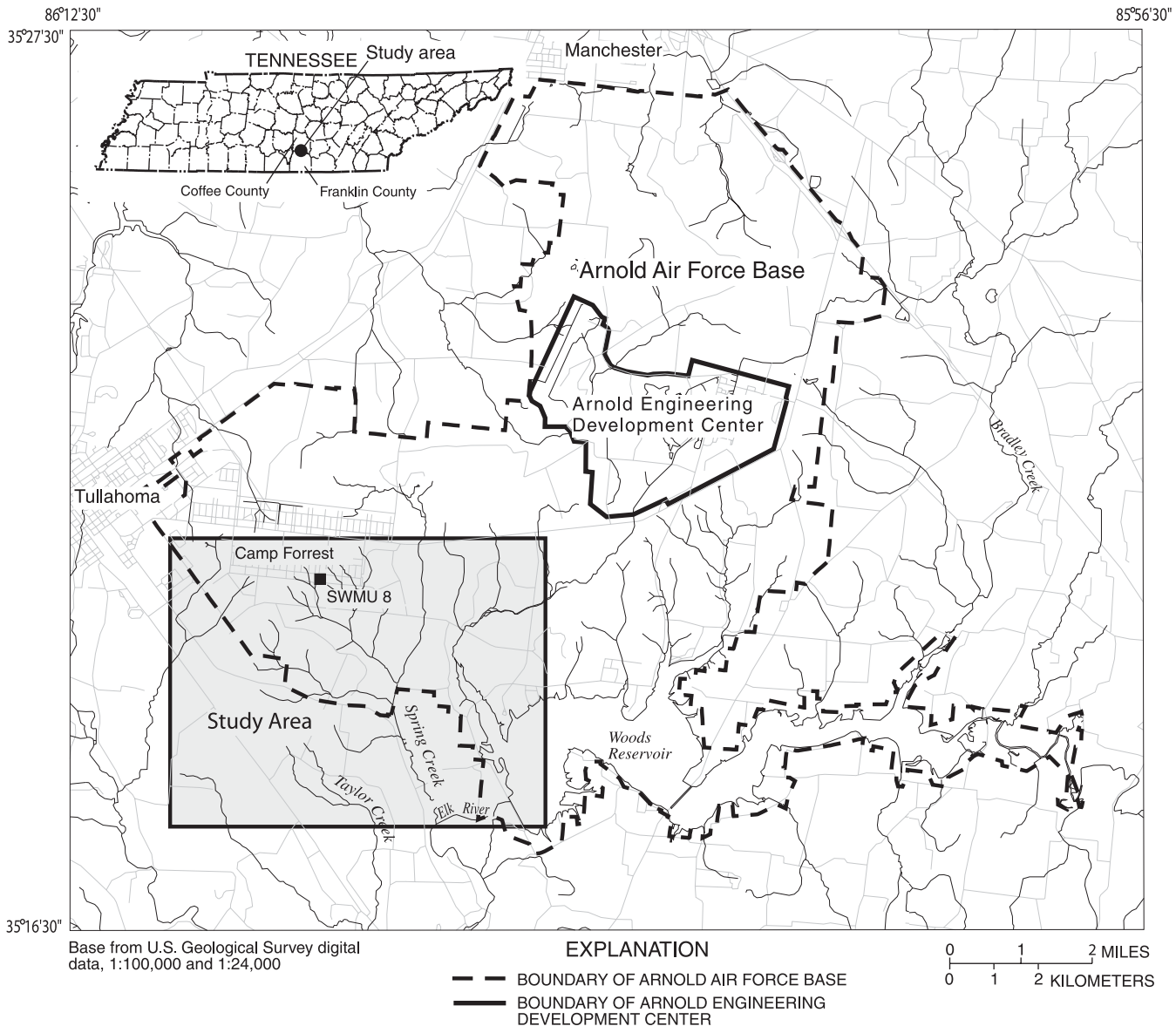

Figure 1. Location of the study area in Middle Tennessee.

Numerous site-specific ground-water-contamination investigations have been conducted at designated solid waste management units (SWMU's) at AAFB. Several synthetic volatile organic compounds (VOC's) have been identified in the ground water near SWMU 8. SWMU 8 is located in the western part of AAFB at the former water treatment plant for Camp Forrest, an Army training center from 1941 to 1946. Filtration cells and underground holding tanks at the defunct Camp Forrest water treatment plant were used to dispose of chemical wastes between 1953 and 1980 (CH2M HILL, 1999). Chlorinated solvents such as tetrachloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), and 1,1,1-trichoroethane (1,1,1-TCA) have been detected in ground water at AAFB southeast of SWMU 8. Trichlorofluoromethane (TCFM) has been detected in ground water at AAFB southeast of SWMU 8 and along Spring Creek south of AAFB (CH2M HILL, 1999).

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 Spring Creek area during April and May 2000. The objectives of the study were to (1) advance understanding of the ground-water-flow system in the Spring Creek area, and (2) determine if VOC's in ground water from AAFB have affected private water supplies in the Spring Creek area.

Purpose and Scope

This report documents (1) water-level measurements made in and water-quality analyses of samples from 35 private wells in the Spring Creek area and (2) water levels measured in 22 existing monitoring wells located primarily at AAFB. The study focused on sampling wells located within the Spring Creek area that are used as sources of drinking water. Information concerning water-well construction and ground-water altitude data also were collected during the study. 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). These results of 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 region of Tennessee (Miller, 1974) and ranges from poorly drained, flat uplands to valley-dissected, sloping escarpments. The study area is located south of the Camp Forrest area of AAFB and lies in the Elk River drainage basin (fig. 1). Land-surface altitudes range from approximately 1,100 feet above sea level in the Camp Forrest area to approximately 910 feet at the confluence of Spring Creek and the Elk River.

Hydrogeologic Setting

The AAFB area is located in a fractured carbonate terrane covered by regolith derived from the in-situ weathering of Mississippian-age carbonates. These geologic units comprise (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 clayey chert rubble with some silt and sand. Typically, the regolith grades 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). Bedrock underlying the regolith consists of the Fort Payne Formation, which is an indurated siliceous limestone containing many chert nodules and platy chert stringers. The bedrock in the Fort Payne Formation in the AAFB area is generally 20 to 230 feet thick. 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). 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 significant lateral extent; therefore, water is able to flow between these zones at most locations. The shallow aquifer is described as alluvium, residual silt, clay, sand, and clay-size chert

Stratigraphy	Thickness, in feet	Lithology	Hydrogeologic unit	Alternate 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.)

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 rubble at the base of the regolith and solution openings in the upper part of the bedrock (Burchett and Hollyday, 1974). The Fort Payne aquifer corresponds to the lower part of the Fort Payne Formation where solution openings are less developed. 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. Data were collected from a total of 35 private and 22 monitoring wells (fig. 3). Depths to ground water were determined for 22 of the private wells and all 22 monitoring wells (table 1). Well depths for private wells were measured or 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 AEDC wells were obtained from CH2M HILL (1999).

Water-level altitudes ranged from 930 to 1,062 feet above sea level. Depths to water ranged from 8 to 83 feet below land surface (table 1). Two ground-water features are evident from the potentiometric-surface map of the Manchester aquifer (fig. 4). A prominent ground-water trough occurs southeast of SWMU 8 along the axis of Spring Creek. A ground-water ridge is present along the AAFB boundary south of SWMU 8 and extends toward Spring Creek.

GROUND-WATER QUALITY

Water-quality samples collected from 29 private wells in the Spring Creek area were analyzed for VOC's (table 2). Water samples collected were analyzed for VOC's by Severn Trent Laboratories (formerly Quanterra Laboratories) in Denver, Colorado. Analyses were performed using U.S. Environmental

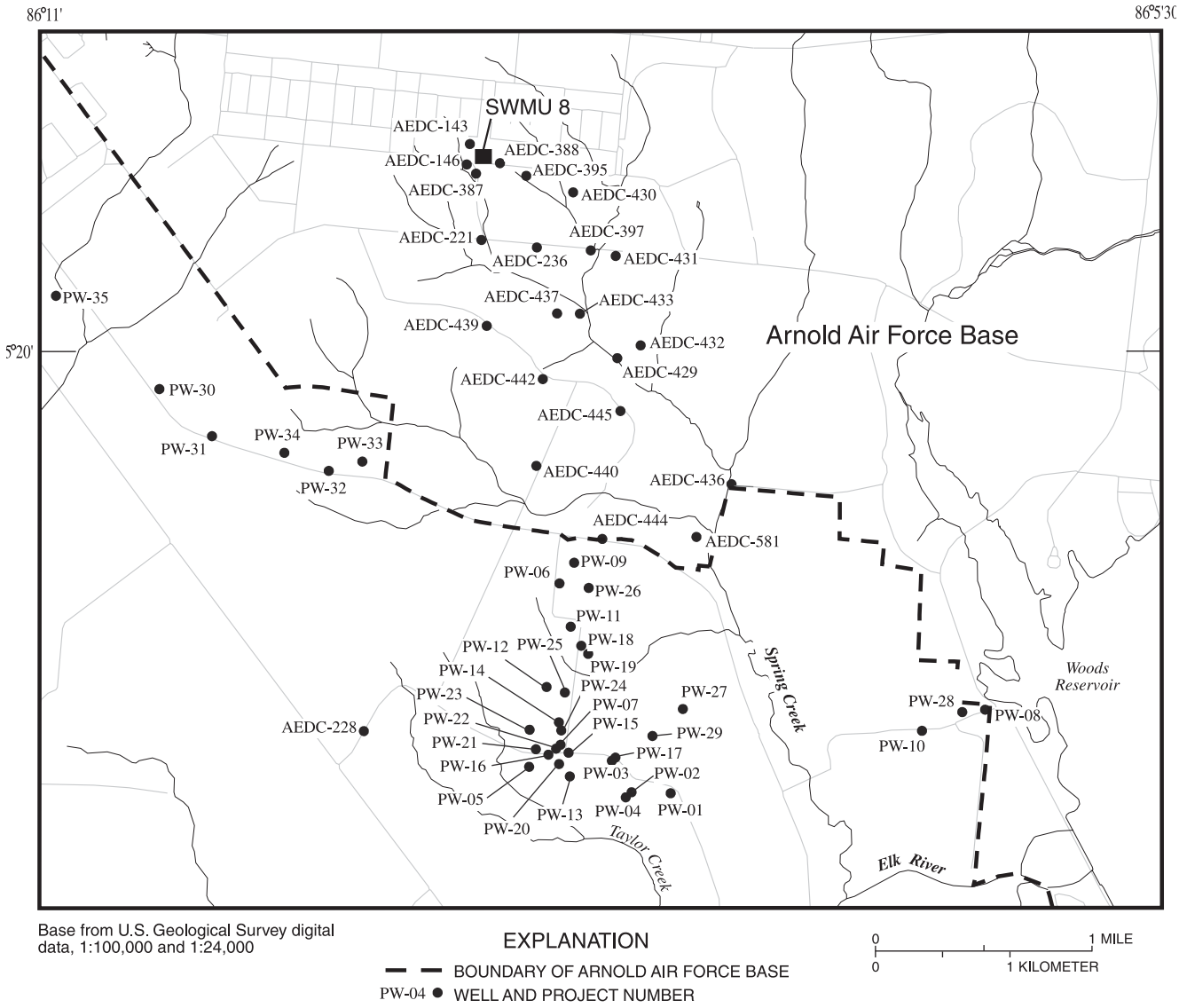

Figure 3. Private and monitoring wells at which water-level or water-quality data were collected in the Spring Creek area near Arnold Air Force Base, Tennessee.

Protection Agency (U.S. EPA) Method 8260b. Method detection limits (table 2) are less than 1 microgram per liter (µg/L) for all VOC's identified as a contaminant of concern for AAFB (primarily chlorinated solvents).

Field sampling procedures followed those outlined in the U.S. EPA Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (U.S. Environmental Protection Agency, 1997). Wells were purged and sampled from a spigot located closest to the well head, preferably between the well head and any storage/pressure tanks. Water samples were collected after specific conductance, pH, dissolved oxygen, and temperature stabilized. For most wells, field measurements stabilized within 30 minutes. In the few wells where field measurements did not stabilize, samples were collected at the discretion of the field team leader; however, these wells also were purged at least 30 minutes. After purging, specific conductance, pH, dissolved oxygen, and water temperature were measured at each well. Water samples then were collected for analysis of the VOC's (table 2). Water samples were treated and shipped in accordance with current U.S. EPA sampling protocols.

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

[°, degrees; ', minutes; ", seconds; --, no data]

Project number	Latitude	Longitude	Water level, in feet above sea level	Land surface, in feet above sea level	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Well type
PW-01	35°18'14"	86°07'54"	940	1,002	62	79	Measurement	Private
PW-02	35°18'14"	86°08'06"	--	985	--	70	Owner	Private
PW-03	35°18'22"	86°08'12"	935	991	56	68	Measurement	Private
PW-04	35°18'13"	86°08'08"	937	979	42	61	Measurement	Private
PW-05	35°18'20"	86°08'36"	--	998	--	72	Owner	Private
PW-06	35°19'04"	86°08'27"	947	1,006	59	75	Measurement	Private
PW-07	35°18'25"	86°08'27"	938	997	59	72	Measurement	Private
PW-08	35°18'34"	86°06'22"	957	980	23	81	Measurement	Private
PW-09	35°19'10"	86°08'23"	947	1,003	56	86	Measurement	Private
PW 10	35°18'29"	86°06'40"	--	1,003	--	85	Owner	Private
PW-11	35°18'54"	86°08'24"	--	1,004	--	105	Owner	Private
PW-12	35°18'39"	86°08"31"	--	997	--	72	Owner	Private
PW-13	35°18'18"	86°08'24"	--	986	--	75	Owner	Private
PW-14	35°18'31"	86°08'27"	--	988	--	65	Owner	Private
PW-15	35°18'24"	86°08'24"	--	993	--	82	Owner	Private
PW-16	35°18'23"	86°08'30"	935	1,001	66	75	Owner	Private
PW-17	35°18'22"	86°08'11"	936	992	56	72	Measurement	Private
PW-18	35°18'49"	86°08'21"	--	1,003	--	74	Owner	Private
PW-19	35°18'47"	86°08'19"	944	1,003	59	67	Measurement	Private
PW-20	35°18'21"	86°08'27"	--	994	--	91	Owner	Private
PW-21	35°18'24"	86°08'34"	--	1,002	--	--	--	Private
PW-22	35°18'23"	86°08'28"	938	1,000	62	72	Measurement	Private
PW-23	35°18'29"	86°08'36"	938	1,001	63	83	Measurement	Private
PW-24	35°18'29"	86°08'27"	939	991	52	76	Measurement	Private
PW-25	35°18'38"	86°08'26"	941	995	54	61	Measurement	Private
PW-26	35°19'03"	86°08'18"	--	995	--	--	--	Private
PW-27	35°18'34"	86°07'51"	930	1,004	74	95	Measurement	Private
PW-28	35°18'33"	86°06'29"	--	991	--	--	--	Private
PW-29	35°18'28"	86°07'60"	949	994	45	85	Owner	Private
PW-30	35°19'51"	86°10'25"	1,039	1,062	23	62	Measurement	Private

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

Project number	Latitude	Longitude	Water level, in feet above sea level	Land surface, in feet above sea level	Depth to water, in feet below land surface	Well depth, in feet below land surface	Depth source	Well type
PW-31	35°19'40"	86°10'09"	1,034	1,100	66	75	Measurement	Private
PW-32	35°19'32"	86°09'35"	1,003	1,063	60	77	Measurement	Private
PW-33	35°19'34"	86°09'25"	974	1,055	81	97	Measurement	Private
PW-34	35°19'36"	86°09'48"	1,004	1,077	73	85	Measurement	Private
PW-35	35°20'15"	86°10'55"	1,011	1,032	21	--	--	Private
AEDC-143	35°20'50"	86°08'53"	1,062	1,084	21	90	CH2M HILL, 1999	Monitoring
AEDC-146	35°20'45"	86°08'54"	1,048	1,060	11	65	CH2M HILL, 1999	Monitoring
AEDC-221	35°20'27"	86°08'50"	1,013	1,025	12	77	CH2M HILL, 1999	Monitoring
AEDC-228	35°18'29"	86°09'25"	964	1,031	67	78	CH2M HILL, 1999	Monitoring
AEDC-236	35°20'25"	86°08'34"	951	1,022	71	87	CH2M HILL, 1999	Monitoring
AEDC-387	35°20'43"	86°08'52"	1,038	1,050	13	55	CH2M HILL, 1999	Monitoring
AEDC-388	35°20'46"	86°08'45"	1,021	1,067	46	89	CH2M HILL, 1999	Monitoring
AEDC-395	35°20'43"	86°08'37"	973	1,047	74	95	CH2M HILL, 1999	Monitoring
AEDC-397	35°20'25"	86°08'18"	950	1,002	52	73	CH2M HILL, 1999	Monitoring
AEDC-429	35°19'59"	86°08'10"	945	977	32	65	CH2M HILL, 1999	Monitoring
AEDC-430	35°20'39"	86°08'23"	951	1,023	72	85	CH2M HILL, 1999	Monitoring
AEDC-431	35°20'23"	86°08'10"	949	1,018	69	86	CH2M HILL, 1999	Monitoring
AEDC-432	35°20'02"	86°08'03"	962	1,017	55	64	CH2M HILL, 1999	Monitoring
AEDC-433	35°20'09"	86°08'21"	947	990	43	75	CH2M HILL, 1999	Monitoring
AEDC-436	35°19'28"	86°07'36"	944	952	8	21	CH2M HILL, 1999	Monitoring
AEDC-437	35°20'09"	86°08'28"	947	1,011	63	94	CH2M HILL, 1999	Monitoring
AEDC-439	35°20'06"	86°08'48"	954	1,037	83	91	CH2M HILL, 1999	Monitoring
AEDC-440	35°19'33"	86°08'34"	952	1,002	51	74	CH2M HILL, 1999	Monitoring
AEDC-442	35°19'54"	86°08'32"	947	1,013	66	100	CH2M HILL, 1999	Monitoring
AEDC-444	35°19'15"	86°08'14"	960	996	36	65	CH2M HILL, 1999	Monitoring
AEDC-445	35°19'46"	86°08'09"	940	1,016	76	86	CH2M HILL, 1999	Monitoring
AEDC-581	35°19'16"	86°07'47"	940	957	16	56	CH2M HILL, 1999	Monitoring

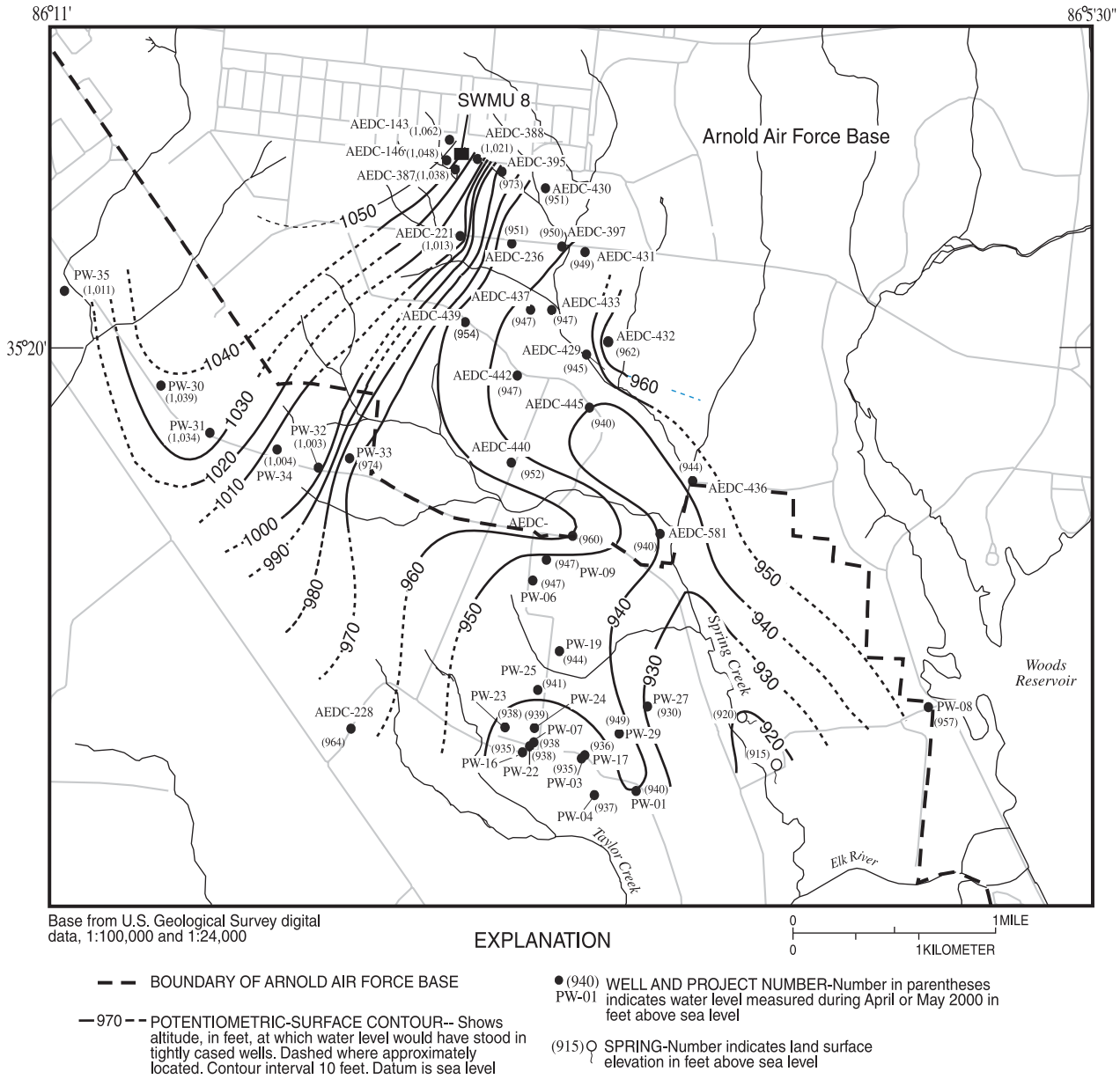

Figure 4. Altitude of the potentiometric surface of the Manchester aquifer in the Spring Creek area near Arnold Air Force Base, Tennessee, April and May 2000.

Physical Properties

The complete analytical results for the physical properties of the ground-water samples are in appendix 1. Values for the physical properties reported in appendix 1 were measured in the field at the time of sample collection. Specific conductance for water samples ranged from 19 to 388 microsiemens per centimeter (µS/cm). The median value for specific conductance is 82 µS/cm (table 3). The range and median value for pH in sampled water are 4.7 to 7.5, and 6.1, respectively (table 3).

Volatile Organic Compounds

Concentrations of 50 of the 55 VOC's analyzed for were less than method detection limits (table 2). Acetone, chloromethane, 2-butanone, tetrachloroethylene, and chloroform (appendix 2) were detected in concentrations exceeding method detection limits. Only chloroform and acetone were detected in concentrations equal to or exceeding reporting limits. Chloroform was detected in a water sample from well PW-08 at a concentration of 1.2 µg/L (appendix 2). Acetone was detected in a water sample from well PW-25 at a concentration of 10 µg/L. Acetone was also detected

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

Analyte	Reporting limit, in micrograms per liter	Method detection limit, in micrograms per liter
Acetone	10	2.43
Acetonitrile	20	6.81
Acrolein	20	2.85
Acrylonitrile	20	1.45
Benzene	1.0	0.10
Bromodichloromethane	1.0	0.11
Bromoform	1.0	0.11
Bromomethane	2.0	0.15
2-Butanone (MEK)	5.0	0.72
Carbon disulfide	1.0	0.15
Carbon tetrachloride	1.0	0.10
Chlorobenzene	1.0	0.10
Chloroprene	1.0	0.10
Dibromochloromethane	1.0	0.10
Chloroethane	2.0	0.10
Chloroform	1.0	0.10
Chloromethane	2.0	0.21
Allyl chloride	2.0	0.19
1,2-Dibromo-3-chloropropane (DBCP)	2.0	0.28
1,2-Dibromoethane (EDB)	1.0	0.16
Dibromomethane	1.0	0.15
Trans-1,4-Dichloro-2-butene	1.0	0.31
Dichlorodifluoromethane	2.0	0.16
1,1-Dichloroethane	1.0	0.10
1,2-Dichloroethane	1.0	0.14
1,1-Dichloroethylene	1.0	0.14
Cis-1,2-Dichloroethylene	1.0	0.11
Trans-1,2-Dichloroethylene	0.5	0.12
1,2-Dichloropropane	1.0	0.12
Cis-1,3-Dichloropropene	1.0	0.10
Trans-1,3-Dichloropropene	1.0	0.10
1,4-Dioxane	200	7.97
Ethylbenzene	1.0	0.10
Ethyl methacrylate	1.0	0.50
2-Hexanone	5.0	0.70
Iodomethane	1.0	0.10
Isobutyl alcohol	50	11.72
Methacrylonitrile	10	1.00
Methylene chloride	1.0	0.19
Methyl methacrylate	1.0	0.25
4-Methyl-2-pentanone	5.0	0.67
Propionitrile	5.0	2.96
Styrene	1.0	0.10
1,1,1,2-Tetrachloroethane	1.0	0.10
1,1,2,2-Tetrachloroethane	1.0	0.23
Tetrachloroethylene	1.0	0.10
Toluene	1.0	0.10
1,1,1-Trichloroethane	1.0	0.10
1,1,2-Trichloroethane	1.0	0.18
Trichloroethylene	1.0	0.10
Trichlorofluoromethane	2.0	0.15
1,2,3-Trichloropropane	1.0	0.10
Vinyl acetate	2.0	0.11
Vinyl chloride	2.0	0.13
Xylenes (total)	1.0	0.30

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

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

Physical property	Minimum	Maximum	Median
Specific conductance (µS/cm)	19	388	82
pH (standard units)	4.7	7.5	6.1
Dissolved oxygen (mg/L)	3.3	8.9	7.7
Temperature (°C)	14.0	17.0	15.0

in a duplicate sample from PW-25 at an estimated concentration of 7.2 µg/L (appendix 2), which is less than the reporting limit for acetone.

The only contaminant of concern detected was PCE. PCE was detected in a water sample from well PW-19 at an estimated concentration of 0.44 µg/L (fig. 5; appendix 2). VOC concentrations less than reporting limits are considered estimates and are indicated by the symbol "J" in appendix 2. Chloromethane and 2-butanone were detected in water samples from well PW-23 at estimated concentrations of 0.84 and 3.0 µg/L, respectively. 2-Butanone also was detected in a sample from well PW-22 at an estimated concentration of 1.7 µg/L (appendix 2). Acetone and 2-butanone are common laboratory contaminants (U.S. Environmental Protection Agency, 1999a). Chloroform and chloromethane are disinfectant byproducts of the chlorination of water containing naturally occurring organic matter (Agency for Toxic Substances and Disease Registry, 1990; 1997). None of the sample results exceed drinking water maximum contaminant levels for public-water systems.

Quality-Assurance/Quality-Control Samples

Field quality-assurance/quality control (QA/QC) samples included equipment blanks, trip blanks, duplicate samples, and replicate samples for matrix spikes. Sampling procedures followed those outlined by the U.S. EPA Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (U.S. Environmental Protection Agency, 1997). One QA/QC duplicate sample was collected and analyzed for every 10 VOC samples collected. Equipment blanks and

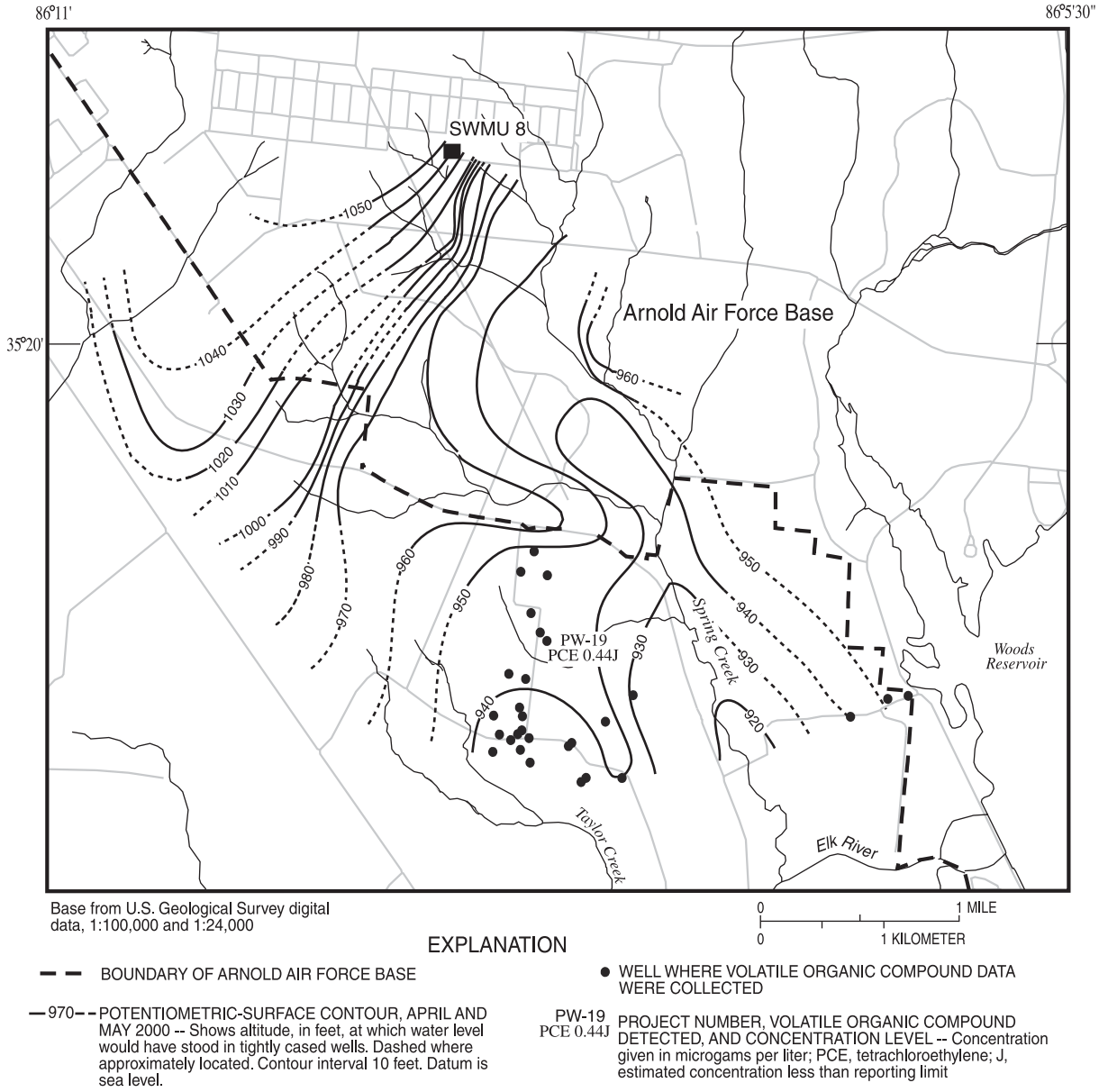

Figure 5. Summary of volatile organic compounds of concern detected in water samples from private wells in the Spring Creek area near Arnold Air Force Base, Tennessee.

replicate samples for matrix spikes were collected and analyzed for every 20 samples collected. A trip blank accompanied each sample shipment. Duplicate VOC samples were collected from wells PW-06, PW-15, and PW-25. Analytical results for duplicates are shown for the detected compounds in appendix 2. Analytical results for detected compounds in equipment blanks and trip blanks are presented in appendix 3. VOC's were not detected in any of the equipment blanks. Acetone was detected in one trip blank at a concentration of 11 µg/L (appendix 3).

Severn Trent Laboratories followed standard analytical QA/QC practices for all VOC analyses. These practices include lab blanks, quality-control standards, surrogate spikes, matrix spikes, and duplicate analyses (Quanterra Laboratories, 1998). A level III data validation was performed by Dames and Moore, Inc., for 10 of the VOC sample results. The validation was based on the U.S. EPA National Functional Guidelines for Data Review (U.S. Environmental Protection Agency, 1999b), modified to reflect the level of validation requested, the specifics of the analytical method employed, and the provisions of the

approved specific quality-assurance protocol. The purpose of data validation is to assess the effect of the overall analytical process on the usability of the data.

The data validation determined that non-detections (results) for acetone, acrolien, acrylonitrile, 2-butanone, 1,4-dioxane, acetonitrile, propionitrile, and methacrylonitrile were unreliable because of calibration failures (R. Aryan-Nejad, Dames and Moore, Inc., written commun., 2000). The validation also determined that the method detection limit for dichlorodifluoromethane may be inaccurate because of calibration failures or poor instrumentation response. None of these compounds were contaminants of concern for the study.

SUMMARY

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. Several volatile organic compounds (VOC's), primarily chlorinated solvents, have been identified in the ground water near Solid Waste Management Unit 8 in the Spring Creek area. During April and May 2000, a study of the ground-water resources in the Spring Creek area was conducted to determine if VOC's 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 sampling private wells located within the Spring Creek area that are used as sources of drinking water.

Ground-water-flow directions were determined 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 35 private and 22 monitoring wells during the period of study. Depths to ground water were determined for 22 of the private wells and all 22 of the monitoring wells. The wells ranged in depth from 21 to 105 feet. Water-level altitudes ranged from 930 to 1,062 feet above sea level**.** Depths to water ranged from 8 to 83 feet below land surface. Water-quality samples were collected from 29 private wells which draw water from either gravel zones in the upper part of the Manchester aquifer, fractured bedrock in the lower part of the Manchester aquifer, or a combination of these two zones.

Concentrations of 50 of the 55 VOC's analyzed for were less than method detection limits. Acetone, chloromethane, 2-butanone, tetrachloroethylene, and chloroform were detected in concentrations exceeding the method detection limits. Only chloroform and acetone were detected in concentrations equal to or exceeding reporting limits. Chloroform was detected in a sample from one well at a concentration of 1.2 micrograms per liter (µg/L). Acetone was detected in a sample from another well at a concentration of 10 µg/L. Acetone also was detected in a duplicate sample from the well at an estimated concentration of 7.2 µg/L, which is less than the reporting limit for acetone. Acetone is a common laboratory contaminant, and chloroform is a disinfectant byproduct of the chlorination of water containing naturally occurring organic matter. The only contaminant of concern detected was tetrachloroethylene. Tetrachloroethylene was detected in only one sample, and this detection was at an estimated concentration below the reporting limit. None of the VOC concentrations exceeded drinking water maximum contaminant levels for public water systems.

Water-level and water-quality data collected during the study of private and monitoring wells in the Spring Creek area provide information that can aid in characterizing the regional ground-water-flow patterns and water quality for AAFB. The potentiometric-surface map and water-quality results from this report can further assist environmental managers at AAFB in assessing the relative risk of past, current, and possible future activities at the facility on local water resources.

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Appendixes

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

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

Project number	USGS station number	Date	Time	Specific conductance (μS/cm)	pH (standard units)	Dissolved oxygen (mg/L)	Temperature (°C)
PW-01	351814086075401	04/05/00	1315	29	5.6	8.8	16.5
PW-02	351814086080601	04/05/00	1505	133	6.3	6.7	14.0
PW-03	351822086081201	04/05/00	1615	107	5.9	8.1	15.0
PW-04	351813086080801	04/05/00	1750	108	6.1	6.6	15.0
PW-05	351820086083601	04/06/00	0910	119	5.7	7.3	15.5
PW-06	351904086082701	04/06/00	1020	115	6.2	8.0	15.5
PW-07	351825086082701	04/06/00	1150	78	6.1	7.9	15.0
PW-08	351834086062201	04/06/00	1410	91	5.0	3.8	16.0
PW-09	351910086082301	04/06/00	1530	125	6.3	7.2	15.0
PW-10	351829086064001	04/12/00	1025	282	7.5	3.3	15.5
PW-11	351854086082401	04/12/00	1150	98	6.2	8.6	15.5
PW-12	351839086083101	04/12/00	1410	31	4.7	7.9	15.5
PW-13	351818086082401	04/12/00	1525	82	6.1	7.9	15.0
PW-14	351831086082701	04/12/00	1625	32	5.6	8.2	14.5
PW-15	351824086082401	04/12/00	1735	79	6.2	7.8	15.0
PW-16	351823086083001	04/18/00	1110	68	5.5	7.5	14.5
PW-17	351822086081101	04/18/00	1625	186	6.1	7.9	15.0
PW-18	351849086082101	04/19/00	0900	133	6.3	7.6	15.5
PW-19	351847086081901	04/19/00	0945	388	5.8	5.6	14.5
PW-20	351821086082701	04/19/00	1045	89	6.2	7.6	15.5
PW-21	351824086083401	04/19/00	1245	80	6.1	7.5	17.0
PW-22	351823086082801	04/19/00	1425	71	6.0	8.3	15.0
PW-23	351829086083601	04/19/00	1535	69	6.1	7.7	15.0
PW-24	351829086082701	04/19/00	1700	75	5.9	7.8	15.0
PW-25	351838086082601	04/19/00	1815	68	5.8	7.7	15.0
PW-26	351903086081801	04/20/00	0905	60	6.0	7.7	15.5
PW-27	351834086075101	04/20/00	1135	94	6.4	8.1	15.0
PW-28	351833086062901	04/24/00	1050	19	5.2	5.1	15.0
PW-29	351828086076001	04/24/00	1330	80	6.5	8.9	14.5

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

[µg/L, micrograms per liter; J, estimated concentrations less than reporting limits; D, duplicates. Values given as < (less than) indicate that the concentration was below the method detection limit and does not indicate the presence or absence of the compound. Analytes are not listed where no concentrations were detected. Samples were analyzed for compounds listed in table 2]

Project number	USGS station number	Date	Time	Acetone (µg/L)	Chloro-methane (µg/L)	2-Butanone (µg/L)	Tetra-chloro-ethylene (µg/L)	Chloro-form (µg/L)
PW-01	351814086075401	04/05/00	1315	<10	<2	<5	<1	<1
PW-02	351814086080601	04/05/00	1505	<10	<2	<5	<1	<1
PW-03	351822086081201	04/05/00	1615	<10	<2	<5	<1	<1
PW-04	351813086080801	04/05/00	1750	<10	<2	<5	<1	<1
PW-05	351820086083601	04/06/00	0910	<10	<2	<5	<1	<1
PW-06	351904086082701	04/06/00	1020	<10	<2	<5	<1	<1
PW-06D	351904086082701	04/06/00	1025	<10	<2	<5	<1	<1
PW-07	351825086082701	04/06/00	1150	<10	<2	<5	<1	<1
PW-08	351834086062201	04/06/00	1410	<10	<2	<5	<1	1.2
PW-09	351910086082301	04/06/00	1530	<10	<2	<5	<1	<1
PW-10	351829086064001	04/12/00	1025	<10	<2	<5	<1	<1
PW-11	351854086082401	04/12/00	1150	<10	<2	<5	<1	<1
PW-12	351839086083101	04/12/00	1410	<10	<2	<5	<1	<1
PW-13	351818086082401	04/12/00	1525	<10	<2	<5	<1	<1
PW-14	351831086082701	04/12/00	1625	<10	<2	<5	<1	<1
PW-15	351824086082401	04/12/00	1735	<10	<2	<5	<1	<1
PW-15D	351824086082401	04/12/00	1740	<10	<2	<5	<1	<1
PW-16	351823086083001	04/18/00	1110	<10	<2	<5	<1	<1
PW-17	351822086081101	04/18/00	1625	<10	<2	<5	<1	<1
PW-18	351849086082101	04/19/00	0900	<10	<2	<5	<1	<1
PW-19	351847086081901	04/19/00	0945	<10	<2	<5	0.44J	<1
PW-20	351821086082701	04/19/00	1045	<10	<2	<5	<1	<1
PW-21	351824086083401	04/19/00	1245	<10	<2	<5	<1	<1
PW-22	351823086082801	04/19/00	1425	<10	<2	1.7J	<1	<1
PW-23	351829086083601	04/19/00	1535	<10	0.84J	3.0J	<1	<1
PW-24	351829086082701	04/19/00	1700	<10	<2	<5	<1	<1
PW-25	351838086082601	04/19/00	1815	10	<2	<5	<1	<1
PW-25D	351838086082601	04/19/00	1820	7.2J	<2	<5	<1	<1
PW-26	351903086081801	04/20/00	0905	<10	<2	<5	<1	<1
PW-27	351834086075101	04/20/00	1135	<10	<2	<5	<1	<1
PW-28	351833086062901	04/24/00	1050	<10	<2	<5	<1	<1
PW-29	351828086076001	04/24/00	1330	<10	<2	<5	<1	<1

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

[µg/L, micrograms per liter; Values given as < (less than) indicate that the concentration was below the method detection limit and does not indicate the presence or absence of the compound. Analytes are not listed where no concentrations were detected. Samples were analyzed for compounds listed in table 2]

Blank sample identifier	Analytical report lot number	Date	Time	Acetone (µg/L)	Chloro-methane (µg/L)	2-Butanone (µg/L)	Tetrachloro-ethylene (µg/L)	Chloro-form (µg/L)
Trip blank 1	D0D140141	04/13/00	1400	11	<1	<1	<5	<1
Trip blank 2	D0D200232	04/19/00	1130	<10	<1	<1	<5	<1
Trip blank 3	D0D210249	04/20/00	1300	<10	<1	<1	<5	<1
Trip blank 4	D0D250130	04/24/00	1600	<10	<1	<1	<5	<1
Equipment blank 1	D0D140141	04/12/00	1200	<10	<1	<1	<5	<1
Equipment blank 2	D0D210249	04/20/00	1145	<10	<1	<1	<5	<1