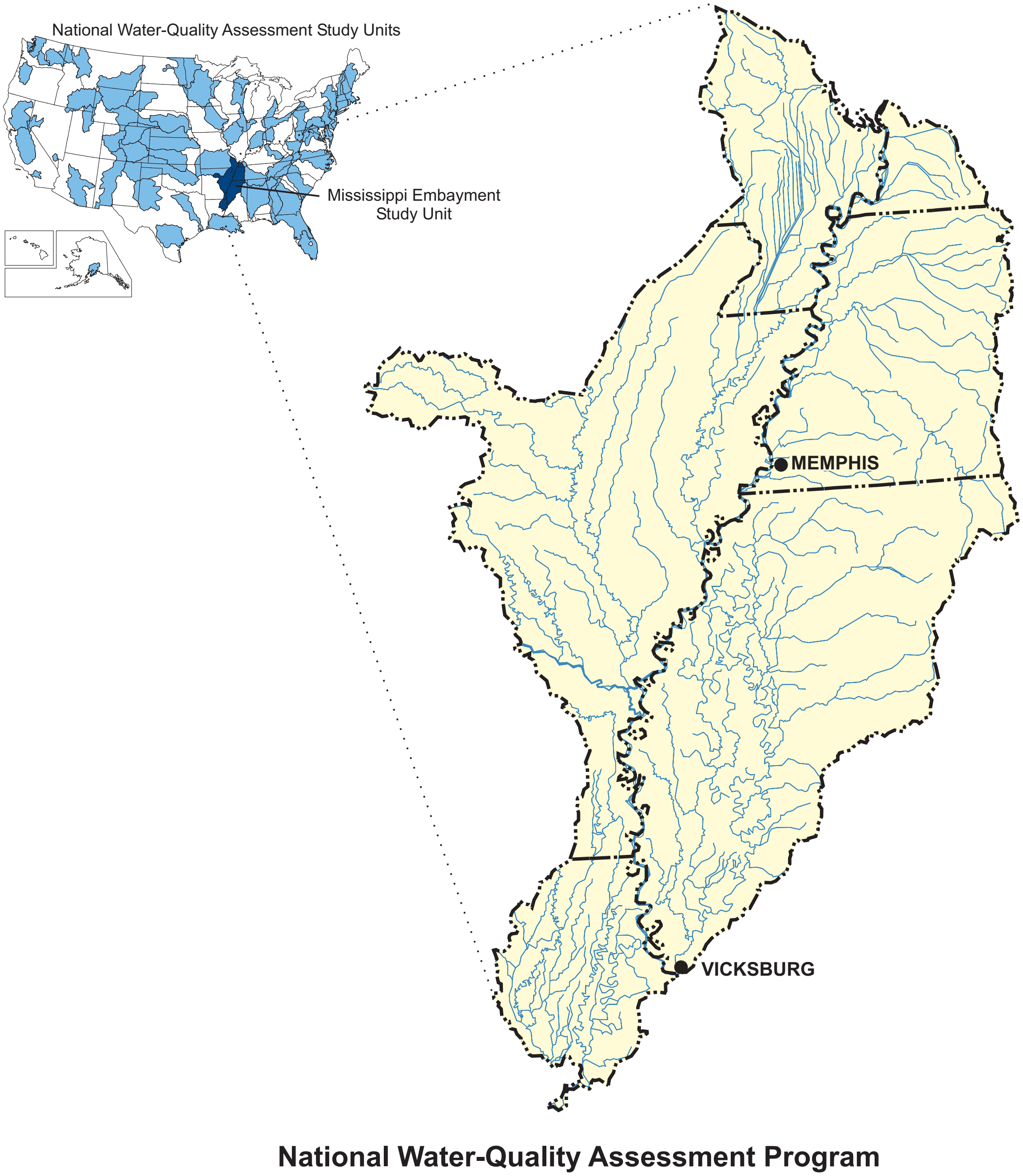
QUALITY OF SHALLOW GROUND WATER IN RECENTLY DEVELOPED RESIDENTIAL AND COMMERCIAL AREAS, MEMPHIS VICINITY, TENNESSEE, 1997

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 02-4294



National Water-Quality Assessment Program

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

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by Gerard J. Gonthier

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National Water-Quality Assessment Program

Jackson, Mississippi
2002

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

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information
write to:

District Chief
U.S. Geological Survey
308 South Airport Road
Jackson, Mississippi 39208-6649

Copies of this report can be
purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
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http://wwwrvares.er.usgs.gov/nawqa_home.html.

FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
Area		
square foot per day (ft^2/d)	0.09290	square meter per day
square mile (mi^2)	2.590	square kilometer
Volume		
gallon (gal)	3.785	liter
gallon (gal)	0.003785	cubic meter
gallon (gal)	3.785	cubic decimeter
Flow rate		
foot per second (ft/s)	0.3048	meter per second
foot per day (ft/d)	0.3048	meter per day
foot per year (ft/yr)	0.3048	meter per year
million gallons per day (Mgal/d)	0.04381	cubic meter per second
inch per year (in/yr)	25.4	millimeter per year
Mass		
pound, avoirdupois (lb)	0.4536	kilogram
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter
tritium unit (TU)	0.118	becquerel per liter
tritium unit (TU)	3.2	picocurie per liter
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day
Hydraulic gradient		
foot per mile (ft/mi)	0.1894	meter per kilometer
Application rate		
pounds per acre (lb/acre)	1.121	kilograms per hectare

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

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 both the United States and Canada, formerly called Sea Level Datum of 1929.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Altitude, as used in this report, refers to distance above or below sea level.

*__Transmissivity__**:** The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or picograms per kilogram of water (pg/kg).

1 liter of water by volume is approximately 1 kilogram by mass.

1000 grams (g) = 1 kilogram (kg)

1000 milligrams (mg) = 1 gram

1000 micrograms (µg) = 1 milligram

ACRONYMS USED IN THIS REPORT:
MCL-Maximum Contaminant Level
SMCL-Secondary Maximum Contaminant Level
NAWQA-National Water-Quality Assessment program
GIRAS-Geographic Information Retrieval and Analysis System
GIS-Geographic Information System, VOC-Volatile Organic Compound
NWQL-National Water-Quality Laboratory
DOC-Dissolved Organic Carbon
USGS-U.S. Geological Survey
LOWESS-LOcally WEighted Scatterplot Smoothing
TU-Tritium Unit.
USEPA-U.S. Environmental Protection Agency

QUALITY OF SHALLOW GROUND WATER IN RECENTLY DEVELOPED RESIDENTIAL AND COMMERCIAL AREAS, MEMPHIS VICINITY, TENNESSEE, 1997

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ABSTRACT

Twenty-four monitor wells screened in the shallow water-table aquifer and eight monitor wells screened in the upper part of the Memphis aquifer in the Memphis vicinity, Tennessee, were sampled as part of the Mississippi Embayment National Water-Quality Assessment Program. These samples were collected during April and May 1997, and were analyzed for turbidity, water temperature, pH, specific conductance, dissolved oxygen concentration, alkalinity, major ions, nutrients, 18 trace elements, 85 pesticides, 87 volatile organic compounds (VOCs), radioisotopes, and stable isotopes. The Memphis study area consists of 76 square miles of residential-commercial areas ranging in age from 5 to 25 years.

Atrazine was the only compound in this study detected at a concentration that exceeded a U.S. Environmental Protection Agency primary drinking-water standard. Manganese, iron, and dissolved solids concentrations in water from some wells exceeded secondary standards. At least one pesticide was detected in water from 24 of 32 wells. The most frequently detected pesticides in water from the monitor wells were atrazine, simazine, and metolachlor. At least one VOC was detected in water from 31 of 32 wells. The most frequently detected VOCs in water from the wells were carbon disulfide, chloroform, m- and p-xylenes, tetrachloroethene, and toluene.

Water from 17 wells was a sodium bicarbonate type water; water from 12 wells was a calcium-magnesium bicarbonate type water; water from 2 wells was a sodium chloride type water; water from 1 well was a sodium mixed anion type water. Based on both tritium and chlorofluorocarbon data, the average age of water from the monitor wells in the Memphis study area was estimated to range from 10 to more than 43 years old. Occurrence of VOCs increased with increasing urban land use.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) Program to provide a consistent description of the Nation’s ground- and surface-water resources. The NAWQA Program consists of more than 50 of the Nation’s drainage basins or aquifer systems, referred to as study units. The objectives of the NAWQA Program are to (1) determine the general ground- and surface-water quality of the Nation’s water resources, (2) determine the natural and anthropogenic factors affecting water quality, and (3) determine any changes in water quality through time (Leahy and others, 1990). Study units are designed so that ground water is sampled once every 10 years. The Mississippi Embayment study unit is one of 17 study units that began in 1994.

Ground water from the Memphis aquifer is the primary source of drinking water for the Memphis metropolitan area. Shallow ground water in the metropolitan area tends to percolate down to recharge the deeper Memphis aquifer. Monitoring the quality of shallow ground water aids in the early detection of potential contaminants that may eventually degrade the water quality of the Memphis aquifer.

Purpose and Scope

This report describes the results of a study to determine the occurrence and distribution of inorganic and organic constituents in shallow ground water underlying recently developed residential and commercial areas, ranging from 5 to 25 years old, in and adjacent to Memphis, Tennessee. These areas are referred to collectively in this report as the study area. Shallow ground water occurs in the water-table aquifer and in the upper part of the Memphis aquifer. Brief descriptions of the climate, physiography, geology, hydrogeology, land use, pesticide application, and toxic releases are included. Land use and well characteristics affecting ground-water quality are also discussed. In addition, surface-water sample results from Fletcher Creek are compared to ground-water results.

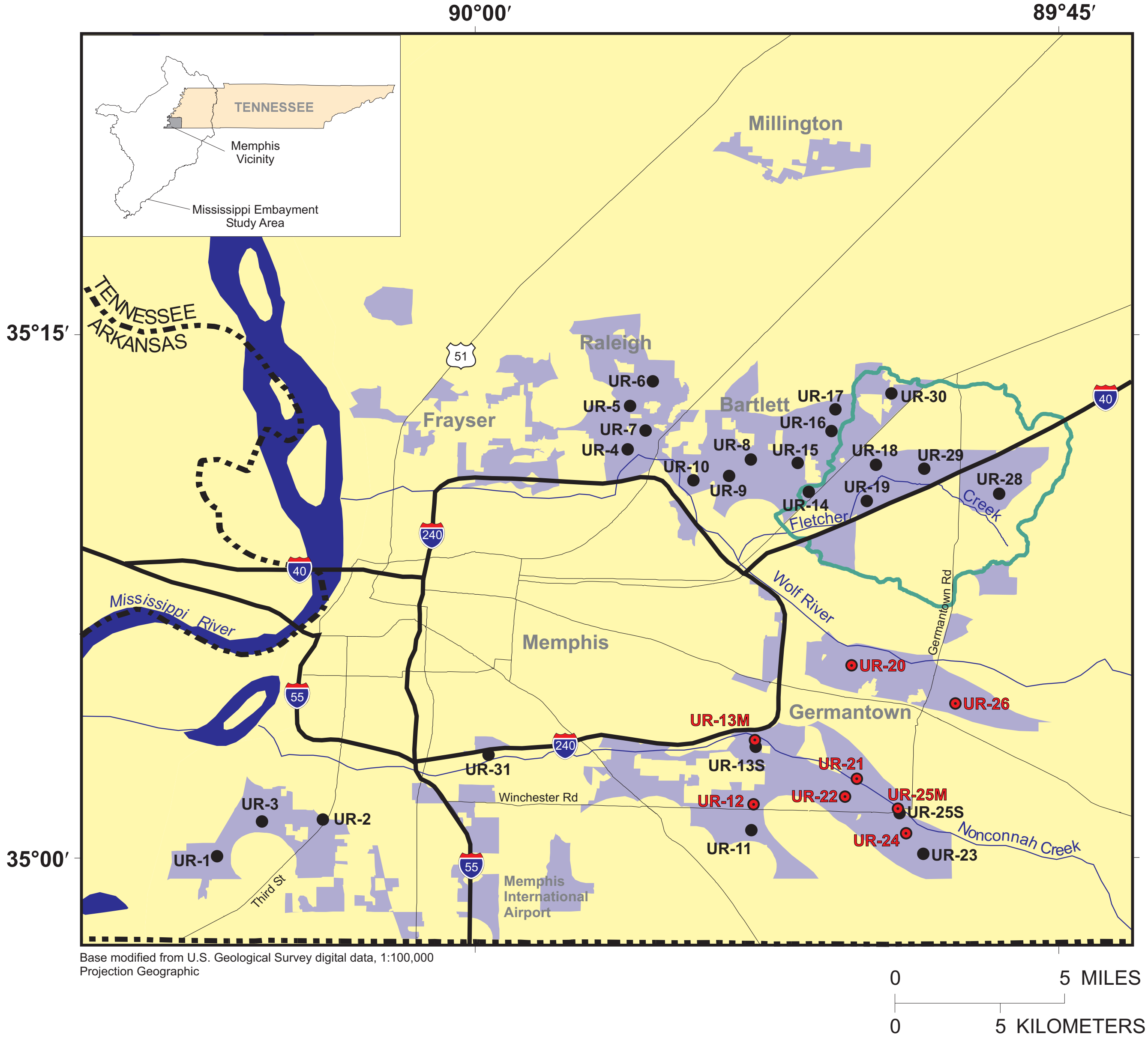
During summer 1996, 30 monitor wells were installed in the study area by USGS personnel; sediment and soil samples were collected at each well site. During April and May 1997, water samples were collected from all 30 wells and from 2 wells owned by Memphis Light, Gas, and Water Division. Of the 32 wells where water samples were collected, 24 wells were completed in the shallow water-table aquifer, and 8 wells were completed in the upper part of the Memphis aquifer. Soil samples were analyzed for pH, and sediment from four distinct lithologic units was analyzed for grain size, inorganic carbon, and organic carbon content. The depth to water below land surface was measured prior to sampling. Water samples were analyzed for turbidity, water temperature, pH, specific conductance, dissolved oxygen concentration, and alkalinity (hereafter referred to as field measurements), major ions, nutrients, trace elements, pesticides, volatile organic compounds, radioisotopes, and stable isotopes. Land use was assessed within 164 and 1,640 feet (ft) (50 and 500 meters) of each well. Ancillary information including date of installation, well depth, water level, casing material, depth to top and bottom of the screen, driller's and natural gamma logs, and discharge rates was also collected.

Acknowledgments

The author extends his deep appreciation to the following land owners in Tennessee for allowing wells to be installed on their property: City of Memphis, Shelby County Government, City of Germantown, City of Bartlett, and Church of Christ at 3867 Horn Lake Rd. The author also extends his deep appreciation to Charlie Pickle and Torrence Myers from the Memphis Light, Gas, and Water Division for their assistance. James Outlaw with the Ground-Water Institute, the University of Memphis, and the Memphis District of the U.S. Army Corps of Engineers provided valuable assistance in obtaining land-use information in the Memphis study area. J. Carter S. Gray, Memphis and Shelby County Health Department, permitted the installation of wells. Evan Spann, Joe Galluzzi, Dr. David N. Lumsden, and Dr. Dan Larsen from the Department of Geological Sciences, University of Memphis, collaborated with the U.S. Geological Survey in sediment sampling and analyses. The following people from the U.S. Geological Survey provided significant assistance: Larry Thomas and Kevin Kelly installed the monitor wells; Eric Strom and Bill Parks interpreted the geology and hydrogeology in the vicinity of the monitor wells; and Tony Schrader and Larry Remsing collected water-quality samples.

ENVIRONMENTAL SETTING

The Mississippi Embayment Study Unit comprises approximately 49,800 square miles (mi^2) and includes eastern Arkansas, western Kentucky, northeastern Louisiana, northwestern Mississippi, southeastern Missouri, and western Tennessee. The Memphis metropolitan area is within Shelby County, Tennessee, near the center of the study unit (fig. 1). The study area consists of 76 mi^2 of residential-commercial areas ranging in age from 5 to 25 years. These recently developed residential-commercial areas are scattered mostly outside of the loop made by interstate routes I-40, I-240, and I-55 and include parts of Memphis, Germantown, Bartlett, Raleigh, Frayser, and Millington.



EXPLANATION

RECENTLY DEVELOPED RESIDENTIAL AND COMMERCIAL AREA--(the "Study Area")

Fletcher Creek Basin Boundary

UR-24 WELL AND NUMBER - Screened in the top of the Memphis aquifer

UR-11 WELL AND NUMBER - Screened in the shallow water-table aquifer

Figure 1. Locations of monitoring wells in recently developed reidential and commercial areas, Memphis vicinity, Tennessee, 1997.

Climate

The climate in the Memphis vicinity is humid and temperate. Mean annual air temperature is 62.3 degrees Fahrenheit (^{O}F). Mean monthly temperature ranges from about 40 ^{O}F in January to 83 ^{O}F in July. Mean annual precipitation is 52.10 inches (in.). Mean monthly precipitation is greatest in December (5.74 in. and least in October (3.01 in.), but precipitation is fairly evenly distributed throughout the year. Mild drought conditions are common during the summer months when evapotranspiration is high (U.S. National Climatic Data Center, 1999).

Physiography

The study area is located within the East Gulf Coastal Plain Province, which was defined by Fenneman (1938). A bluff just west of the study area bounds the western edge of the East Gulf Coastal Plain. Directly west of the bluff is the Mississippi River and the Mississippi Alluvial Plain (fig. 2). The Mississippi Alluvial Plain consists of nearly flat land with local relief of 5 to 10 ft. Land-surface altitude in the Mississippi Alluvial Plain within the Memphis vicinity ranges from 180 to 220 ft above sea level and increases northward. The East Gulf Coastal Plain consists of rolling hills with local relief of 15 to 100 ft; land-surface altitude of the East Gulf Coastal Plain within the Memphis vicinity ranges from 200 to 390 ft above sea level.

The East Gulf Coastal Plain is dissected by small alluvial valleys created by meandering streams. Streams in the study area flow from east to west draining to the Mississippi River. The Wolf River and Nonconnah Creek are the largest streams that flow through the study area (fig. 1); each have small alluvial valleys. Land-surface altitude in the small alluvial valleys ranges from about 200 ft above sea level where the Wolf River and Nonconnah Creek flow into the Mississippi River to about 300 ft above sea level at Nonconnah Creek in the southeastern part of the study area. Land-surface altitude at the tops of the rolling hills ranges from about 300 ft above sea level in the southwestern part of the study area to about 390 ft above sea level in the southeastern part of the study area.

Geology

In the Memphis vicinity, Tertiary-age sands and clays dip west towards the axis of the Mississippi Embayment, a large geologic structural trough. Tertiary formations include, in ascending order, the Claiborne Group and the Jackson Formation (Cushing and others, 1964). Overlying the Tertiary deposits, in ascending order, are the fluvial deposits and loess (table 1). The Mississippi River Valley alluvium lies beneath the Mississippi Alluvial Plain west of the study area. The upper Claiborne and Jackson Formations are of Eocene age and consist of a series of sands and clays that range in thickness from 650 to 1,070 ft in the Memphis vicinity. The lower three-fourths of the Claiborne consists of a massive sand called the Memphis Sand, which ranges in thickness from 650 to 820 ft in the Memphis vicinity, and is the primary source of drinking water for Memphis (Parks, 1990; and Parks and Carmichael, 1990b). Three formations above the Memphis Sand (Cook Mountain, Cockfield, and Jackson) consist mainly of clay and silt, which make up the Jackson-upper Claiborne confining unit. The Cook Mountain Formation in the Memphis vicinity, is typically a fine clay that overlies the Memphis Sand. The transition between the Memphis Sand and the Cook Mountain Formation within the southeastern part of the study area is very thin interbedded sands and clays.

The Cockfield Formation, which is the uppermost part of the Claiborne Group, consists of sand, silt, and clay within the study area and overlies the Cook Mountain Formation (Parks and Carmichael, 1990a). Northwest of the study area, the Jackson Formation generally consists of clay and silt that overlie the Cockfield Formation. The top of the Jackson-upper Claiborne confining unit has been eroded and roughly parallels the topography. The Jackson-upper Claiborne confining unit ranges in thickness from 0 to 250 ft in the Memphis vicinity, becomes thinner from west to east, and pinches out beneath the fluvial deposits at the eastern edge of the Memphis vicinity. East of the study area, the Memphis Sand is in contact with the base of the fluvial deposits.

The fluvial deposits consist of sand and gravel that lie unconformably over the Jackson-upper Claiborne confining unit and the Memphis Sand. Locally, the sand and gravel are cemented with iron oxide to form thin layers of hard ferruginous sandstone or conglomerate in the lower parts of the fluvial deposits (Parks, 1990). Fluvial deposits range in thickness from 0 to 100 ft in the Memphis vicinity and are generally thicker at the base of hills than at the top of hills.

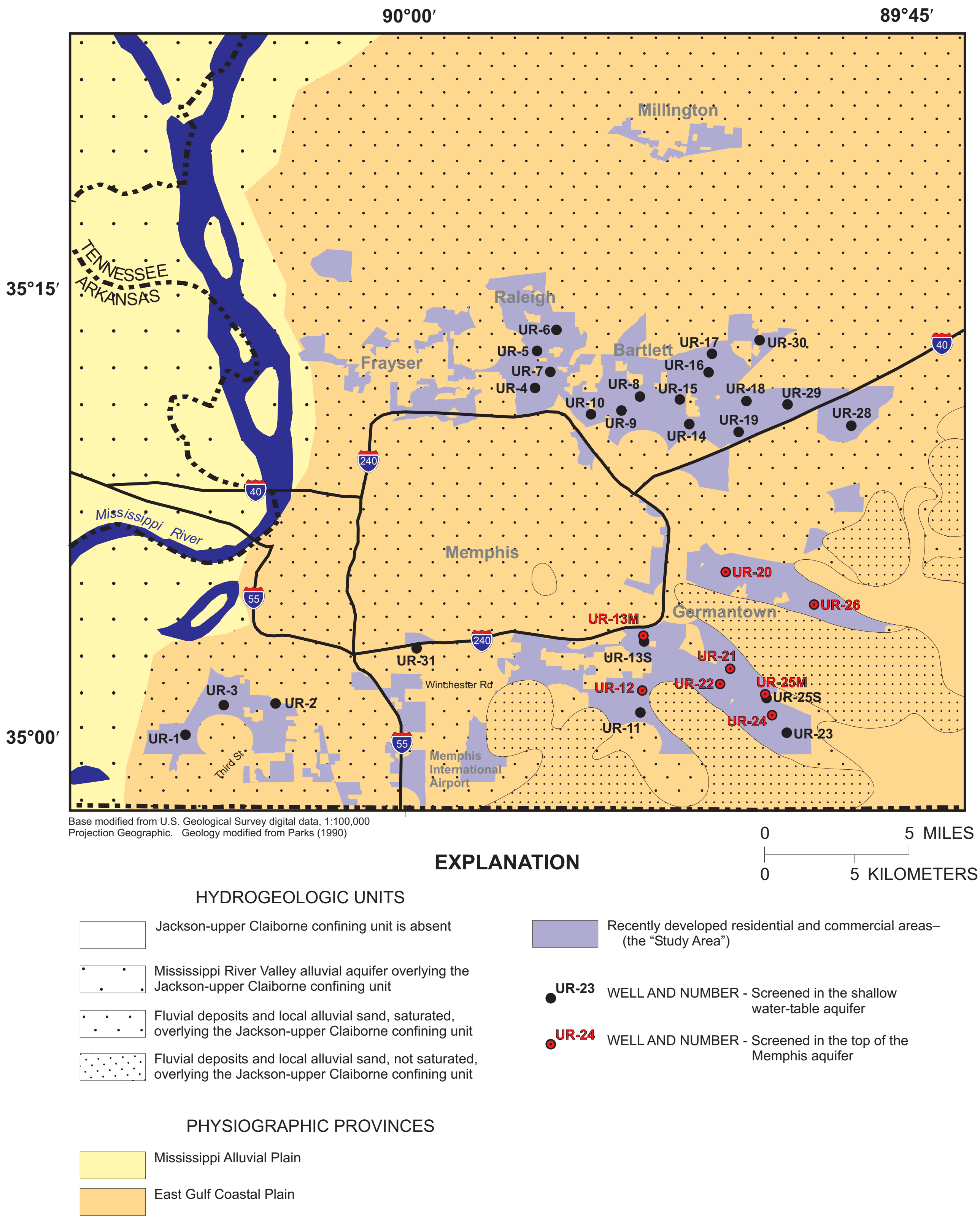


Figure 2. Hydrogeology and physiography in the Memphis vicinity, Tennessee, 1997.

Table 1. Relation of local geologic units within the Memphis vicinity, Tennessee, East Gulf Coastal Plain, with hydrogeologic units

[Modified from Parks (1990). Shading indicates fine grain material and low permeability]

Geology					Hydrogeology	
Geologic age		Geologic groups	Local geologic units		Hydrogeologic unit in the Memphis study area	Lithologic characteristics
Period	Epoch					
Quaternary	Pleistocene	Surficial	Alluvium	Loess	Loess	Silt
Quaternary and Tertiary (?)	Pleistocene and Pliocene (?)			Fluvial deposits	Shallow water table aquifer	Sand, gravel, minor clay, and ferruginous siltstone
Tertiary	Eocene	Jackson	Jackson Formation		Jackson-upper Claiborne confining unit	Fine clay and silt and some sand
		Claiborne	Cockfield Formation			
			Cook Mountain Formation			
			Upper part of Memphis Sand		Upper part of Memphis aquifer	Sand and some gravel interbedded with fine clay

Loess consists of windblown silt that covered the fluvial deposits during the Pleistocene Epoch. The loess thins from west to east. Thickness of the loess ranges from only a few feet at the eastern edge of the Memphis vicinity to about 65 ft near the bluff at the western edge of the Memphis vicinity (Parks, 1990; and Parks, 1993). Streams in the study area have eroded and redeposited (reworked) the fluvial deposits and loess in narrow alluvial valleys.

Hydrogeology

The shallow hydrogeologic units in the Memphis vicinity, in order of increasing depth, are the loess silt, fluvial deposits and local alluvial aquifer (shallow water-table aquifer), Jackson-upper Claiborne confining unit, and the upper part of the Memphis aquifer. The local alluvial deposits in the narrow valleys and the fluvial deposits are collectively referred to henceforth in this report as the shallow water-table aquifer. The loess impedes recharge of water to the shallow water-table aquifer.

The shallow water-table aquifer was not used (in 1997) as a primary ground-water resource within the Memphis vicinity. Some small domestic and livestock wells in rural areas near the Memphis metropolitan area pumped from the shallow water-table aquifer. Numerous monitor wells are completed in the shallow water-table aquifer. Memphis Light, Gas, and Water Division (MLGW) has installed at least 33 monitor wells in the shallow water-table aquifer within several municipal well fields in the Memphis area. Other wells are screened in the shallow water-table aquifer to monitor local conditions and assess local contamination.

The shallow water-table aquifer is locally confined by the loess silt in the western part of the study area where the water level is above the top of the sand

and gravel. The shallow water-table aquifer is a true water-table aquifer in most of the Memphis vicinity--where the water level is below the base of the loess silt. Saturated thickness of the shallow water-table aquifer generally decreases from west to east. In the central and eastern parts of the Memphis vicinity, the water table rests on the top of the Jackson upper-Claiborne confining unit. Locally, where the water table is below the base of the loess silt, the saturated thickness decreases with increasing elevation of the top of the Jackson-upper Claiborne confining unit. Because the top of the Jackson-upper Claiborne roughly parallels the surface topography, areas where the fluvial deposits are dry [referred to as “no significant saturation thickness zones” by Parks (1990)] are on hills, in the eastern part of the Memphis vicinity.

Water-level altitude in the shallow water-table aquifer roughly parallels the land-surface altitude, but irregularities in the surface of the top of the Jackson-upper Claiborne confining unit causes highly localized variations in water-level altitude. Water in the shallow water-table aquifer flows from areas of high elevation toward streams in the study area. Within the Memphis vicinity, water levels in the shallow water-table aquifer range from 0 to 130 ft, and are about 70 ft higher than water levels in the Memphis aquifer (Parks, 1990).

The fine clay of the Jackson-upper Claiborne confining unit has a low permeability that retards the flow of water between the shallow water-table aquifer and the Memphis aquifer. In some locations, however, mainly in the eastern part of the Memphis vicinity, the Jackson-upper Claiborne confining unit is thin or absent, and some water in the shallow water-table aquifer flows into the Memphis aquifer (Parks, 1990; Bradley, 1991; Parks and Mirecki, 1992; and Kingsbury and Parks, 1993).

The Memphis aquifer is heavily pumped in the Memphis vicinity. Ground-water pumpage from the Memphis aquifer in 1995 for Shelby County--in the vicinity of Memphis--was 190 million gallons per day (Mgal/d) (Kingsbury, 1996). The Memphis aquifer is predominantly pumped by MLGW and other municipalities such as Germantown, Bartlett, and Raleigh, Tennessee, and Southaven, Mississippi, and by industrial operations. MLGW pumped 140 Mgal/d from the Memphis aquifer in 1995 (Memphis Light, Gas and Water Division, 1995).

Ground-water pumping has created a cone of depression in the potentiometric surface of the Memphis aquifer in the Memphis metropolitan area (Parks, 1990; and Parks and Carmichael, 1990b). Parks (1990) reported that in late summer and fall 1988, water levels in the production zone of the Memphis aquifer ranged from lower than 120 ft above sea level in the western interior of the interstate loop (downtown Memphis) to higher than 260 ft above sea level where the Jackson-upper Claiborne confining unit pinches out just east of the study area. The resulting head gradient between downtown Memphis and the edge of the Jackson-upper Claiborne confining unit was about 8 feet per mile (ft/mi). The upper part of the Memphis aquifer--where eight of the monitor wells are screened--probably is hydraulically separated from the main production zone of the Memphis aquifer by interbedded sands and clays that were noted during drilling. Parks and Carmichael (1990b) reported an average transmissivity for the Memphis aquifer in Shelby County of 33,400 square feet per day (ft^2/d), based on 60 aquifer tests. Assuming a thickness of 700 ft, permeability of the Memphis aquifer in Shelby County is estimated to be about $5.5x10^{-4}$ feet per second (ft/s) [48 feet per day (ft/d)]. Assuming a permeability of 48 ft/d, a porosity of 0.3 for sand (Freeze and Cherry, 1979), and a head gradient of 8 ft/mi, water in the Memphis aquifer is estimated to flow at a rate of 0.24 ft/d or 89 feet per year (ft/yr); water would take about 60 years to flow 1 mile.

Land Use

Urban development in the Memphis vicinity has been intensive from the 1960’s through the 1990’s. Land use in the study area during 1965 was predominantly agriculture (Sease and others, 1970). Land use in the Memphis vicinity was predominantly residential in 1992 with some light commercial and industrial areas (fig. 3).

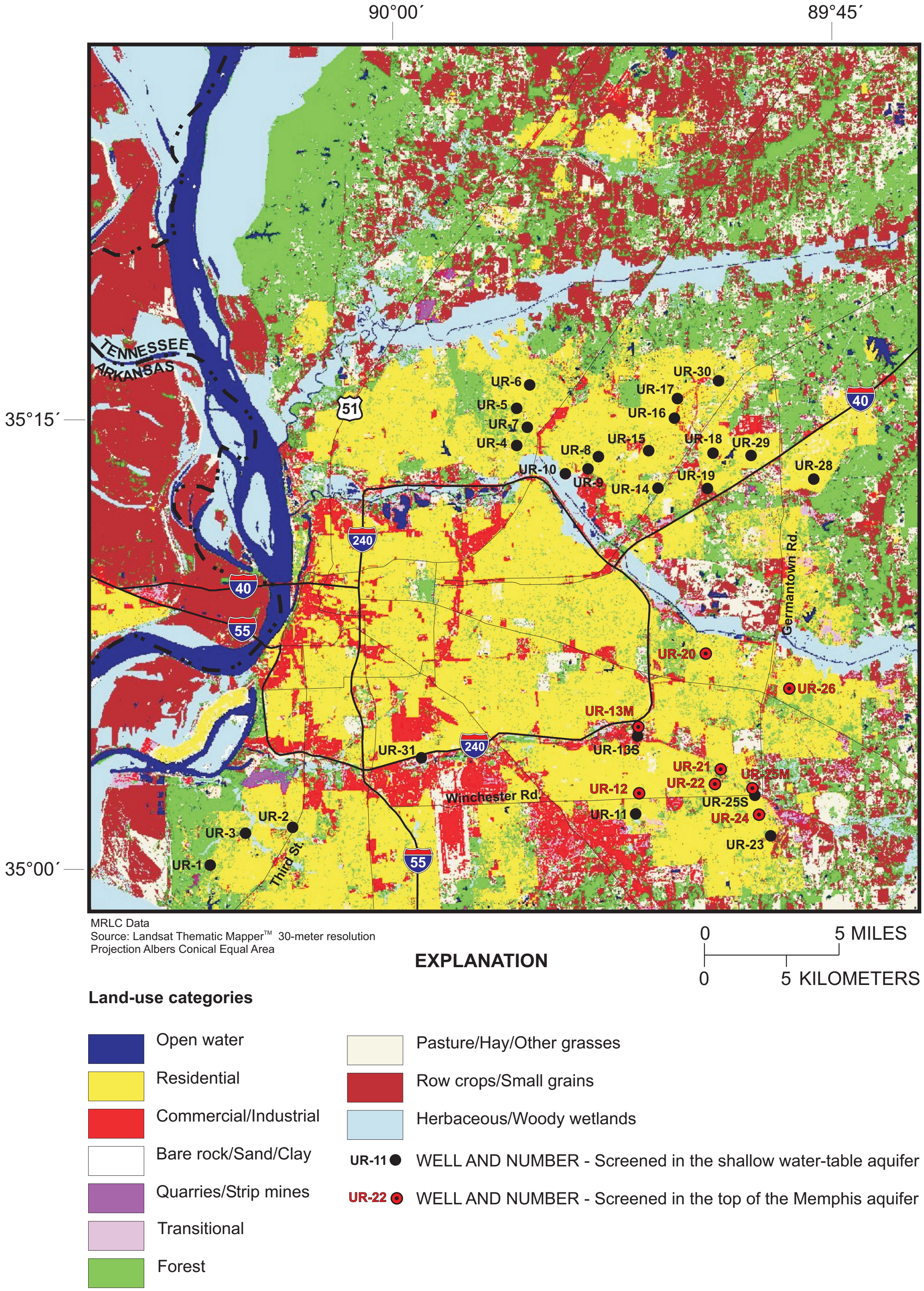


Figure 3. Land use in the Memphis vicinity, Tennessee, 1992.

Pesticide Application and Toxic Release Inventory

Amounts of pesticides applied to agricultural land in Shelby County, Tennessee, during 1995 are listed in table 2. Pesticides were applied primarily to cotton, soybeans, corn, sorghum, apples, wheat, sweet potatoes, alfalfa, peas, and hay. Almost 128,000 pounds (lb) of herbicides was applied. The most heavily used herbicide was fluometuron; more than 16,000 lb of fluometuron as active ingredient was applied to cotton. The second most heavily used herbicide was metolachlor (nearly 14,800 lb active ingredient), which was applied to soybeans, cotton, corn, and sorghum. The third most heavily used herbicide was trifluralin (about 14,400 lb active ingredient), which was applied to cotton and soybeans. Other heavily used herbicides were glyphosate, which was applied to fields prepared for soybeans, cotton, and corn, and monosodiummethanearsonate (MSMA), which was applied to cotton. More than 26,000 lb of insecticides as active ingredient was applied. The most heavily used insecticide was aldicarb (more than 8,000 lb), which was applied to cotton. Other heavily used insecticides —dicrotophos, disulfoton, and chlorpyrifos —also were applied to cotton. About 7,500 lb of fungicides as active ingredient was applied. The most heavily used fungicide was pentachloronitrobenzene (PCNB); (nearly 4,100 lb active ingredient), which was applied to cotton. The second most heavily used fungicide was mancozeb, which was applied to wheat and apples.

Pesticide usage in urban areas was not determined. The types of pesticides used in urban areas can differ considerably from those used in agricultural areas (Barbash and Resek, 1996). Whitmore and others (1992) list the pesticides most frequently applied in 1990 by private home owners around homes and in gardens throughout the United States. The list is extensive and does not necessarily reflect the pesticide usage in Memphis. Throughout the United States, some of the herbicides most heavily used by home owners are acifluorfen, 2, 4-D, glyphosate, and MCPP. Atrazine is sold for use on residential lawns in various parts of the United States (U.S. Environmental Protection Agency, 1994; Clawges and others, 1999; and Stell and others, 1995). Some of the insecticides most heavily used by home owners are allethrin, carbaryl, chlorpyrifos, diazinon, malathion, piperonyl butoxide, propoxur, and permethrin. Some of the fungicides most heavily used by home owners are benomyl, captan, chlorothalonil, and triforine. Pesticides also are used by professional applicators for commercial landscape maintenance, termite control around structures, and golf course maintenance. Local governments apply herbicides such as tebuthiuron and prometon to rights-of-way for weed control, and spray insecticides to kill mosquitoes for disease and nuisance control (Barbash and Resek, 1996).

A Toxic Release Inventory was developed by the U.S. Environmental Protection Agency (USEPA) to quantify the releases of hazardous materials into the environment. Toxic releases into the environment in the Memphis vicinity (Memphis and Millington, Tennessee) during 1995 are summarized in table 3 (U.S. Environmental Protection Agency, 1995). Most toxic releases to the environment in Memphis and Millington were to the air with smaller amounts of toxic releases to water or land. Forty compounds were reported released to the air in Memphis or Millington during 1995. Seventeen compounds were reported released to water; two compounds were reported released to land. More than 4 million pounds of ammonia were reported released to the air during 1995, making ammonia the compound most heavily released. Almost 33,000 lb of nitrate compounds was reported released to water, making nitrate compounds the most heavily released to water. About 250 lb of methanol was reported released to land (not shown in table 3), making methanol the most heavily released compound to land. Also released to land were 5 lb of copper compounds.

METHODS OF STUDY

The design and data-collection methods used for this study were similar to methods used for other NAWQA study units to ensure consistency and comparability of results. Squillace and Price (1996) describe the criteria used to delineate an urban land-use study area based on land-use activities. Scott (1990) describes methods used to make an unbiased selection of site locations. Lapham and others (1995) describe site selection and well documentation, and Koterba and others (1995) describe ground-water sample-collection methods for the NAWQA Program. Shelton (1994) describes collection and processing of stream-water samples.

Table 2. Estimated pesticide application to agricultural land in Shelby County, Tennessee, 1995

[Data are from the National Center for Food and Agricultural Policy (1996). Only crops with greater application rates than 100 pounds reported are listed individually, whereas totals for each listed pesticide include all crops. Analysis comments pertain to whether the water samples were analyzed for this pesticide. --, no data available]

Pesticide	Main crops	Total pounds of active ingredient	Total acres treated	Pounds per acre	Analysis comments
Herbicides					
Fluometuron	cotton	16,022	20,028	0.80	analyzed
Metolachlor	soybeans, cotton, corn, sorghum	14,758	10,827	1.4	analyzed
Trifluralin	cotton, soybeans	14,444	20,055	.72	analyzed
Glyphosate	soybeans, cotton, corn	14,422	19,501	.74	not analyzed
MSMA	cotton	12,239	12,239	1.0	not analyzed
Pendimethalin	soybeans, cotton	8,290	12,118	.68	analyzed
Alachlor	soybeans, corn, sorghum	7,353	3,098	2.4	analyzed
Atrazine	corn, sorghum	5,156	3,622	1.4	analyzed
Bentazon	soybeans	3,538	5,443	.65	analyzed
Paraquat	soybeans, cotton, corn	3,427	7,160	.48	not analyzed
2, 4-D	grains, pasture, soybeans	3,017	4,985	.61	analyzed
Linuron	soybeans, cotton	2,902	4,409	.66	analyzed
Cyanazine	cotton, corn	2,827	4,711	.60	analyzed
Metribuzin	soybeans	2,437	10,214	.24	analyzed
Acifluorfen	soybeans	2,394	9,209	.26	analyzed
Fluazifop	cotton, soybeans	2,206	23,269	.09	not analyzed
DSMA	cotton	1,669	1,113	1.5	not analyzed
Clomazone	soybeans	1,465	2,930	.50	not analyzed
Fomesafen	soybeans	1,381	4,605	.30	not analyzed
Sethoxydim	cotton, soybeans	1,277	9,683	.13	not analyzed
Butylate	corn	935	261	3.6	analyzed
Simazine	corn	820	660	1.2	analyzed
Imazaquin	soybeans	792	11,302	.07	not analyzed
Norflurazon	cotton	712	1,780	.40	analyzed
Clethodim	soybeans	628	4,186	.15	not analyzed
Prometryn	cotton	556	1,113	.50	not analyzed
Fenoxaprop	soybeans	327	2,512	.13	not analyzed
Imazethapyr	soybeans	327	5,442	.06	not analyzed
Lactofen	cotton, soybeans	318	2,787	.11	not analyzed
Propachlor	sorghum	266	84	3.2	analyzed

Table 2. Estimated pesticide application to agricultural land in Shelby County, Tennessee, 1995--Continued

Pesticide	Main crops	Total pounds of active ingredient	Total acres treated	Pounds per acre	Analysis comments
Chlorimuron	soybeans	201	10,047	.02	not analyzed
2, 4-DB	alfalfa	129	1,865	.07	analyzed
Diclofop	wheat	123	164	.75	not analyzed
Total Herbicides		**127,779**	--	--	--
		Insecticides			
Aldicarb	cotton	8,011	13,352	.60	analyzed
Dicrotophos	cotton	5,074	21,140	.24	not analyzed
Disulfoton	cotton	2,670	3,338	.80	analyzed
Chlorpyrifos	cotton, corn, sorghum	2,385	2,759	.86	analyzed
Azinphos-methyl	cotton	1,649	8,929	.18	analyzed
Dimethoate	cotton	1,202	6,676	.18	not analyzed
Oxamyl	cotton	1,113	2,225	.50	analyzed
Thiodicarb	cotton, soybeans	960	1,531	.63	not analyzed
Profenofos	cotton	834	1,113	.75	not analyzed
Carbaryl	soybeans, wheat	595	669	.89	analyzed
Acephate	cotton	414	668	.62	not analyzed
Malathion	wheat	351	352	1.0	analyzed
Cypermethrin	cotton	234	3,338	.07	not analyzed
Carbofuran	corn	187	193	.97	analyzed
Lambdacyhalothrin	cotton	167	5,563	.03	not analyzed
Oil	apples	143	10	15	not analyzed
Esfenvalerate	cotton	134	3,342	.04	analyzed
Methomyl	wheat	115	254	.45	analyzed
Bifenthrin	cotton	109	1,558	.07	not analyzed
Total Insecticides		**26,664**	--	--	--
		Fungicides			
PCNB	cotton	4,095	5,118	.80	not analyzed
Mancozeb	wheat, apples	1,349	768	1.8	not analyzed
Etridiazole	cotton	979	4,896	.20	not analyzed
Thiophanate methyl-	soybeans	502	837	.60	not analyzed
Propiconazole	wheat	171	1,559	.11	not analyzed
Captan	apples	112	15	7.3	not analyzed
Total Fungicides		**7538**	--	--	--

Table 3. Summary of toxic release inventory for Memphis and Millington, Tennessee, 1995

[Compiled from data from the U.S. Environmental Protection Agency (1995); --, not reported or not applicable. One release to land of 250 pounds of methanol and one release to land of 5 pounds of copper are not listed in the table]

Constituent	Air			Water		
	Number of reported releases	Median release (pounds)	Total released (pounds)	Number of reported releases	Median release (pounds)	Total released (pounds)
1,1,1-trichloroethane	2	1,450	2,900	1	--	5
1,2,4-trimethylbenzene	3	12,321	26,949	--	--	--
2,4-D	1	--	255	--	--	--
Acetonitrile	1	--	147,793	--	--	--
Acrylonitrile	2	1,701	3,401	--	--	--
Ammonia	8	65,551	4,092,906	4	621	6,331
Antimony compounds	3	8	63	--		--
Arsenic compounds	2	122	243	1	--	5
Barium compounds	2	260	520	--		--
Benzene	1	--	6,394	1	--	2
Bromacil	1	--	500	--	--	--
Carbon tetrachloride	1	--	74	--	--	--
Chlordane	1	--	823	1	--	22
Chlorine	3	500	2,569	--	--	--
Chlorodifluoromethane	1	--	17,500	--	--	--
Chloromethane	1	--	44,000		--	--
Chromium compounds	1	--	55	1	--	1
Copper compounds	2	225	450	3	13	1,548
Cumeme	2	817	1,633	--	--	--
Cyanide compounds	2	763	1,526	1	--	47
Dichlorodifluoromethane	1	--	1,287	--	--	--
Diuron	1	--	1,500	--	--	--
Ethylbenzene	2	1,142	2,283	1	--	1
Heptachlor	1	--	203	1	--	6
Hexachlorobenzene	1	--	15	--	--	--
Hydrochloric acid	2	44,179	88,358	--	--	--
Hydrogen cyanide	2	65,308	139,615	--	--	--
Hydrogen fluoride	1	--	541	--	--	--
Lead compounds	3	500	3,307	1	--	56
Methyl ethyl ketone	5	12,000	96,589	--	--	--
Methanol	11	7,700	991,643	2	476	952
Methyl methacrylate	2	127,747	255,493	--	--	--
Methylene chloride	4	10,680	45,186	--	--	--
Methyl isobutyl ketone	5	1,000	20,882	--	--	--
Naphthalene	3	500	1,655	--	--	--
Nitrate compounds	1	--	65	1	--	32,828
Phosphoric acid	2	1,553	3,105	--	--	--
Styrene	1	--	2,388	--	--	--
Sulfuric acid	1	--	74,020	--	--	--
Tetrachloroethene	1	--	4,558	--	--	--
Toluene	9	71,059	1,861,477	1	--	3
m-xylene	2	2,933	5,866	1	--	6
o-xylene	1	--	1,837	1	--	3
p-xylene	1	--	1,585	1	--	2
Xylene (mixed isomers)	9	6,850	227,439	--	--	--
Zinc compounds	4	8,750	63,670	3	12	9,204

Design of Ground-Water Sampling Network

The sampling network for this study was designed to acquire a representative sample of shallow ground water within a recently developed residential-commercial setting. The ground-water sampling sites were selected based on the following criteria: within residential-commercial areas between 5 and 25 years old; at least 3,048 ft (1,000 m) from industrial land use; and within the shallow water-table aquifer where the saturated layer was thick enough for water samples to be collected from a 10-ft-long well screen. Sites for monitor-well installation within the study area were selected randomly by using a geographical information system (GIS)-based program (Scott, 1990). Wells were installed as close to the selected locations as possible. Almost all wells were installed in city rights-of-way.

Well Drilling and Sediment-Sample Collection

Thirty wells were installed in the study area during June through September of 1996. Holes were drilled by using dry hollow-stem augers (7-in. outer diameter, 4-in. inner diameter.). Wells were constructed with 2-in. diameter polyvinyl chloride (PVC) casing with a 10-ft long, 2-in.-diameter PVC slotted screens. Wells were completed by using standard procedures described by Lapham and others (1995) and the Memphis and Shelby County Health Department (1996). Strom (1997) logged the wells using natural gamma radiation and interpreted contacts between hydrogeologic units. Twenty-two wells were completed in the shallow water-table aquifer. Eight wells were completed in the upper part of the Memphis aquifer. Two sites had nested wells with one well screened in the shallow water-table aquifer and one well screened in the upper part of the Memphis aquifer. Well depths ranged from 33 to 109 feet (table 4).

During drilling, lithology and sediment moisture content were described. Soil also was mixed with an equal weight of distilled deionized water and measured for pH. Sediment from different hydrogeologic units was collected from 2-ft-long split spoons and from drill cuttings and sent to the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado, for analysis (table 5). Sediment data are described and listed in Appendix 1. Maps from Parks (1990), driller’s logs, and natural gamma log interpretations from Strom (1997) were used to determine the aquifer in which each well was screened.

Collection of Land-Use Information

Land use and possible sources of contamination within 164 and 1,641 ft (50 and 500 m) of each well were documented during 1997. Possible sources of contamination included the presence of oil spills, dead vegetation, boreholes, construction projects, gas stations, oil production wells, swimming pools, and pesticide mixing operations. Land-use categories included residential, commercial-community, light industrial, low development parks (such as playgrounds and ball fields), high development parks (such as golf courses and theme parks), vacant land, construction, transportation, utilities, agriculture, rangeland (small perennial vegetation), forest, wetland, and surface water. Land use within 50 m of each well was mapped on site based on direct observation. Land use within 500 m of each well was delineated by using two sets of aerial photographs from 1994 and 1996, 7-1/2-minute topographic maps, and by field verification and interpreting aerial photographs. Land uses within 500 m of each well were calculated by using a technique developed by Harvey and others (1996).

Ground-Water Sample Collection and Analysis

Analyses of water samples from the 32 monitor wells listed in table 4 include major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, bromide, and fluoride), nutrients (nitrite, nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, phosphorus, and orthophosphate), 18 trace elements, 85 pesticides, 87 VOCs, and tritium. During 1997, water samples from 26 of the 32 wells were analyzed for radon-222, water samples from 13 wells were analyzed for radium-226, and water samples from 12 wells were analyzed for stable oxygen and hydrogen isotopes. Field measurements (depth to water, turbidity, water temperature, pH, specific conductance, dissolved oxygen, and alkalinity) were made at all sites. During September 1998, water from 10 of the 32 wells was analyzed for chlorofluorocarbons (CFCs) to date ground water, and water from 5 of the 32 wells was

Table 4. Selected information for the monitor wells sampled in recently developed residential and commercial areas, Memphis vicinity, Tennessee, 1997

[D M S.T, degrees, minutes, seconds, and tenths of second; ft, feet; Dev., development of wells; vol., volume of water; gal., gallons; QA, quality-assurance samples that were collected; Shallow (f), fluvial deposits of the shallow water-table aquifer; Shallow (a), alluvial deposits of the shallow water-table aquifer; b, equipment blank of some constituents; R, replicate sample for most constituents; -, no quality assurance sample; S, pesticide and volatile organic compounds were spiked in the field; t, trip blank for volatile organic compounds; r, replicate sample for radon or dissolved organic carbon, only; 2T1 and 2T2, Memphis, Light, Gas, and Water Division monitor wells that were sampled as UR-14and UR-15, respectively; *, well was developed by Memphis, Light, Gas, and Water Division, no development data available]

Station number (refers to fig. 1)	Location information			Drilling information			Sample information				
	North latitude (D M S.T)	West longitude (D M S.T)	Land-surface altitude (ft)	Date of drilling and sediment sample	Well depth (ft)	Screened aquifer	Date of primary water sample	Sampler type	Dev. vol. (gal)	Purge vol. (gal)	QA data
UR-1	35 01 48.9	90 06 38.1	267	1996 Jul 08	70	Shallow (f)	1997 May 22	Submersible	700	28.8	b
UR-2	35 02 45.3	90 03 54.6	281	1996 Jul 09	64	Shallow (f)	1997 May 06	Submersible	388	32.9	R
UR-3	35 02 41.7	90 05 29.4	239	1996 Jul 09	68	Shallow (f)	1997 May 06	Submersible	172	26	-
UR-4	35 12 16.7	89 56 05.4	242	1996 Jul 25	38	Shallow (f)	1997 May 13	Bailer	21	2.7	-
UR-5	35 13 23.5	89 56 00.8	330	1996 Jul 26	46	Shallow (f)	1997 Apr 29	Submersible	91	15.8	-
UR-6	35 14 02.5	89 55 25.8	310	1996 Jul 26	40	Shallow (f)	1997 May 01	Submersible	170	21.4	b
UR-7	35 12 46.6	89 55 36.8	293	1996 Jul 25	49	Shallow (f)	1997 May 13	Submersible	38	9.0	-
UR-8	35 12 00.8	89 52 44.8	278	1996 Jul 20	44	Shallow (f)	1997 Apr 22	Submersible	331	22.2	-
UR-9	35 11 36.2	89 53 27.3	295	1996 Jul 27	45	Shallow (f)	1997 Apr 30	Submersible	77	22.7	-
UR-10	35 11 36.8	89 54 25.6	239	1996 Sep 24	48	Shallow (f)	1997 Apr 23	Submersible	368	43.3	S, t
UR-11	35 02 29.3	89 52 54.3	291	1996 Jul 01	53	Shallow (f)	1997 May 20	Submersible	110	19.5	R
UR-12	35 03 08.1	89 52 50.1	293	1996 Jun 21	109	Memphis	1997 May 22	Bailer	17	0	-
UR-13M	35 04 42.7	89 52 48.0	268	1996 Jun 20	98	Memphis	1997 May 14	Bailer	36	4.5	-
UR-13S	35 04 42.4	89 52 47.7	268	1996 Jul 31	33	Shallow (a)	1997 May 14	Submersible	595	21.2	-
UR-14 (2T1)	35 11 11.4	89 51 24.7	310	1986 Nov 05	90	Shallow (f)	1997 Apr 30	Submersible	*	44.8	-
UR-15 (2T2)	35 11 55.7	89 51 42.7	284	1990	51	Shallow (f)	1997 May 22	Submersible	*	23	-
UR-16	35 12 45.1	89 50 50.5	311	1996 Jul 17	88	Shallow (f)	1997 Apr 22	Submersible	468	30.3	-
UR-17	35 13 19.4	89 50 43.5	304	1996 Jul 16	48	Shallow (f)	1997 Apr 24	Submersible	270	18.6	b
UR-18	35 11 52.7	89 49 42.0	265	1996 Jul 12	68	Shallow (f)	1997 Apr 24	Submersible	180	14.2	-
UR-19	35 10 56.7	89 49 56.5	270	1996 Jul 19	65	Shallow (f)	1997 Apr 29	Submersible	100	29.8	-
UR-20	35 06 43.1	89 50 19.9	268	1996 Jun 10	76	Memphis	1997 May 15	Submersible	275	33	b
UR-21	35 03 47.8	89 50 11.5	283	1996 Jun 17	88	Memphis	1997 May 07	Submersible	70	19.7	-
UR-22	35 03 20.0	89 50 29.2	286	1996 Jun 19	98	Memphis	1997 May 07	Submersible	210	20.4	S
UR-23	35 01 52.0	89 48 29.4	328	1996 Jul 11	43	Shallow (f)	1997 May 08	Submersible	131	12.9	-
UR-24	35 02 24.1	89 48 54.9	295	1996 Jun 14	99	Memphis	1997 May 08	Submersible	143	22.9	-
UR-25M	35 02 58.7	89 49 04.2	291	1996 Jun 12	94	Memphis	1997 May 21	Bailer	24	1	r
UR-25S	35 02 58.1	89 49 04.1	291	1996 Jul 31	43	Shallow (a)	1997 May 21	Bailer	22	3	-

Table 5. Laboratory analysis methods for measured sediment properties and water-quality constituents, Memphis vicinity, Tennessee, 1996-97

[USGS, U.S. Geological Survey; VOCs, volatile organic compounds; DOC, dissolved organic carbon; CFC, chlorofluorocarbons; UV, ultra violet]

Characteristic, constituent or constituent group	Analysis method	Reference
Grain size, sediment	Sieve, greater than 1 mm Visual accumulation tube, 62 to 500 microns Pipette splitting, 2 to 16 microns	Guy (1969)
Carbon, sediment	Induction furnace and modified Van Slyke	Wershaw and others (1987)
Major ions, water	Atomic absorption spectrometry	Fishman and Friedman (1989)
Nutrients, water	Colorimetry	Fishman and Friedman (1989)
DOC, water	UV-promoted persulfate oxidation and infrared spectrometry	Brenton and Arnett (1993)
Trace elements, water	Atomic absorption spectrometry	Fishman and Friedman (1989)
Pesticides, water	Gas chromatography/mass spectrometry	Zaugg and others (1995)
Pesticides, water	Liquid chromatography with UV detection	Werner and others (1996)
VOCs, water	Purge and trap capillary gas chromatography/mass spectrometry	Rose and Schroeder (1995)
Radon-222, water	Liquid scintillation, 100-minute counting time	American Society for Testing and Materials (1995)
Tritium, water	Electrolytic enrichment with gas counting	Ostlund and Dorsey (1975)
CFCs, water	Purge and trap gas chromatography	Bullister and Weiss (1988)
Oxygen-18, water	Equilibration with gaseous CO_2 and mass spectrometry	Epstein and Mayeda (1953)
Deuterium-2, water	Equilibration with hydrogen and mass spectrometry	Coplen and others (1991)

resampled and reanalyzed for VOCs in order to assess the persistence of VOCs in water from wells. Table 5 lists information about the methods used to analyze water samples.

Of the 32 wells, water samples were collected from 26 wells by using a portable submersible pump. Six wells with low yields were sampled by using a fluoropolymer bailer. Radon samples were not collected from the bailer because radon degases from the water in the bailer. CFC samples were collected by using copper tubing in place of fluoropolymer hose.

Sample collection began after purging several casing volumes and stabilizing field measurements (Koterba and others, 1995). Risk of sample contamination was minimized through the use of trace-level sampling protocols as described by Koterba and others (1995). CFCs were sampled by using techniques that were more stringent than the trace-level protocols used for sampling other constituents (J.E. Wayland, U.S. Geological Survey, written commun., 1994). Pesticide samples were delivered overnight to a local USGS office for solid phase extraction (SPE) then forwarded to the NWQL in Denver, Colorado. Major-ion, nutrient, trace-element, VOC, and radon samples were sent overnight to the NWQL. At the end of the sampling period, tritium samples were sent to the Isotope Tracer Laboratory in Menlo Park, California, and stable hydrogen and oxygen samples were sent to the Isotope Fractionation Laboratory in Reston, Virginia. CFC samples were sent to the CFC laboratory in Reston, Virginia, for analysis and interpretation of ground-water recharge dates. Ground-water quality data are listed in Appendix 2. Detections of VOCs and pesticides with concentrations below the lowest calibration standard were reported as estimated values (Connor and others, 1998).

Quality-Assurance Data Collection

Quality-assurance samples were collected at 12 locations and included field equipment blanks, source solution blanks, replicate samples, field-spiked samples, and a quality-assurance experiment. Field equipment blanks of VOCs were collected at four wells and at one equipment storage site. Field equipment blanks of major ions, nutrients, dissolved organic carbon (DOC), trace elements, and pesticides were collected at three wells, and one equipment storage site. Source solution blanks were collected with all nutrient field-equipment blanks and with two of the four DOC field-equipment blanks. Replicate samples of sediment were collected at one drilling site (UR-20) during the construction of one well. Replicate samples of major ions, nutrients, DOC, trace elements, and radon were collected at two wells. Samples were spiked in the field with pesticides and VOCs at three wells. A quality-assurance experiment also was conducted in September 1998 to determine the effectiveness of purging in rinsing residual VOCs from sampling equipment prior to sampling.

Data were statistically analyzed for quality-assurance purposes. Water from all wells had cation-anion balance errors of less than 10 percent. Data from blanks indicated that contamination from field equipment did not significantly contribute to the concentrations of constituents detected in water from wells, with the possible exceptions of nitrite, ammonia, DOC, aluminum, cobalt, copper, and zinc. The resulting detections of nitrite, ammonia, DOC, aluminum, cobalt, copper, and zinc in field-equipment blanks were used as a basis for increasing the reporting limit. Source solution blanks for VOCs indicated that the water used for equipment blanks often contained detectable concentrations of VOCs. Spike data indicated that most pesticides and all VOCs had recoveries between 60 and 140 percent. Some pesticides consistently had recoveries below 60 percent; these were aldicarb sulfone, aldicarb sulfoxide, chlorothalonil, dichlobenil, oryzalin, and cis-permethrin. A few pesticides had recoveries consistently above 140 percent; these were carbofuran, azinphos-methyl, simazine, and tebuthiuron. Ground-water quality assurance data are listed in Appendix 3.

Statistical Methods of Data Analysis

Data were statistically analyzed by using methods presented by Helsel and Hirsch (1992). Scatter plots and trilinear diagrams were used to graphically present the data. The parametric LOcally WEighted Scatterplot Smoothing (LOWESS) procedure was used to summarize relations on scatter plots (Cleveland, 1979). LOWESS lines are only a visual aid and do not confirm statistically significant relations. The nonparametric Wilcoxon rank-sum test was used to indicate the difference between groups of water samples collected from wells screened in the shallow water-table aquifer or the upper part of the Memphis aquifer. Sample sizes of groups of data were a maximum of 24 for shallow water-table aquifer wells and 8 for the upper part of the

Memphis aquifer wells. Statistical techniques accounted for the effects of small sample size on results. The medians of the groups were assumed to be significantly different from one another if the probability that the observed difference occurs by chance (p-value) was less than 5 percent (<0.05). Kendall's tau test was used to indicate the strength of monotonic correlation between concentrations of constituents in samples and site characteristics such as well depth or percent of a specific land use surrounding the well. As used in this report, one constituent or property is considered correlated to another if the p-value associated with the Kendall's tau test is less than 0.05. Some correlations with a p-value greater than 0.05 were presented if they were noteworthy.

GROUND-WATER QUALITY

Field Measurements

A summary of field measurements made during this study is listed in table 6. Water-level altitudes measured in the monitor wells indicate that water in the shallow water-table aquifer flows from high topographic areas towards major streams, and water in the upper part of the Memphis aquifer flows towards the city of Memphis. At the two nested sites, the water level in the two shallow wells was 58 ft higher than the water level in the two deep wells. Water from the monitor wells was mostly free of suspended sediment after purging, thus making turbidity fairly low (less than 200 Nephelometric turbidity units or NTU) with the exception of one well (UR-4). Dissolved oxygen was detected in water at concentrations at or above 0.1 mg/L in all but one of the monitor wells (UR-20). Specific conductance was greater in water from monitor wells screened in the shallow water-table aquifer than in water from monitor wells screened in the upper part of the Memphis aquifer (p-value = 0.032).

Field-measurement values measured in the monitor wells were similar to historical data for ground water in the Memphis vicinity (Parks and others, 1995; Parks and Mirecki, 1992).

Major Ions

Major ions usually determine some basic chemical characteristics of water such as taste and hardness. Calcium and magnesium contribute to hardness of water, which is an indicator of the water's ability to form insoluble residues with soaps and to form scale in plumbing features associated with heating water (Hem, 1985). Dissolved solids can affect suitability of water for drinking purposes. A summary of major-ion concentrations in ground water collected from the 32 monitor wells during this study is listed in table 7. Sodium, calcium, and magnesium were the principal cations in water from the monitor wells, averaging 36, 35, and 27 percent of the cation equivalents, respectively. Bicarbonate was the principal anion averaging 88 percent of the anion equivalents (table 7; fig. 4). Water from 17 wells was predominantly a sodium bicarbonate type water, whereas water from 12 wells was predominantly a calcium-magnesium bicarbonate type water. Despite the dominance of bicarbonate in water from the monitor wells, water from two wells was predominantly a sodium chloride type water, and water from one other well was predominantly a sodium mixed anion type water. In water from the two wells where chloride was the major anion, chloride was slightly more dominant than bicarbonate. Chloride concentration in these two wells was much higher than the chloride concentration in the other wells.

The calcium (Ca) to magnesium (Mg) equivalent ratio was about 1.2, with little variation, for water from most monitor wells. This Ca/Mg ratio can be seen on the cation trilinear diagram of figure 4 as an almost linear distribution of data points. Calcium concentrations correlated to magnesium concentrations with a Kendall's tau of +0.87 and a p-value of <0.0001. Calcium and magnesium concentrations are expected to be correlated because they are chemically similar and commonly have similar sources. Chloride (Cl) concentrations in all monitor wells correlated to bromide (Br) concentrations with a Kendall's tau of +0.58 and a p-value of <0.0001 (fig. 5). The Br/Cl ratio averaged 0.0203, with little variation, in water from seven monitor wells screened in the shallow water-table aquifer and having concentrations of chloride greater than 20 mg/L. The similar Br/Cl equivalent ratios for wells with elevated chloride concentrations (greater than 20 mg/L) indicate that a common source may be contributing both chloride and bromide to water in the shallow water-table aquifer. Water from one well had dissolved solids concentrations greater than the secondary standard (formerly known as the secondary maximum contaminant level or SMCL) of 500 mg/L set by the U.S.

Table 6. Summary of field-measurement data for water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[NTU, Nephelometric turbidity units; >, greater than; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mg/L,milligrams per liter]

Field parameter	Units	Minimum	Median	Maximum
Depth to water	Feet	8.3	31.1	99.8
Turbidity	NTU	0.8	8.9	>1,000
Water temperature	°C	16.5	19	22
pH	pH units	5.6	6.1	6.8
Specific conductance	µS/cm at 25 °C	76	234.5	1,000
Dissolved oxygen concentration	mg/L	<0.1	2.7	5.8
Alkalinity	mg/L as $CaCO_3$	19	77.5	287

Table 7. Summary of major-ion concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[Concentrations are in milligrams per liter. na, not applicable; <, less than]

Major constituents	Equivalents of cations and anions (average percent)	Concentrations (in milligrams per liter)		
		Minimum	Median	Maximum
Cations				
Sodium	36	6.4	17.5	122
Calcium	35	2.4	13.5	54
Magnesium	27	0.9	6.8	30
Potassium	1	0.2	1.1	4.6
Anions				
Bicarbonate, as HCO_3	88	26.8	90.8	335
Chloride	8	2.6	8.6	240
Sulfate	3	0.43	7.7	44
Bromide	<1	0.02	0.1	2.2
Fluoride	<1	<0.1	<0.1	0.32
Other				
Silica, as SiO_2	na	12	28	64
Dissolved solids residue at 180 °C	na	64	147	557

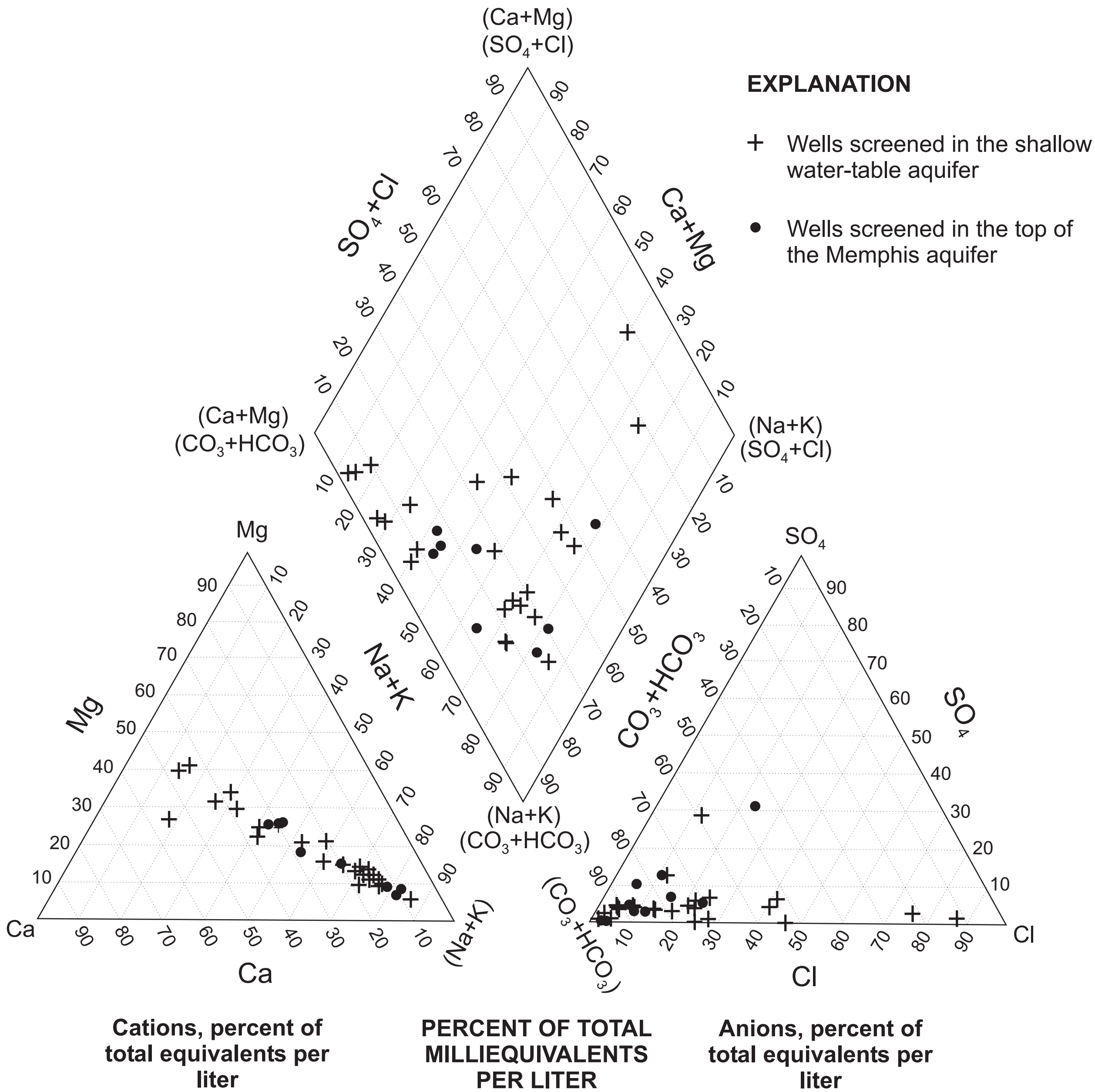


Figure 4. Piper diagram of the chemistry of water from 32 monitor wells, Memphis vicinity, Tennessee, 1997.

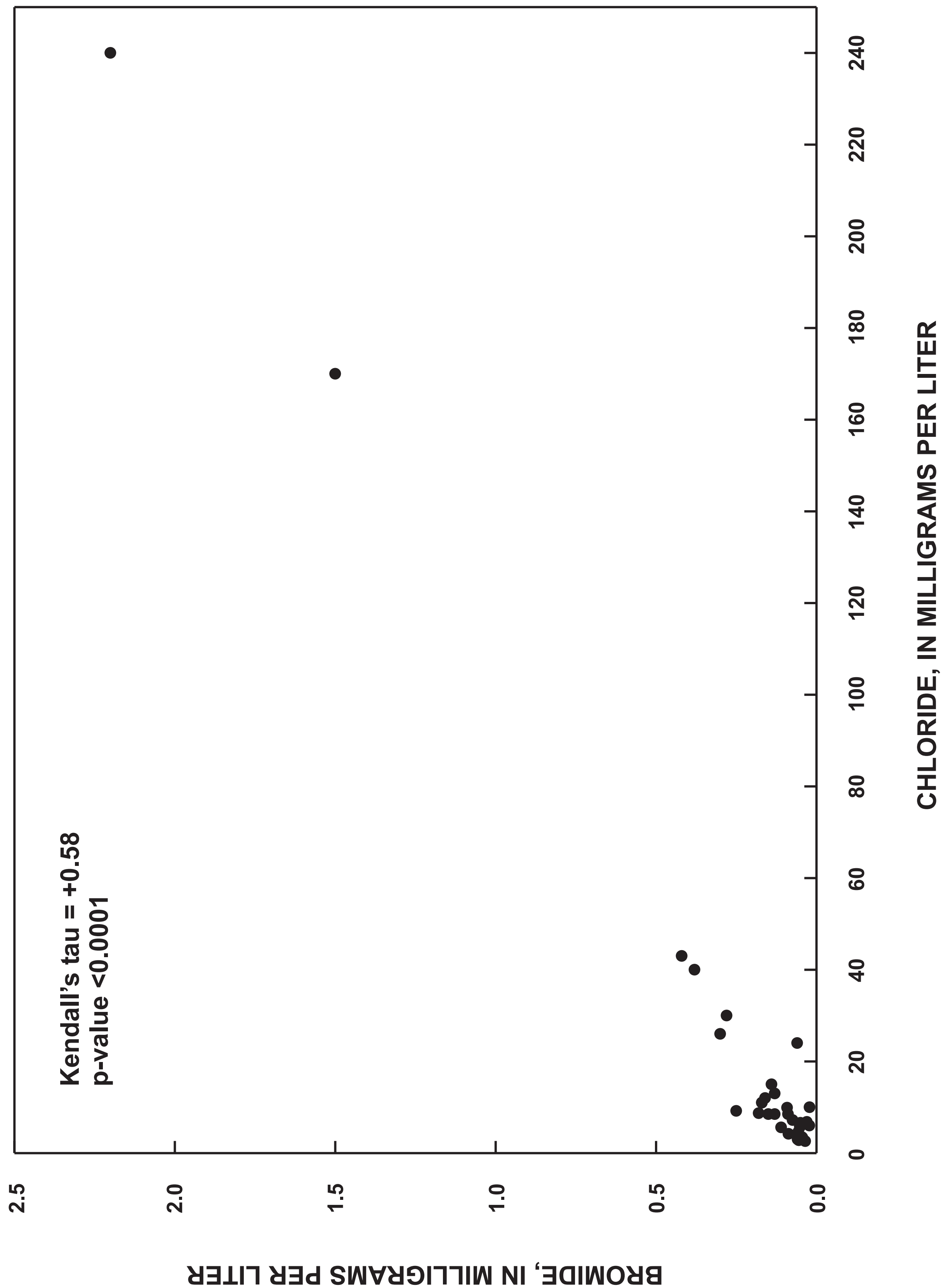


Figure 5. Relation of bromide concntrations with chloride concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997.

Environmental Protection Agency (1999). All other major ion concentrations were less than primary drinking-water standards or SMCLs. Dissolved solids concentrations are greater in water from monitor wells screened in the shallow water-table aquifer than in water from monitor wells screened in the upper part of the Memphis aquifer (p-value = 0.032).

Nutrients

Nutrients discussed in this report consist of the major chemical species of nitrogen and phosphorus. Nutrients can have an effect on human health. Some nutrients can have an association with other surface-derived contaminants. Nitrate and phosphorus in water can promote the growth of pathogens that may cause gastrointestinal-related illness. Elevated concentrations of nitrate in drinking water have been associated with methemoglobinemia or "blue-baby" syndrome and with increased rates of stomach cancer (Dorsch and others, 1984; Forman and others, 1985; Fan and others, 1987; National Research Council, 1985).

Ground-water samples were analyzed for nitrite, nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, phosphorus, and orthophosphate. Nutrients were present in low concentrations in water from monitor wells in the study area (table 8). No nutrient concentration exceeded a primary standard. The most frequently detected nutrient was nitrite plus nitrate nitrogen, which was detected in water from 19 of the 32 monitor wells. Nitrite plus nitrate nitrogen was also the nutrient with the greatest concentration (6.18 mg/L). Fewer detections of ammonia plus organic nitrogen (5 detections) than detections of ammonia nitrogen (13) in water from monitor wells in the study area is possibly a result of a greater detection limit for ammonia plus organic nitrogen (0.2 mg/L) than for ammonia nitrogen (0.015 mg/L). Only three concentrations of ammonia were at or above the ammonia plus organic nitrogen detection limit of 0.2 mg/L. Nitrite plus nitrate nitrogen concentrations are higher in wells with elevated dissolved oxygen concentrations (greater than or equal to 0.5 mg/L) than in wells without elevated dissolved oxygen concentrations (p-value = 0.0026). This would be expected because nitrate is the most naturally oxygenated of nitrogen species, and nitrate as a surface contaminant would reside with dissolved oxygen from the atmosphere. Nitrate plus nitrite nitrogen concentrations were significantly greater in water from wells screened in the shallow water-table aquifer than in water from wells screened in the upper part of the Memphis aquifer (p-value = 0.01).

Trace Elements

Trace elements analyzed in water samples from the monitor wells included: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, uranium, and zinc. This diverse group of constituents is generally categorized as metals that naturally occur in ground water at concentrations significantly less than the natural concentrations of major ions in ground water. Some trace elements such as barium, manganese, and iron are more abundant than the other trace elements, and are sometimes included in discussions of the major ions.

A wide range of toxicity can be associated with different trace elements. The human body needs iron, copper, manganese, and zinc in trace quantities, but larger amounts of these elements in the body may be toxic. Other trace elements such as arsenic and cadmium are toxic even at trace quantities in the human body. Some of the more toxic trace elements are cumulative, systemic poisons that can be categorized as carcinogens. Chronic exposure to certain trace elements can cause damage to the digestive, respiratory, and nervous systems (Sittig, 1985). The U.S. Environmental Protection Agency (2000a) has set primary standards for most trace elements. Iron and manganese can cause staining to plumbing and laundry; for these and other aesthetic reasons, the U.S. Environmental Protection Agency (2000b) has set secondary standards for iron and manganese.

Trace element concentrations in water from monitor wells are summarized in table 9. Of the 18 analyzed trace elements, 11 were detected in water from monitor wells. Barium, manganese, chromium, iron, and nickel were detected in water from 29 or more of the 32 monitor wells. Six other trace elements were detected in water from two or more monitor wells: zinc, cobalt, arsenic, selenium, aluminum, and molybdenum. The greatest concentration of a trace element was 6,670 μg/L for manganese. The greatest median concentration was 84 μg/L for barium. Manganese and barium were detected in water from all 32 monitor wells. Trace element concentrations did not exceed

Table 8. Summary of nutrient concentrations in water from 32 monitor wells and primary drinking-water standards, Memphis vicinity, Tennessee, 1997

[Concentrations are in milligrams per liter; <, less than; Primary drinking-water standards are from the U.S. Environmental Protection Agency (2000); --, no primary drinking-water standard established]

Constituent	Reporting limit	Number of detections	Median	Maximum concentration	Primary drinking water standard
Nitrite as N	0.01	2	<0.01	0.013	1
Nitrite plus nitrate as N	0.05	19	0.33	6.18	10
Ammonia as N	0.015	13	<0.015	0.94	--
Ammonia plus organic nitrogen as N	0.2	5	<0.2	0.88	--
Phosphorus	0.01	11	<0.01	0.083	--
Orthophosphate as P	0.01	13	<0.01	0.085	--
Organic carbon	5.0	0	<5.0	<5.0	--

Table 9. Summary of trace-element concentrations in water from 32 monitor wells and drinking water standards, Memphis vicinity, Tennessee, 1997

[Concentrations are in micrograms per liter; Drinking water standards are from U.S. Environmental Protection Agency (2000); --, no drinking water standard established; <, less than]

Constituent	Reporting limit	Number of detections	Median	Maximum concentration	Standards for drinking water
Barium, Ba	1	32	84	474	2,000[a]
Manganese, Mn	1	32	57.5	6,670	50[b]
Chromium, Cr (total)	1	31	4	7.9	100[a]
Iron, Fe	5	30	18	5,300	300[b]
Nickel, Ni	1	29	2	8.8	--
Zinc, Zn	6	12	<6	59	5,000[b]
Cobalt, Co	2	8	<2	7.5	--
Arsenic, As	1	6	<1	2	50[a]
Selenium, Se	1	5	<1	4	50[a]
Aluminum, Al	5	4	<5	5.2	50[b]
Molybdenum, Mo	1	2	<1	1.6	--
Copper, Cu	2	0	<2	<2	1,300[a]
Antimony, Sb	1	0	<1	<1	6[a]
Beryllium, Be	1	0	<1	<1	4[a]
Cadmium, Cd	1	0	<1	<1	5[a]
Lead, Pb	1	0	<1	<1	15[a]
Silver, Ag	1	0	<1	<1	100[b]
Uranium, U	1	0	<1	<1	--

[a] Primary Standard
[b] Secondary Standard

primary standards (table 9). Manganese concentrations in water from 16 wells exceeded the secondary standard of 50 µg/L. Iron concentrations in water from eight monitor wells exceeded the secondary standard of 300 µg/L.

Iron and zinc concentrations were significantly greater in water from monitor wells screened in the upper part of the Memphis aquifer than in water from monitor wells screened in the shallow water-table aquifer (p-values for iron and zinc were 0.02 and 0.04, respectively). Arsenic was detected in water from 3 of 8 monitor wells screened in the upper part of the Memphis aquifer, and in water from 3 of 24 monitor wells screened in shallow water-table aquifer. Chromium concentrations were greater in water from monitor wells screened in the shallow water-table aquifer than in water from monitor wells screened in the upper part of the Memphis aquifer (p-value = 0.024). Bicarbonate concentrations increased with increasing chromium concentrations (Kendall's tau = +0.26; p-value = 0.035). Nickel concentrations increased slightly with increasing chromium concentrations (Kendall's tau = +0.22; p-value = 0.08).

Pesticides

Pesticides in water supplies have been of interest since before 1972 when the manufacture and usage of DDT was banned in the United States. Pesticides can have adverse effects on health. Many pesticides are used today to control plants, insects, and fungi that inhibit the growth of crops, obscure rights-of-way, create a nuisance, and threaten human health. Pesticides have widely varying chemical and physical properties, and have a tendency to reside in the soil zone (Hem, 1985). Herbicides are generally more soluble than other pesticides, and are more likely to infiltrate to the water table.

At least one of the 85 analyzed pesticide compounds was detected in water from 24 of the 32 monitor wells sampled in the study area. Twenty-six pesticide compounds (24 herbicides and 2 insecticides) were detected (table 10). Atrazine and simazine, each detected in water from 12 of the wells, were the most frequently detected herbicides. Atrazine was the only compound in this study to be detected at a concentration near to the primary drinking-water standard; the atrazine concentration (3.14 µg/L) in one sample from well UR-24 slightly exceeded the U.S.Environmental Protection Agency primary drinking-water standard of 3.00 µg/L. Metolachlor was detected in water from 10 wells. Deethylatrazine, a degradation product of atrazine, was detected in water from eight wells. Dieldrin, detected in water from two wells, was the most frequently detected insecticide. About 26 percent of all pesticide detections used for interpretations have estimated values (below the lowest calibration standard).

The greatest pesticide concentration was an estimated value of 15 µg/L of 2, 4-D, a widely used herbicide (table 10). Six other pesticides--picloram, dieldrin, atrazine, metolachlor, tebuthiuron, and dicamba--were detected at concentrations greater than 1 µg/L. Twelve pesticides, the largest number of pesticides detected in water from any of the monitor wells, were detected in water from well UR-24. No pesticides were detected in water from eight wells (UR-3, UR-4, UR-6, UR-9, UR-10, UR-19, UR-23, and UR-30). Of the 26 detected pesticide compounds (table 10), 12 pesticides were reported to have greater than 100 lb of active ingredient applied to land within Shelby County, Tennessee (table 2).

Concentrations of the four most frequently detected pesticide compounds correlated positively to each other. Atrazine concentrations increased with increasing concentrations of simazine, metolachlor, and deethylatrazine (Kendall's tau values were +0.50, +0.44, +0.57 and p-values were 0.014, 0.034, and 0.005, respectively). Simazine concentrations also increased with increasing deethylatrazine concentrations (Kendall's tau = +0.45 and p-value was 0.026). Seven of the eight wells with deethylatrazine detections also had atrazine detections. Eight of the 12 wells with simazine detections also had atrazine detections.

Pesticides were detected more often and at greater concentrations in water from monitor wells screened in the upper part of the Memphis aquifer than monitor wells screened in the shallow water-table aquifer. All of the monitor wells with no detections of pesticides were screened in the shallow water-table aquifer. Concentrations of atrazine, simazine, and metolachlor were greater in water from wells screened in the upper part of the Memphis aquifer than in water from wells screened in the shallow water-table aquifer (p-values for atrazine, simazine, and metolachlor were 0.049, 0.029, and 0.009, respectively). The number of different pesticides detected in water from the upper part of the Memphis aquifer decreased from south and southeast (UR-12, UR-22, UR-24, UR-25M, and UR-26) to northwest (UR-13M, UR-20, and UR-21).

Table 10. Summary of pesticide concentrations in water from 32 monitor wells and primary drinking-water standards, Memphis vicinity, Tennessee, 1997

[Concentrations are in micrograms per liter; Primary drinking-water standards are from U.S. Environmental Protection Agency (2000); E, estimated value]

Constituent	Reporting limit	Number of detections	Maximum concentration	Primary drinking-water standard	Pesticide type
Atrazine	0.001	12	3.14	3	Herbicide
Simazine	0.005	12	.41	4	Herbicide
Metolachlor	0.002	10	2.09	none	Herbicide
Deethylatrazine	0.002	8	.11	none	Herbicide[1]
Tebuthiuron	0.01	4	1.76	none	Herbicide
Metribuzin	0.004	4	.49	none	Herbicide
Bentazon	0.014	4	.12	none	Herbicide
Picloram	0.05	3	E4	500	Herbicide
Dieldrin	0.001	2	3.2	none	Insecticide
Fenuron	0.013	2	.57	none	Herbicide
Bromacil	0.035	2	.27	none	Herbicide
Diuron	0.02	2	.19	none	Herbicide
Acetochlor	0.002	2	.12	none	Herbicide
Pendimethalin	0.004	2	.084	none	Herbicide
2, 4-D	0.035	1	E15	70	Herbicide
Dicamba	0.035	1	E1.5	none	Herbicide
Alachlor	0.002	1	.15	2	Herbicide
Fluometuron	0.035	1	.11	none	Herbicide
Carbofuran	0.003	1	E0.09	40	Insecticide
Cyanazine	0.004	1	.089	[2]1	Herbicide
Prometon	0.018	1	.051	none	Herbicide
Thiobencarb	0.002	1	.036	none	Herbicide
EPTC (Eptam)	0.002	1	.02	none	Herbicide
Trifluralin	0.002	1	.014	none	Herbicide
Propanil	0.004	1	.005	none	Herbicide
DCPA (Dacthal)	0.002	1	E0.001	none	Herbicide

[1] A degradation product of triazine herbicides, primarily atrazine

[2] Drinking-water goal

Surface water from the Fletcher Creek watershed within the study area was sampled for pesticides from 1996-97 (table 11). Pesticide concentrations were generally greater in surface water from Fletcher Creek than in ground water from the monitor wells. Atrazine, simazine, metolachlor, deethylatrazine, tebuthiuron, and metribuzin had abundant (greater than 30 percent of the samples) to moderate (between 12 and 30 percent of the samples) detections in both surface water and ground water. Bentazon had moderate detections in ground water but no detections in surface water, whereas chlorpyrifos, diazinon, carbaryl, malathion, pronamide, MCPA, trichlopyr, benfluralin, dichlorprop, and molinate had abundant to moderate detections in surface water but no detections in ground water.

Volatile Organic Compounds

Volatile organic compounds are highly soluble, mobile, persistent in ground water, and many are suspected carcinogens (Lapham and Tadayon, 1996). Many commonly used substances such as gasoline, refrigerants, paint products, and plastics contain VOCs. Samples collected for this study were analyzed for VOCs with a minimum reporting level as low as nanograms per liter (0.005 µg/L). These very sensitive analyses increase the chances of detecting VOCs in ground water and also increased the chances of detecting VOCs originating from extraneous sources (such as contamination during the sample process). As a result, the interpretation of quality-assurance data is especially important in the interpretation of the VOC results.

At least one of the 87 analyzed VOCs was detected in water from 31 of the 32 monitor wells in the study area. A total of 27 VOCs were detected in ground water (table 12). This report uses common VOC names. The International Union of Pure and Applied Chemistry (IUPAC) conventional names for VOCs are provided in table 13.

Table 11. Pesticide occurrence in water from 32 monitor wells in the Memphis vicinity (ground water) compared to water in Fletcher Creek (surface water), Memphis, Tennessee, 1996-97

	Not detected (surface water) 0 of 25 samples	Rare (surface water) 1 - 2	Moderate (surface water) 3 - 7	Abundant (surface water) 8 - 25
Abundant (ground water) 10 -32				Atrazine Simazine Metolachlor
Moderate (ground water) 4-9	Bentazon			Deethylatrazine Tebuthiuron Metribuzin
Rare (ground water) 1-3	Picloram Dieldrin Fenuron Bromacil Fluometuron	Dicamba Carbofuran Thiobencarb	Acetochlor Alachlor Cyanazine EPTC (Eptam) Propanil DCPA (Dacthal)	Diuron Pendimethalin 2,4-D Prometon Trifluralin
Not detected (ground water) 0 of 32 wells		p, p’ DDE Methylparathion Acifluorfen Methylazinphos	Trichlopyr Benfluralin Dichlorprop Molinate	Chlorpyrifos Diazinon Carbaryl Malathion Pronamide MCPA

Table 12. Summary of volatile-organic-compound (VOC) concentrations in water from 32 monitor wells and primary drinking-water standards, Memphis vicinity, Tennessee, 1997

[Concentrations are in micrograms per liter. Primary drinking-water standards are from U.S. Environmental Protection Agency (2000); THM, trihalomethanes; BTEX, a group of gasoline compounds, benzene, toluene, ethylbenzene, and total xylenes; TMB, trimethylbenzenes; CFC, chlorofluorocarbons; E, estimated value below lowest calibration standard]

Constituent	Qualitative reporting limit	Number of detections	Maximum concentration	Primary drinking-water standard	VOC type
Carbon disulfide	0.05	14	0.157	none	Miscellaneous
Chloroform	0.05	12	2.06	[1]100	Halogenated alkane-THM
m- and p-xylenes	0.05	12	E0.05	[2]10,000	Alkyl benzene-BTEX
Tetrachloroethene	0.05	7	0.443	5	Halogenated alkene
Toluene	0.05	7	0.282	1,000	Alkyl benzene-BTEX
Chloromethane	0.2	6	E0.06	none	Halogenated alkane
1, 2, 4-trimethylbenzene	0.05	6	E0.02	none	Alkyl benzene-TMB
1, 3, 5-trimethylbenzene	0.05	6	E0.01	none	Alkyl benzene-TMB
Benzene	0.05	5	E0.01	5	Aromatic hydrocarbon
1, 1-dichloroethane	0.05	4	0.201	none	Halogenated alkane
Dichlorodifluoromethane	0.2	3	E0.3	none	Halogenated alkane-CFC-12
1, 2, 3-trimethylbenzene	0.05	3	E0.01	none	Alkyl benzene-TMB
1, 1-dichloroethene	0.1	2	E0.07	7	Halogenated alkene
Trichloroethene	0.05	2	E0.05	5	Halogenated alkene
1, 1, 1-trichloroethane	0.05	2	E0.03	200	Halogenated alkane
o-xylene	0.05	2	E0.01	[2]10,000	Alkyl benzene-BTEX
1, 4-dichlorobenzene	0.05	2	E0.01	75	Halogenated benzene
Acetone	5	1	E0.6	none	Ketone
cis-1, 2-dichloroethene	0.05	1	0.566	70	Halogenated alkene
Trichlorofluoromethane	0.1	1	0.233	none	Halogenated alkane-CFC-11
Di-isopropylether	0.1	1	E0.03	none	Ether
Chloroethane	0.1	1	E0.02	none	Halogenated alkane
MTBE	0.1	1	E0.02	none	Ether
trans-1, 2-dichloroethene	0.05	1	E0.01	100	Halogenated alkene
Bromodichloromethane	0.1	1	E0.01	[1]100	Halogenated alkane-THM
Ethylbenzene	0.05	1	E0.01	700	Alkyl benzene-BTEX
Chlorobenzene	0.05	1	E0.003	100	Halogenated benzene

[1]Primary drinking-water standard for the total trihalomethanes

[2]Primary drinking-water standard for the total xylenes

Table 13. Names of volatile organic compounds used in this report and International Union of Pure and Applied Chemistry (IUPAC) conventional names

[CAS, Chemical Abstracts Service]

Name used in this report	IUPAC conventional names	CAS registry number	Other common names
Carbon disulfide	Dithiocarbonic anhydride	75-15-0	Carbon bisulfide
Chloroform	Trichloromethane	67-66-3	
m- and p-xylenes	1,3- and 1,4-Dimethylbenzene	108-38-3 and 106-42-3	
Tetrachloroethene	Tetrachloroethene	127-18-4	Perchloroethylene
Toluene	Methyl benzene	108-88-3	Phenylmethane
Chloromethane	Chloromethane	74-87-3	Methyl chloride
1, 2, 4-trimethylbenzene	1, 2, 4-Trimethylbenzene	95-63-6	Pseudocumene
1, 3, 5-trimethylbenzene	1, 3, 5-Trimethylbenzene	108-67-8	Mesitylene
Benzene	Benzene	71-43-2	
1, 1-dichloroethane	1, 1-Dichloroethane	75-34-3	Ethylidene chloride
Dichlorodifluoromethane	Dichlorodifluoromethane	75-71-8	CFC-12
1, 2, 3-trimethylbenzene	1, 2, 3-Trimethylbenzene	526-73-8	Hemimellitene
1, 1-dichloroethene	1, 1-Dichloroethene	75-35-4	
Trichloroethene	1,1,2-Trichloroethene	79-01-6	
1, 1, 1-trichloroethane	1,1,1-Trichloroethane	71-55-6	Methyl chloroform
o-xylene	1,2-Dimethylbenzene	95-47-6	
1, 4-dichlorobenzene	1,4-Dichlorobenzene	106-46-7	p-dichlorobenzene
Acetone	2-Propanone	67-64-1	Dimethyl ketone
cis-1, 2-dichloroethene	*cis*-1,2-Dichloroethene	156-59-2	
Trichlorofluoromethane	Trichlorofluoromethane	75-69-4	CFC-11
Di-isopropylether	2,2’-Oxybis[propane]	108-20-3	Isopropyl ether
Chloroethane	Chloroethane	75-00-3	
MTBE	2-Methoxy-2-methylpropane	1634-04-4	tert-Butyl methyl ether
trans-1, 2-dichloroethene	*trans*-1, 2-Dichloroethene	156-60-5	
Bromodichloromethane	Bromodichloromethane	75-27-4	Dichlorobromomethane
Ethylbenzene	Ethylbenzene	100-41-4	Phenylethane
Chlorobenzene	Chlorobenzene	108-90-7	Monochlorobenzene
Trichlorotrifluoroethane	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	CFC-113

Carbon disulfide was the most frequently detected VOC; it was detected in water from 14 of the 32 monitor wells. Carbon disulfide is commonly used in manufacturing carbon tetrachloride, flotation agents, cellophane, and solvents, but also may originate naturally from the microbial reduction of sulfate under anoxic conditions (Howard, 1990). Chloroform and m- and p-xylenes were detected in water from 12 of the wells. Chloroform is used in industry but also is a by-product of chlorine disinfection of water that contains small amounts of organic carbon compounds; m- and p-xylenes are associated with paints, dye media, insecticides, resins, fibers, and motor fuels. Tetrachloroethene and toluene were detected in water from seven of the wells. Tetrachloroethene (also referred to as perchloroethylene or PCE) is used in dry cleaning solvents, metal surface cleaning agents, and vapor degreasing. Toluene is associated with fuel, paints, paint thinner, and glue. Chloroform had the greatest concentration (2.06 µg/L) of any VOC detected; cis-1, 2-dichloroethene had the second greatest concentration (0.566 µg/L). Water from four wells (UR-14, UR-16, UR-25M, and UR-28) had detections of eight different VOCs. Of the 27 detected VOCs (table 12), 11 were reported released to the environment in Memphis and Millington, Tennessee (table 3). VOC concentrations were below drinking-water standards, generally by several orders of magnitude (table 12). About 90 percent of the VOC detections used for interpretation have estimated values.

Some VOCs were areally distributed. The sum of VOC concentrations in water from wells screened in the upper part of the Memphis aquifer decreased from southeast to northwest. Trimethylbenzene compounds were detected in six wells screened in the shallow water-table aquifer in the northeastern part of the study area (the six wells were UR-14, UR-16, UR-18, UR-19, UR-29, and UR-30). Chlorofluorocarbons (CFCs) were detected in four wells screened in the shallow water-table aquifer in the northern and northeastern part of the study area (the four wells were UR-6, UR-8, UR-29, and UR-30). Trihalomethane concentrations (sum of chloroform and bromodichloromethane concentrations) were greatest in water from three wells screened in the shallow water-table aquifer in Bartlett (UR-14, UR-15, and UR-17).

The number of different VOCs detected in water from wells screened in the shallow water-table aquifer increased with increasing depth to water (Kendall's tau = +0.37; p-value = 0.012; fig. 6). Concentrations of m- and p-xylenes also increased with increasing depth to water (Kendall's tau = +0.38; p-value = 0.011; fig. 6). Carbon disulfide concentrations were greater in water from wells screened in the upper part of the Memphis aquifer than in water from wells screened in the shallow water-table aquifer (p-value = 0.008). Concentrations of carbon disulfide decreased with increasing concentrations of chromium (Kendall's tau = -0.35; p-value = 0.006; fig. 7).

Some VOC concentrations correlated to the amount of pumping that occurred at the well. Carbon disulfide concentrations decreased with increasing volumes of water pumped to develop or purge each well (Kendall's tau values for development and purge were both -0.33; p-values for development and purge were both 0.009). Toluene concentrations decreased with increasing volumes of water pumped to develop each well (Kendall's tau = -0.25; p-value = 0.05). Decreases in VOC concentration with increases in the volume of water pumped during the development and purge of the wells can be related to: 1) residual VOCs that may be associated with well installation such as drilling activities or polyvinyl chloride (PVC) casing, and 2) changes in the ground-water flow pattern surrounding the well during the time in which the well is being pumped. The extent of pumping may alter ground-water flow patterns in such a way that VOC concentrations may be lowered during pumping.

Five wells were resampled for VOCs in spring 1997 and September 1998 in order to determine the persistence of VOCs in ground water in the study area (table 14). Results indicate that VOC detections were variable from one year to the next, with the exception of chloroform (table 14). Trimethylbenzenes, xylenes, benzene, and 1, 4-dichlorobenzene were detected in 1997 but were not detected in 1998. Toluene was detected in 1998 but was not detected in 1997. Chloroform was detected in the same two wells in both 1997 and in 1998. In 1998, dichlorodifluoromethane (CFC-12), and trichlorofluoromethane (CFC-11) were not detected in the VOC analyses but were detected at extremely low concentrations in CFC analyses (see section on dating parameters).

Surface water from the Fletcher Creek watershed within the study area was sampled for VOCs from 1996-97 (table 15). A greater number of VOCs were detected in ground water from the monitor wells than in surface water from the Fletcher Creek watershed. Carbon disulfide had frequent detections in both surface water and ground water. Also frequently detected in

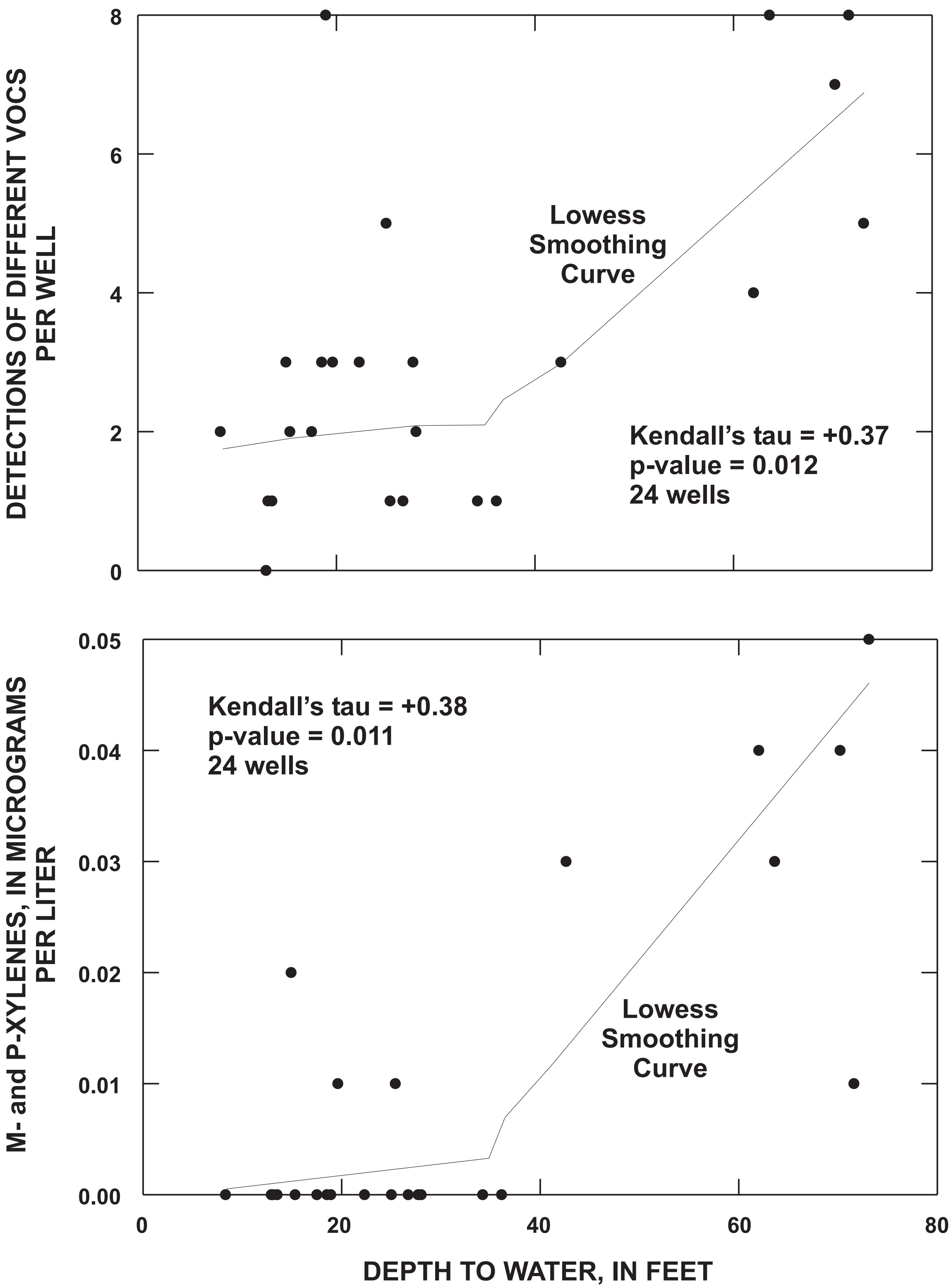


Figure 6. Relations of detections of different volatile-organic-compounds (VOCs) per well and m- and p-xylene concentrations with depth to water below land surface, at 24 monitor wells screened in the shallow water-table aquifer, Memphis vicinity, Tennessee, 1997.

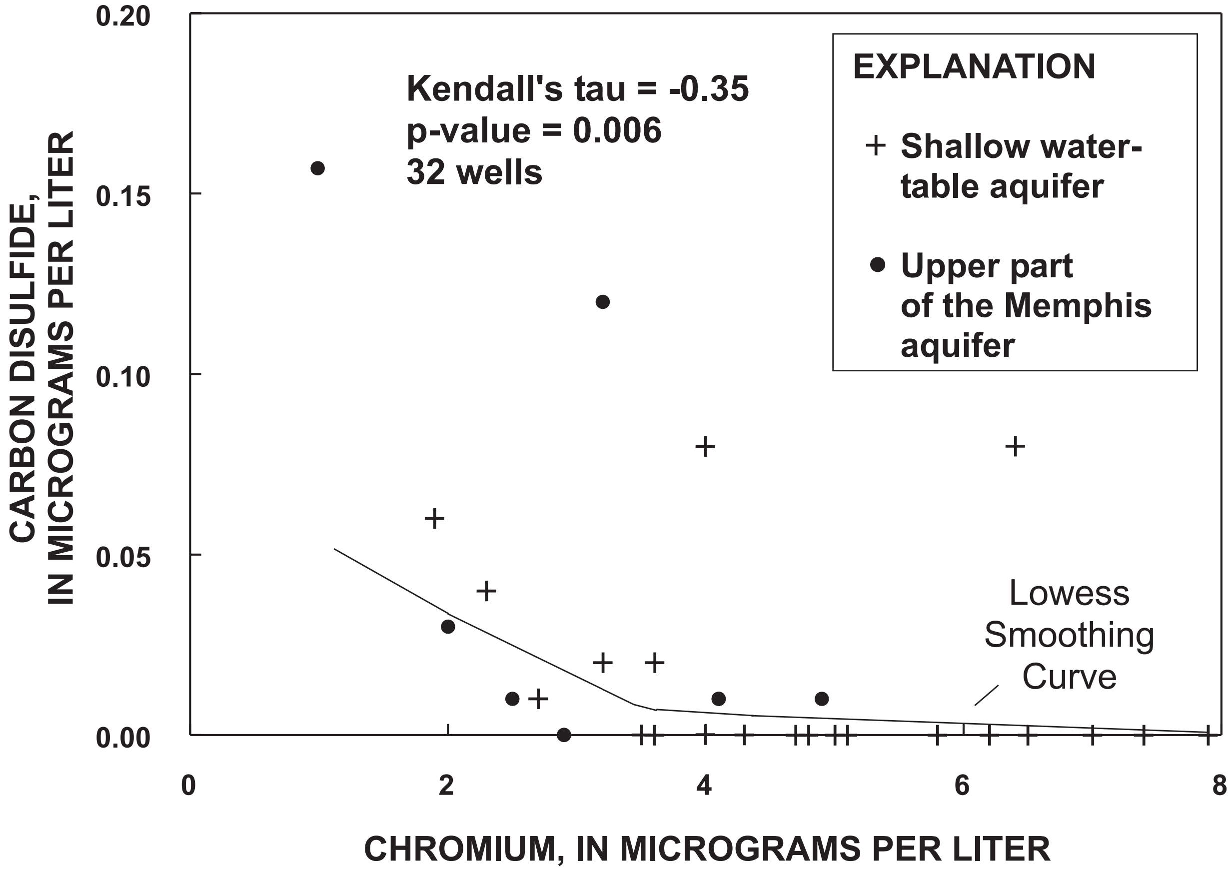


Figure 7. Relation of carbon disulfide concentrations with chromium concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997.

Table 14. Summary of volatile-organic-compound (VOC) concentrations in water from five resampled monitor wells, Memphis vicinity, Tennessee, Spring 1997 and September 1998

[Concentrations are in micrograms per liter; E, estimated value below lowest calibration standard; nd, VOC was analyzed for but was not detected by the Denver National Water-Quality Laboratory; concentrations in parentheses are from the Reston Chlorofluorocarbon laboratory.]

	Qualitative Detection limit		Monitor wells									
			UR-11		UR-16		UR-18		UR-29		UR-30	
Constituent	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Dichlorodifluoromethane (CFC-12)	0.2	0.14	nd	nd	nd	(0.0003)	nd	nd	E0.04	(0.0018)	E0.3	nd
Trichlorofluoromethane (CFC-11)	0.1	0.09	nd	nd	nd	(0.0053)	nd	nd	0.233	(0.0099)	nd	nd
Chloroform	0.05	0.052	nd	nd	E0.02	E0.057	nd	nd	E0.01	E0.01	nd	nd
Tetrachloroethene	0.05	0.1	nd	nd	E0.005	E0.0033	nd	nd	nd	nd	nd	nd
1, 4-dichlorobenzene	0.05	0.05	nd	nd	E0.006	nd	nd	nd	E0.01	nd	nd	nd
benzene	0.05	0.1	nd	nd	nd	nd	nd	nd	nd	nd	E0.01	nd
toluene	0.05	0.05	nd	nd	nd	E0.074	nd	nd	nd	E0.047	nd	nd
m- and p-xylenes	0.05	0.06	nd	nd	E0.03	nd	E0.04	nd	E0.04	nd	E0.05	nd
o-xylene	0.05	0.06	nd	nd	E0.01	nd	nd	nd	nd	nd	nd	nd
1, 2, 3-trimethylbenzene	0.05	0.12	nd	nd	E0.009	nd	E0.01	nd	E0.01	nd	nd	nd
1, 2, 4-trimethylbenzene	0.05	0.056	nd	nd	E0.01	nd	E0.02	nd	E0.02	nd	E0.02	nd
1, 3, 5-trimethylbenzene	0.05	0.044	nd	nd	E0.01	nd	E0.01	nd	E0.01	nd	E0.01	nd

Table 15. Volatile-organic-compound occurrence in water from 32 monitor wells, Memphis vicinity (ground water), 1997, compared to water in Fletcher Creek (surface water), Memphis, Tennessee, 1996-97

[TMB, trimethylbenzene; MIK, methyl isobutyl ketone. Chloroform, m- and p-xylene, 1,4-dichlorobenzene, acetone, methyl ethyl ketone, and tetrahydrofuran were not included in the comparison.]

	Not detected (surface water) 0 of 25 samples	Rare (surface water) 1 - 2	Moderate (surface water) 3 - 7	Abundant (surface water) 8 - 25
Abundant (ground water) 10 -32 of 32 wells				Carbon disulfide
Moderate (ground water) 4-9	Tetrachloroethene 1,1-dichloroethane		1,2,4-TMB 1,3,5-TMB Benzene	Toluene Chloromethane
Rare (ground water) 1-3	CFC-12 1,1-dichloroethene 1,1,1-trichloroethane cis-1,2-dichloroethene CFC-11 Di-isopropylether MTBE trans-1,2-dichloroethene Bromodichloromethane Ethylbenzene Chlorobenzene	Trichloroethene Chloroethane	1,2,3-TMB	
Not detected (ground water) 0		MIK Isopropylbenzene n-butyl benzene Isodurene Prehnitene	n-propy benzene o-ethyl toluene Napthalene	p-isopropyl toluene

both surface water and ground water were toluene, chloromethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and benzene. The compound p-isopropyl toluene had frequent detections in surface water but not in ground water.

Radioisotopes (Radium-226 and Radon-222)

Radium-226 and radon-222 are naturally occurring radioactive isotopes. Radium-226--produced by the decay of uranium-238--has a half-life of 1,620 years (Hem, 1985). Radon-222--produced by the decay of radium-226--has a half life of 3.8 days (Hem, 1985). Rocks and sediment commonly contain large enough concentrations of uranium to cause ground water to have significant concentrations of radium and radon (Rogers, 1958). Radium is soluble in ground water as a cation. Radon is soluble in ground water in the gas phase; hence, water with radon quickly degases when the water comes in contact with the atmosphere (Hem, 1985). Because radon and radium are radioactive, they can pose a health threat.

The U.S. Environmental Protection Agency (1999) set a primary drinking-water standard for radium-226 plus radium-228 of 5 picoCuries per liter (pCi/L). Radium-226 concentrations in water from the 13 monitor wells that were sampled ranged from 0.06 to 0.88 pCi/L (Appendix 2, table 2-13) with a median concentration of 0.33 pCi/L. The U.S. Environmental Protection Agency (1999) set a MCL for radon-222 of 300 pCi/L. At the time of the writing of this report (2001), this MCL is being proposed as a version of a primary drinking-water standard. Radon-222 in water from the 26 sampled monitor wells ranged from less than 80 to 928 pCi/L (Appendix 2, table 2-13) with a median concentration of 257 pCi/L. Water from 9 of 26 monitor wells had radon-222 concentrations greater than the proposed version of a primary drinking-water standard of 300 pCi/L. Radon-222 concentrations in water from the monitor wells were greater than radon-222 concentrations in water from public-supply wells in the deep Tertiary aquifers of the Mississippi Embayment Study Unit (Gonthier, 1999), which ranged from 54 to 270 pCi/L.

Age Dating Constituents (Tritium and Chlorofluorocarbons)

Tritium and chlorofluorocarbons (CFCs) were analyzed to date the water from the monitor wells. Based on both the tritium and CFC data, the average age of the water from most of the monitor wells in the study area was estimated to range from 10 to more than 43 years old. Tritium, a radioactive isotope of hydrogen with a half-life of 12.26 years (Faure, 1986), is produced naturally at very low concentrations in the atmosphere and is incorporated into precipitation. Because tritium is not produced after water infiltrates the soil, tritium can be used to help determine the presence of young ground water (less than about 43 years old in 1997) in a sample. Tritium concentration in water is measured in tritium units (TU); a tritium unit is equivalent to 1 tritium atom for every 10^{18} hydrogen atoms. The concentration of naturally produced tritium in rainwater in the Memphis area is only about 5 TU (International Atomic Energy Agency, 1995; Craig and Lal, 1961).

Nuclear weapons testing during the middle of the 20th century produced tritium amounts much greater than natural processes. Peaks of tritium concentration occurred in 1954 and in 1963 (Stewart and Farnsworth, 1968; International Atomic Energy Agency, 1995; Faure, 1986).

Mixing of older and younger ground water that is flowing through the subsurface will reduce the variation in tritium concentrations with age. Because of the variability in historical tritium concentrations and the mixing of ground water of different ages, it is difficult to specify a particular age date of a water sample based on the tritium concentration alone. The presence of tritium in ground water indicates that at least some of the water in a sample collected in 1997 was younger than 43 years old (circa 1954).

Tritium was detected in water from 30 of the 32 monitor wells in the study area (Appendix 2, table 2-13). Concentrations ranged from <0.31 to 14.4 TU with a median concentration of 5.8 TU. Tritium concentrations were greater in water from wells screened in the shallow water-table aquifer (median concentration of 6.9 TU) than in water from wells screened in the upper part of the Memphis aquifer (median concentration of 0.69 TU; p-value = 0.007).

Concentrations of some chemical constituents correlated to tritium concentrations. Potassium, barium, manganese, and iron concentrations in water from monitor wells decreased with increasing tritium concentrations (Kendall's tau values were -0.49, -0.43, -0.38, and -0.31, respectively; p-values were 0.0001, 0.0007, 0.002, and 0.01, respectively). Carbon disulfide concentrations in water from monitor wells also decreased with increasing tritium concentrations (Kendall's tau = -0.51; p-value = 0.007). The sum of pesticide concentrations in water from wells screened in the shallow water-table aquifer increased with increasing tritium concentrations (Kendall's tau = +0.35; p-value = 0.042).

CFCs are relatively stable VOCs that are used as refrigerants, aerosol propellants, cleaning agents, solvents, and blowing agents in the production of foam rubber and plastics. They were first manufactured in the 1930's and are not naturally occurring. Dating ground water by using CFCs is based on the known solubility of CFCs in water as a function of temperature and historical data on past atmospheric concentrations of CFCs. Three CFCs were analyzed for dating ground water: dichlorodifluoromethane (CFC-12), trichlorofluoromethane (CFC-11), and trichlorotrifluoroethane (CFC-113). Dating of ground water by using CFCs requires sample and analysis procedures that allow for a detection limit for CFCs of about 1 picogram per kilogram (pg/kg) (Busenberg and Plummer, 1992), which is about 0.001 ng/L. CFC concentrations in a water sample, average temperature of water during recharge [16.5 ^{o}C, the average annual air temperature in Memphis (U.S. National Climatic Data Center, 1999)], and atmospheric pressure (754 torr) are used to model the atmospheric concentrations of the three different CFCs at the time the sample water was recharged. The model atmospheric CFC concentrations are matched on a chart of historic (1940-98) atmospheric CFC concentrations. These matches are the model recharge dates listed in table 16. Model recharge dates for the 10 wells were determined by using average concentrations of CFC-11, CFC-12, andCFC-113 in triplicate samples. Results provide an average age of the ground water.

Ten wells were sampled for CFCs during September 1998 in order to date the water (table 16). CFC concentrations can be affected by contamination (addition of CFCs in excess of the amount dissolved in precipitation) or by degradation. CFC-113 appears to have contaminated most of the samples. CFC-11, in particular, degrades under anoxic conditions. The presence of nitrous oxide (N_2O) and low dissolved oxygen concentrations indicated the possible degradation of CFC-11 by bacteria in water from several wells. Consequently, CFC-12 concentrations became the compound most relied upon for CFC dating in this study. Samples with CFC concentrations too great to be used in the model are termed "contaminated" with CFCs (table 16). Large concentrations of CFCs have contaminated the samples of UR-16 and UR-29 so that modelled atmospheric CFC concentrations for these wells exceed actual atmospheric CFC concentrations in the past. CFC model recharge dates of other wells ranged from pre-1945 to 1986 (table 16). CFC concentrations that were within the range of the model may be a mixture of very old water (greater than 100 years) with contaminated water.

Stable Isotopes

Hydrogen and oxygen isotopes in water were used in this study to help verify that ground water came from recent, local precipitation. The important stable isotopes of the water molecule in stable-isotope hydrology are hydrogen (^{1}H), deuterium (^{2}H), oxygen-16 (^{16}O), and oxygen-18 (^{18}O). ^{2}H and ^{18}O are rare compared to ^{1}H and ^{16}O. The isotopic compositions of stable isotopes ^{2}H and ^{18}O are expressed in per mil units, or parts per thousand, as a deviation of the isotopic ratio relative to a reference standard, by using the delta notation (δ):

$$\delta = [(R\text{sample})/(R\text{reference}) - 1] \times 1,000$$

where R is the measured isotopic ratio. The delta symbol (δ) in this report is followed by the heavier isotope of the isotopic pair ^{2}H/^{1}H or ^{18}O/^{16}O. Per mil values in this report are presented relative to the standardized reference compound, Vienna Standard Mean Ocean Water (VSMOW) (Coplen, 1994). The more enriched a water sample is with ^{2}H or ^{18}O, the greater the per mil value will be for that water sample. Modern ocean water (for at least the last 50 years) usually has δ^{2}H and δ^{18}O values close to zero, relative to VSMOW. Most precipitation and ground-water samples have negative δ^{2}H and δ^{18}O values, relative to VSMOW (Craig, 1961).

Stable hydrogen and oxygen isotopes were analyzed in samples from 12 monitor wells in the study area (Appendix 2, table 2-13). The isotopic composition of water samples from all 12 wells was similar to the expected isotopic composition of modern precipitation in the study area. In water from monitor wells, δ^{2}H values ranged from about -32 to -28 per mil, and δ^{18}O values ranged from -5.4 to -5.1 per mil. The median δ^{2}H value of water from the wells (-29 per mil) was the same as the δ^{2}H value for meteoric water in the Memphis vicinity based on a map by Taylor and Margaritz (1978). The δ^{2}H and δ^{18}O values of water from the Memphis monitor wells plot along a line of δ^{2}H and δ^{18}O values of water from 17 public-supply wells screened in the deep Tertiary aquifers within the Mississippi Embayment (fig. 8; Gonthier, 1999). Both the Memphis monitor wells and the public-supply wells from Gonthier (1999) plot near the meteoric water line of Craig (1961).

LAND USE SURROUNDING MONITOR WELLS AND GROUND-WATER QUALITY

Agricultural, commercial, and residential areas can contribute nutrients and pesticides to ground water. Residential and commercial activities can prove to be significant local sources of VOCs. Roadways and railroads (rights-of-way) can be substantial sources for herbicides used in weed control and for VOCs spilled on the land surface or emitted into the air. Industrial

Table 16. Chlorofluorocarbon (CFC), tritium concentrations, and interpreted CFC recharge dates in water from 10 monitor wells, Memphis vicinity, Tennessee, September 1998

[Concentrations are in picograms per kilogram; Contam., CFC concentration was higher than the maximum possible concentration applicable to the CFC recharge model; ‘92/’96, recharge model yields two possible dates of 1992.5 and 1996.0; TU, tritium units; D.O., dissolved oxygen concentration; --, unable to interpret]

Well	Date sampled	Concentrations			Model ground-water recharge dates (years)			Comments by well	CFC interpreted ground-water recharge date	1997 Tritium (TU)
		CFC-11	CFC-12	CFC-113	CFC-11	CFC-12	CFC-113			
UR-3	1998 Sep 17	148	186	10	1971.5	1984.5	1975.0	Early 1980’s. Some N_2O present suggests possible degradation of CFC-11.	1983	3.8
		147	178	14	1971.0	1983.5	1977.5			
		130	166	17	1970.5	1982.5	1979.0			
UR-9	1998 Sep 17	129	115	164	1970.5	1975.5	Contam.	Mid 1970’s. High concentrations of N_2O. Degradation of CFC-11.	1975	5.9
		131	115	245	1970.5	1976.0	Contam.			
		132	107	240	1970.5	1975.0	Contam.			
UR-13S	1998 Sep 16	4	38	87	1953.0	1966.0	Contam.	Mid 1960’s. Low D.O., probable degradation of CFC-11. Trace N_2O.	1966	7.5
		4	39	67	1952.5	1966.5	1991.0			
		3	31	109	1952.5	1964.5	Contam.			
UR-16	1998 Sep 15	6470	343	27	Contam.	Contam.	1982.5	Age is uncertain. Highly contaminated with CFC-11. CFC-12 ground-water concentration is near modelled 1998 atmospheric concentration.	--	8.8
		5900	342	38	Contam.	Contam.	1985.5			
		4950	337	44	Contam.	Contam.	1986.5			
UR-16	1998 Sep 22	4390	305	154	Contam.	Contam.	Contam.	Contaminated with CFCs. High concentrations of N_2O.	--	8.8
		4450	293	199	Contam.	Contam.	Contam.			
		5730	303	188	Contam.	Contam.	Contam.			

Table 16. Chlorofluorocarbon (CFC), tritium concentrations, and interpreted CFC recharge dates in water from 10 monitor wells, Memphis vicinity, Tennessee, September 1998 (Continued)

Well	Date sampled	Concentrations			Model ground-water recharge dates (years)			Comments by well	CFC interpreted ground-water recharge date	1997 Tritium (TU)
		CFC-11	CFC-12	CFC-113	CFC-11	CFC-12	CFC-113			
UR-17	1998 Sep 15	357	246	51	1980.5	1992.5	1987.5	Late 1980's. Medium concentration of N_2O. Degradation of CFC-11 possible.	1989	8.1
		355	230	51	1980.5	1989.5	1988.0			
		333	219	51	1979.5	1988.0	1987.5			
UR-20	1998 Sep 22	5	15	37	1953.5	1959.0	1985.0	Mid 1950's.	1955	<0.31
		4	8	24	1953.0	1954.5	1981.5			
		6	8	31	1954.0	1954.5	1983.5			
UR-22	1998 Sep 16	282	179	46	1976.5	1984.0	1987.0	Mid 1980's. Medium concentration of N_2O. Possible degradation of CFC-11.	1984	7.2
		281	184	34	1976.5	1984.5	1984.5			
		274	181	7	1976.0	1984.0	1973.0			
UR-24	1998 Sep 16	2	2	44	1951.0	1947.0	1986.5	Contaminated with CFC-113.	--	<0.31
		2	1	70	1950.5	1944.0	'92/'96			
		4	<1	76	1953.0	1942.5	Modern			
UR-29	1998 Sep 22	9540	1800	100	Contam.	Contam.	Contam.	Highly contaminated with CFC-11 and CFC-12. High concentrations of N_2O; degradation of CFC-11.	--	10.9
		10080	1810	115	Contam.	Contam.	Contam.			
		9890	1860	130	Contam.	Contam.	Contam.			
UR-31	1998 Sep 16	1	1	30	1950.0	1943.5	1983.5	Old water. Sample contaminated with CFC-113.	--	5.3
		3	1	51	1952.0	1944.5	1987.5			
		2	1	60	1951.5	1945.5	1989.0			

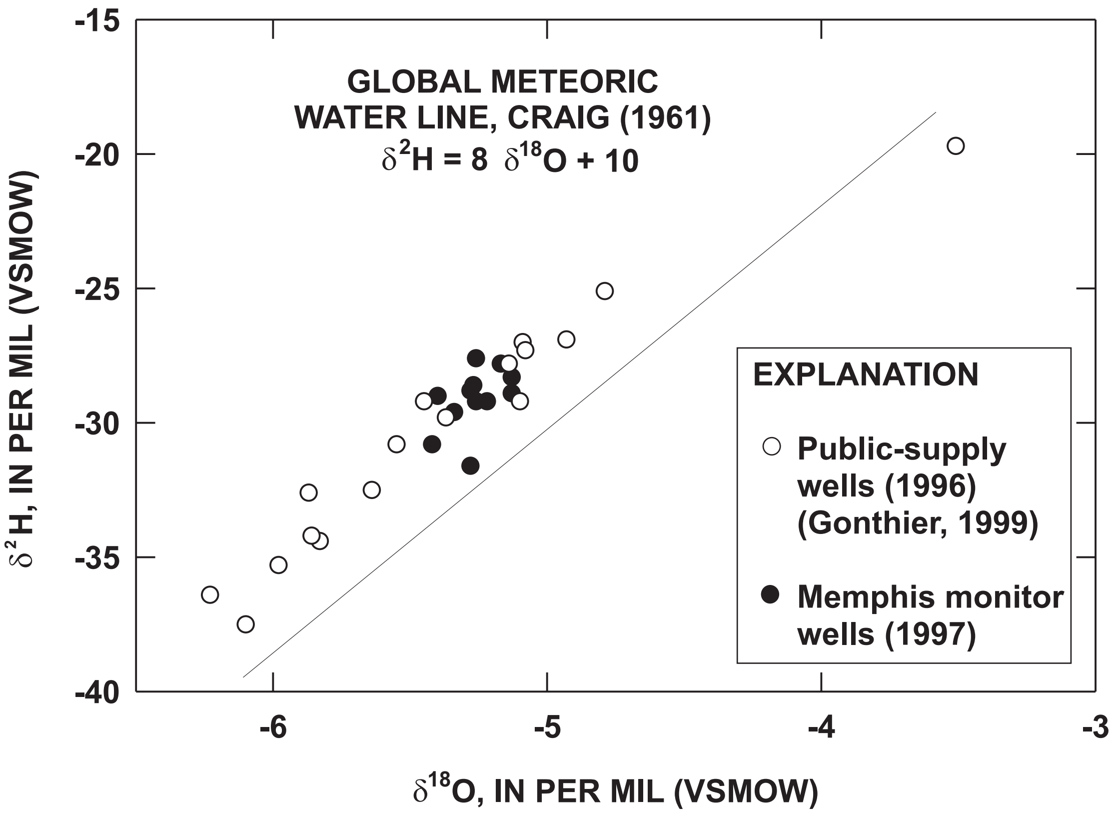


Figure 8. Relation of relative hydrogen isotopic ratio with oxygen isotopic ratios in water from 12 monitor wells, Memphis vicinity, Tennessee, 1997, and water from 17 public-supply wells screened in the deep Tertiary aquifers in the Mississippi Embayment, 1996.

activities can release metals, VOCs, and pesticides into the environment that can eventually enter shallow ground water. Commercial and industrial areas have underground storage tanks that may leak into shallow ground water. Mining for gravel and sand can remove the surficial confining unit and expose the shallow aquifer to the direct influx of contamination from surface sources.

Residential land use was the most abundant land use within 50 m of the wells, averaging 36 percent (table 17). Residential land use within 50 m of the wells was mostly single family homes with some apartment complexes and duplexes, driveways, yards, and sidewalks. Rights-of-way automotive-- mostly city and neighborhood streets along with paved or graveled shoulders--was the second most abundant land use within 50 m of the wells, averaging nearly 17 percent. Forest and vacant land were also important land uses averaging 11 and 9 percent, respectively. Forest land in the study area was primarily pine, oak, and other deciduous species greater than 20 years old. Vacant land consisted of cleared land holdings for sale or pending construction that was mowed at least once per year.

Table 17. Land-use percent within a 50-meter radius of each well, Memphis vicinity, Tennessee, January 1997

[--, this land use was not found within 50 m of this well; for calculating averages, -- equals zero and the sum of round numbers listed in the table is divided by the number of sites (30)]

Site number	Urban land use										Non-urban land use				
	Residential	Commercial-community	Industry	Vacant	Flood control	Parks (low development)	Parks (high development)	Automotive	Utilities	Construction	Agriculture	Range	Forest	Wetland	Water
UR-1	--	--	--	45	--	--	--	19	--	--	--	--	36	--	--
UR-2	25	--	--	--	--	--	--	5	--	--	--	13	57	--	--
UR-3	29	--	--	--	--	--	--	--	69	--	--	--	2	--	--
UR-4	67	--	--	--	12	--	--	21	--	--	--	--	--	--	--
UR-5	7	10	--	37	2	--	--	25	--	5	--	--	14	--	--
UR-6	57	--	--	14	--	--	--	29	--	--	--	--	--	--	--
UR-7	--	25	--	--	--	--	--	8	--	--	--	--	67	--	--
UR-8	44	--	--	--	--	--	--	21	--	--	16	--	19	--	--
UR-9	20	57	--	--	--	--	--	23	--	--	--	--	--	--	--
UR-10	77	--	--	--	--	--	--	20	1	2	--	--	--	--	--
UR-11	--	--	--	29	--	--	--	21	--	--	--	--	50	--	--
UR-12	1	36	--	49	--	--	--	14	--	--	--	--	--	--	--
UR-13[1]	--	--	--	--	--	59	--	10	--	--	--	--	31	--	--
UR-14	--	--	--	--	--	--	--	--	100	--	--	--	--	--	--
UR-15	56	--	--	--	--	--	--	21	23	--	--	--	--	--	--

Table 17. Land-use percent within a 50-meter radius of each well, Memphis vicinity, Tennessee, January 1997 (Continued)

	Urban land use										Non-urban land use				
Site number	Resid-ential	Com-mer-cial-com-munity	Indus-try	Vacant	Flood con-trol	Parks (low develop-ment)	Parks (high develop-ment)	Auto-motive	Utili-ties	Con-struc-tion	Agri-culture	Range	Forest	Wet-land	Water
UR-16	39	--	--	--	35	--	--	26	--	--	--	--	--	--	--
UR-17	--	--	--	--	9	86	--	5	--	--	--	--	--	--	--
UR-18	79	--	--	--	--	--	--	21	--	--	--	--	--	--	--
UR-19	46	--	--	--	--	--	--	23	31	--	--	--	--	--	--
UR-20	78	--	--	--	3	--	--	19	--	--	--	--	--	--	--
UR-21	23	--	--	35	--	8	--	23	--	--	--	--	--	--	11
UR-22	79	--	--	--	--	--	--	21	--	--	--	--	--	--	--
UR-23	59	--	--	--	--	41	--		--	--	--	--	--	--	--
UR-24	86	--	--	--	1	--	--	13	--	--	--	--	--	--	--
UR-25[1]	--	--	--	61	--	--	--	5	5	--	--	--	14	--	15
UR-26	57	--	--	--	--	8	--	35	--	--	--	--	--	--	--
UR-28	69	--	--	--	--	2	--	29	--	--	--	--	--	--	--
UR-29	81	--	--	--	--	--	--	19	--	--	--	--	--	--	--
UR-30	5	--	--	--	--	16	--	20	--	--	9	--	50	--	--
UR-31	--	81	--	--	--	--	--	19	--	--	--	--	--	--	--
Average	33.9	6.5	0	10.3	1.9	8.7	0	16.6	7.3	0.2	0.8	0.4	12.0	0	1.3

[1] A well nest of two wells resides at this site.

Residential land use was the most abundant land use within 500 m of the wells, averaging about 57 percent (table 18). Residential land use within 500 m of the wells was mostly single family homes with some apartment complexes, duplexes, mobile home parks, neighborhood streets, and small vacant lots. Forest was the second most abundant land use within 500 m of the wells, averaging about 13 percent. Commercial-community land use was also a substantial land use within 500 m of the wells averaging nearly 10 percent; commercial-community land use included gas stations, convenience stores, schools, churches, corporate offices, municipal offices, post offices, restaurants, car repair shops, strip malls, car dealerships, large retail and grocery stores, parking lots, and local streets between businesses.

Water-quality data from wells screened in the shallow water-table aquifer correlated to percent of land use within 50 and 500 m of the wells. Twelve correlations were significant between land use within 50 m of the wells and various water-quality constituents. Thirty correlations were significant between land use within 500 m of the wells and various constituents. The large number of correlation tests pertaining to land use within 50 m of the wells (7 land uses and about 25 constituents) would allow for about 12 significant correlations to occur by chance. The large number of correlation tests pertaining to land use within 500 m of the wells (6 land uses and about 25 constituents) would allow for about 7 or 8 significant correlations to occur by chance. Because the number of correlations between land use within 50 m of the wells and constituents are what would be expected by chance, these correlations are not discussed further. Many more correlations between land use within 500 m of the wells and constituents occurred than would be expected by chance, and several of these are discussed below.

Concentrations of chloride in water from wells increased with increasing percentages of urban land within 500 m of the wells (Kendall's tau value is +0.32 and p-value is 0.035). The number of different VOCs detected in wells and the sum of the concentrations of VOCs in wells increased with increasing urban land percentages within 500 m of the wells (Kendall's tau values are +0.32 and +0.31, respectively; p-values are 0.035 and 0.037, respectively). The relations of chloride and sum of VOCs with urban land-use percentages are shown in figure 9. Water preferentially recharges into the subsurface in topographically high areas and flows as ground water to low-lying areas (Freeze and Cherry, 1979). Urban development avoids low-lying flood-prone areas. As anthropogenic compounds, VOCs are likely to occur in recharge areas (topographically high areas) where there is urban development.

Concentrations of calcium, magnesium, bicarbonate, and fluoride increased with increasing percentages of forest land within 500 m of wells (Kendall's tau values are +0.28, +0.34, +0.52, and +0.49, respectively; p-values are 0.07, 0.026, 0.0007, and 0.001, respectively). The relation of bicarbonate concentrations with forested land use (fig. 10) is probably the result of forested land use being concentrated in low-lying flood-prone areas where urban development is negligible. Concentrations of major ions (including bicarbonate) will increase as ground water flows through the subsurface to the low-lying forested areas (general ground-water discussion in Freeze and Cherry, 1979).

Table 18. Land-use percent within a 500-meter radius of each well, Memphis vicinity, Tennessee, January 1997

[--, this land use was not found within 500 m of this well; for calculating averages, -- equals zero and the sum of rounded numbers as listed in the table is divided by the number of sites (30)]

	Urban land use										Non-urban land use				
Station number	Resid-ential	Com-mer-cial com-munity	Industry	Vacant	Flood control	Parks (low dev-elop-ment)	Parks (high dev-elop-ment)	Auto-motive	Utili-ties	Con-struc-tion	Agri-culture	Range	Forest	Wet-land	Water
UR-1	19	--	--	6	--	2	--	--	--	--	2	--	71	--	--
UR-2	30	15	--	7	--	--	--	--	--	12	--	--	36	--	--
UR-3	33	--	--	3	--	--	--	--	10	--	--	--	52	--	2
UR-4	78	--	--	6	--	--	--	--	--	--	--	--	15	--	1
UR-5	46	13	--	3	--	--	--	--	--	1	--	--	35	--	2
UR-6	54	12	--	7	--	--	--	--	--	--	--	--	27	--	--
UR-7	64	17	--	--	--	--	--	--	--	--	--	--	19	--	--
UR-8	44	--	--	--	--	--	--	--	--	6	24	--	22	--	4
UR-9	58	28	3	11	--	--	--	--	--	--	--	--	--	--	--
UR-10	45	--	--	--	--	31	--	--	10	--	--	--	14	--	--
UR-11	25	12.5	20	25	--	3	--	--	2	0.5	--	--	12	--	--
UR-12	50	39	--	8	--	--	--	--	--	--	--	--	3	--	--
UR-13[1]	--	34	--	---	--	18	--	3	14	--	--	--	28	--	3
UR-14	46	3	--	8	--	--	--	--	25	--	--	9	9	--	--
UR-15	76	14	--	3	3	--	--	--	--	--	--	--	4	--	--

Table 18. Land-use percent within a 500-meter radius of each well, Memphis vicinity, Tennessee, January 1997 (Continued)

	Urban land use										Non-urban land use				
Station number	Resid-ential	Com-mer-cial com-munity	Industry	Vacant	Flood control	Parks (low dev-elop-ment)	Parks (high dev-elop-ment)	Auto-motive	Utili-ties	Con-struc-tion	Agri-culture	Range	Forest	Wet-land	Water
UR-16	98	2	--	--	--	--	--	--	--	--	--	--	--	--	--
UR-17	76	6	--	6	3	2	--	--	--	--	--	--	7	--	--
UR-18	97	--	--	--	--	--	--	--	--	--	--	3	--	--	--
UR-19	38.5	7	4	25	--	--	13	0.5	8	--	--	--	4	--	--
UR-20	98	1	--	--	--	--	--	--	--	--	--	--	1	--	--
UR-21	40	7	11	18	--	--	--	8	--	--	--	--	--	6	10
UR-22	72	9	--	18	--	--	--	--	--	1	--	--	--	--	--
UR-23	86	2	--	3	--	4	--	--	--	--	--	--	1	4	--
UR-24	73	--	--	--	--	--	--	--	--	13	--	--	14	--	--
UR-25[1]	20	13	--	15	--	--	--	--	8	18	4	2	16	4	--
UR-26	93	1	--	--	--	--	6	--	--	--	--	--	--	--	--
UR-28	94	--	--	--	--	--	--	--	6	--	--	--	--	--	--
UR-29	76	4	--	14	--	--	--	--	--	4	--	--	2	--	--
UR-30	80	9	--	1	--	9	--	--	--	--	--	1	--	--	--
UR-31	10.5	42	3.5	12	--	--	--	6	--	--	--	--	8	18	--
Average	57.3	9.7	1.4	6.6	0.2	2.3	0.6	0.6	2.8	1.9	1.0	0.5	13.3	1.1	0.7

[1] A well nest of two wells resides at this site.

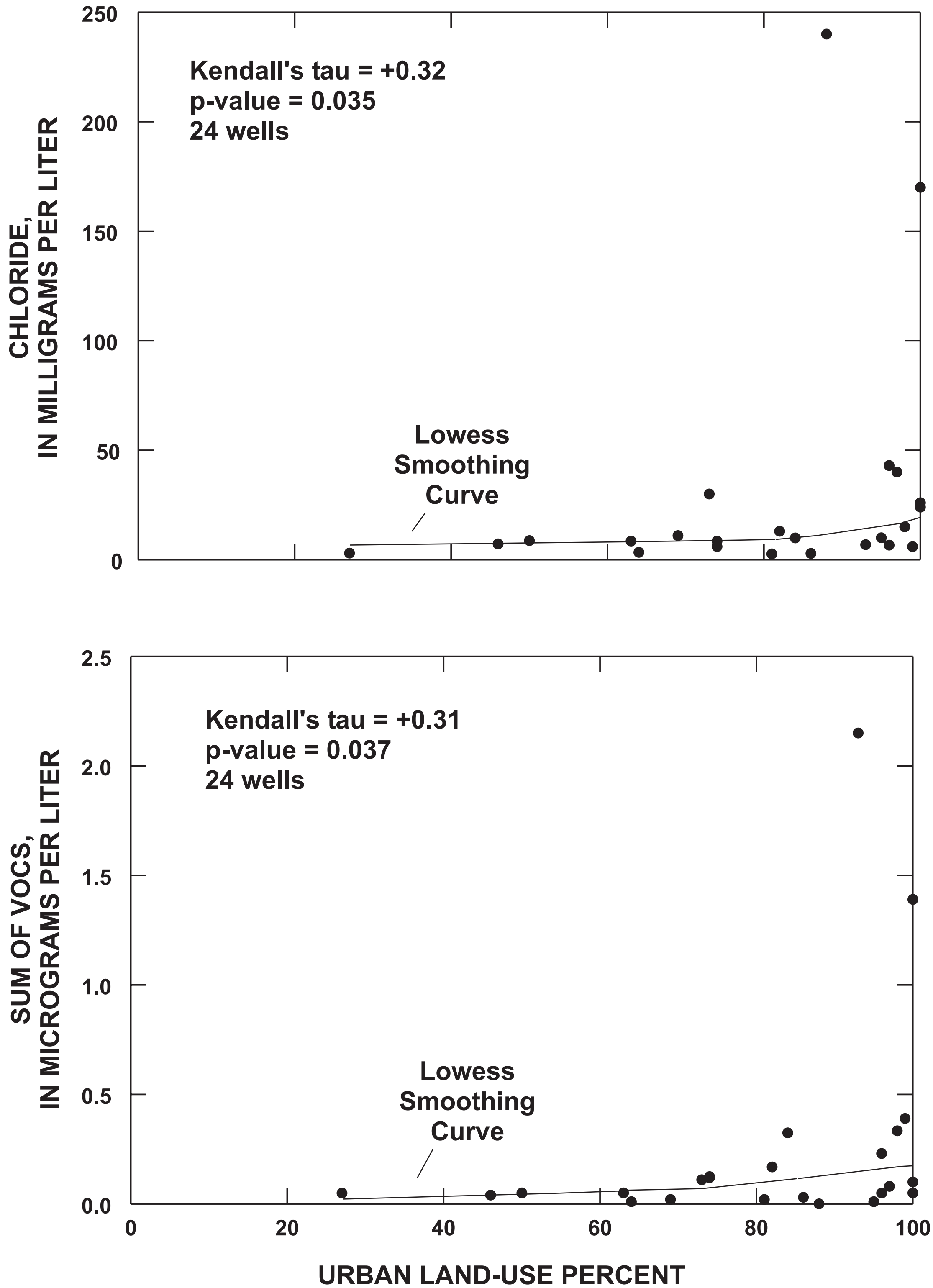


Figure 9. Relations of chloride and sum of volatile-organic-compounds (VOCs) concentrations in water with urban land-use percentages within 500 meters of 24 monitor wells screened in the shallow water-table aquifer, Memphis vicinity, Tennessee, 1997.

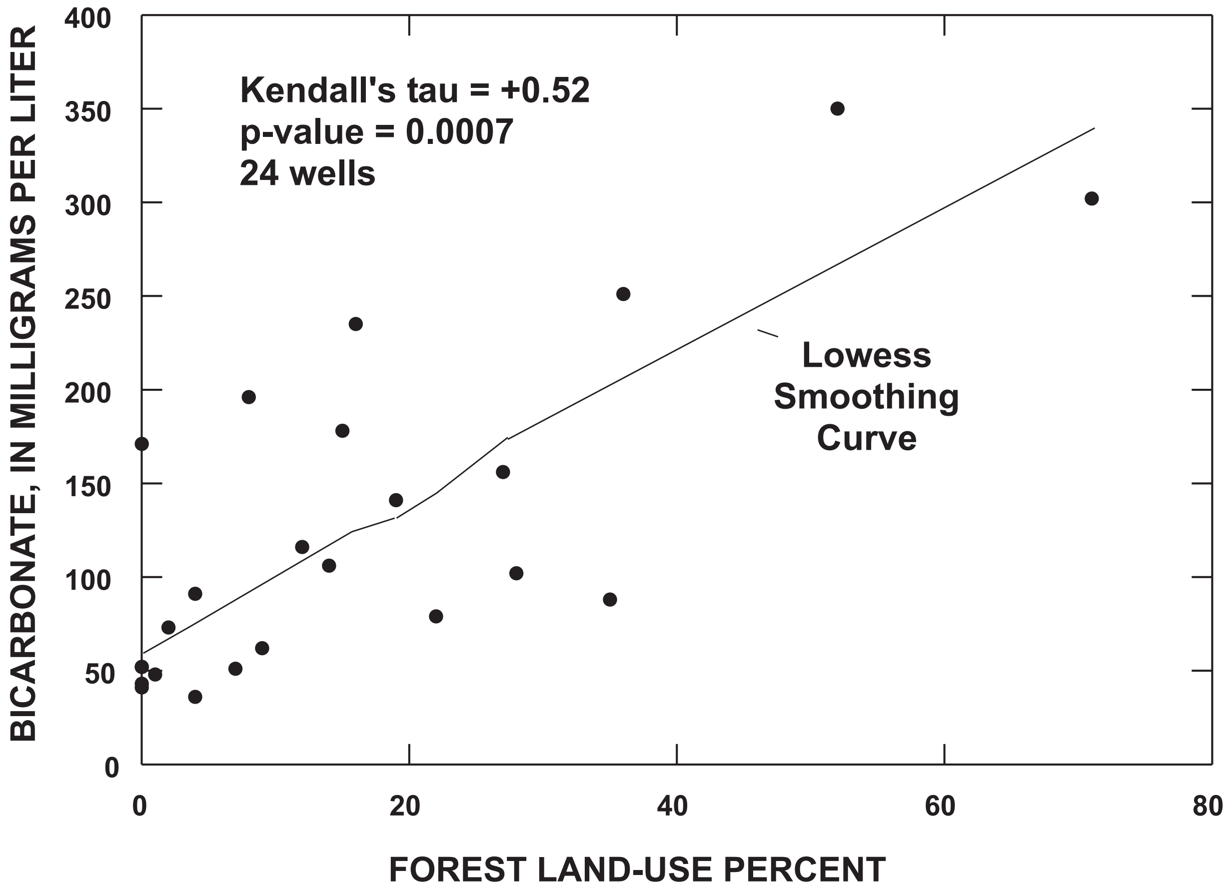


Figure 10. Relation of bicarbonate concentration in water with forest land-use percentages within 500 meters of 24 monitor wells screened in the shallow water-table aquifer, Memphis vicinity, Tennessee, 1997.

SUMMARY

In 1991, the U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) Program to provide a description of the Nation's ground- and surface-water resources. The Mississippi Embayment study unit is one of 17 study units that began in 1994. Ground water from the Memphis aquifer is the primary source of drinking water for the Memphis metropolitan area. Because the shallow water-table aquifer is hydraulically connected to the Memphis aquifer in some places, monitoring the quality of shallow ground water aids in the early detection of potential contaminants that may eventually degrade the water quality of the Memphis aquifer.

During summer 1996, 30 moniitor wells were installed, and sediment and soil samples were collected. During April and May 1997, water samples were collected from 32 wells. Twenty-two wells were completed in the shallow water-table aquifer, and eight wells were completed in the upper part of the Memphis aquifer. Water samples were also collected from two Memphis Light, Gas, and Water monitor wells screened in the shallow water-table aquifer.

The study area consists of 76 mi^2 of residential-commercial areas ranging in age from 5 to 25 years. The hydrogeologic units in the study area, in order of increasing depth, are the loess silt, the fluvial deposits and alluvial aquifer (shallow water-table aquifer), Jackson-upper Claiborne confining unit, and the Memphis aquifer. The loess and Jackson-upper Claiborne confining unit impede ground-water flow. The shallow water-table aquifer is separated from the Memphis aquifer, except where the Jackson-upper Claiborne confining unit is thin or absent just east of the study area. Water levels in the shallow water-table beneath the study area are typically 70 feet higher than water levels in the Memphis aquifer. The upper part of the Memphis aquifer is probably hydraulically separated from the main production zone of the Memphis aquifer by thin interbedded sand and clay. Urban development in the Memphis study area has been intensive from the 1960's through the 1990's.

Water from 17 wells was predominantly a sodium bicarbonate type water, whereas water from 12 wells was predominantly a calcium-magnesium bicarbonate type water. Water from two wells was predominantly a sodium chloride type water, and water from one other well was predominantly a sodium mixed anion type water. Water from one well had dissolved solids concentrations greater than the secondary maximum contaminant level for drinking water. Dissolved solids concentrations are greater in water from monitor wells screened in the shallow water-table aquifer than in water from monitor wells screened in the upper part of the Memphis aquifer. Nitrite plus nitrate nitrogen was the most frequently detected nutrient and is the nutrient with the greatest concentration (6.18 mg/L), which is below the primary drinking-water standard. Nitrite plus nitrate nitrogen concentrations were significantly greater in water from wells screened in the shallow water-table aquifer than in water from in the upper part of the Memphis aquifer.

Of the 18 analyzed trace elements, 11 were detected in ground water. Barium, manganese, chromium,iron, and nickel were detected in at least 29 of the 32 monitor wells. The greatest concentration of a trace element was 6,700 µg/L for manganese. The greatest median concentration was 84 µg/L for barium. Manganese concentrations in water from 16 wells exceeded the secondary standard for drinking water. Iron concentrations in water from eight monitor wells exceeded the secondary standard. Chromium concentrations were greater in water from wells in the shallow water-table aquifer than in water from wells in the upper part of the Memphis aquifer.

At least one of the 85 analyzed pesticide compounds was detected in water from 24 of the 32 monitor wells sampled in the study area. Twenty-six pesticide compounds were detected. Atrazine and simazine were the most frequently detected herbicides. Atrazine was the only compound to be detected at a concentration near the primary drinking-water standard. The greatest pesticide concentration was an estimated value of 15 µg/L for 2, 4-D, a widely used herbicide. Six other pesticides--picloram, dieldrin, atrazine, metolachlor, tebuthiuron, and dicamba--were detected at concentrations greater than 1 µg/L. Pesticide concentrations were generally greater in surface water from Fletcher Creek than in ground water from the monitor wells. Atrazine, simazine, metolachlor, deethylatrazine, tebuthiuron, and metribuzin were frequently detected in both surface water and ground water.

At lease one of the 87 analyzed VOCs was detected in water from 31 of the 32 monitor wells in the study area. Twenty-seven VOCs were detected. Carbon disulfide, the most frequently VOC detected; was detected in water from 14 of the 32 monitor wells. Carbon disulfide is commonly used in manufacturing but

also may originate naturally. Chloroform had the greatest concentration (2.06 µg/L) of any VOC detected in the ground-water samples. VOC concentrations were below drinking-water standards, generally by a few orders of magnitude. The number of different VOCs detected in water from wells screened in the shallow water-table aquifer increased with increasing depth to water. Carbon disulfide concentrations were greater in water from wells screened in the upper part of the Memphis aquifer than in the shallow water-table aquifer. Five wells were resampled for VOCs in September 1998 to determine the persistence of VOCs. Results indicate that VOC detections were variable from one year to the next, with the exception of chloroform. A greater number of VOCs were detected in ground water from the monitor wells than in surface water from the Fletcher Creek watershed. Carbon disulfide, toluene, chloromethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and benzene were frequently detected in both surface water and ground water.

Radium-226 concentrations in water from 13 monitor wells ranged from 0.06 to 0.88 pCi/L. Radon-222 in ground water ranged from less than 80 to 928 pCi/L.

Based on both tritium and CFC data, the average age of ground water from the monitor wells in the Memphis vicinity was estimated to range from 10 to more than 43 years old. Tritium was detected in water from 30 of the 32 monitor wells in the study area. Concentrations ranged from less than 0.31 to 14.4 TU. The median δ^2H value of water from the monitor wells (-29 per mil) was the same as the δ^2H value for meteoric water in the Memphis vicinity, indicating that rainfall is the source for ground water in the Memphis vicinity.

Residential land use was the most abundant land use within 50 and 500 m of the monitor wells, averaging 36 and 57 percent, respectively. Other significant land uses were rights-of-way automotive, forest, vacant land, and commercial-community. Concentrations of chloride and the sum of concentrations of VOC in water from wells increased with increasing percentages of urban land within 500 m of the wells. Concentrations of calcium, magnesium, bicarbonate, and fluoride increased with increasing percentages of forested land within 500 m of wells. Chloride concentrations increased with increasing urban land use; detections of different VOCs and concentrations of VOCs increased with increasing residential and urban land-use percentages within 500 m of the wells.

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Appendix 1. Sediment-Characteristics Data

Depth to the tops of the lithologic units in the monitor wells was interpreted by Strom (1997). Tops of the units generally were deepest below land surface in the western part of the study area and shallowest in the southeastern part of the study area. The top of the fluvial deposits and local alluvial sand ranged in depth from 5 to 38 feet. The top of the Jackson-upper Claiborne clay ranged in depth from 24 to 78 feet. The top of the Memphis Sand ranged in depth from 21 to 89 feet. The surficial deposit was local alluvium for seven wells (UR-13M, UR-13S, UR-21, UR-24, UR-25M, UR-25S, and UR-31). The Jackson-upper Claiborne clay was absent where two wells were located (UR-22 and UR-24). Seven wells were screened partially into the Jackson-upper Claiborne confining unit (UR-4, UR-9, UR-10, UR-11, UR-16, UR-25S, and UR-28), but obtained water from the overlying shallow water-table aquifer.

Median grain size distributions for the loess, fluvial deposits and local alluvial sand, Jackson-upper Claiborne confining unit, and the upper part of the Memphis Sand are summarized in figure 1-1. Using the median value to summarize grain size categories (tables 1-2 through 1-5) provides a representative grain-size profile for each lithologic unit (loess and local alluvial silt, fluvial deposits and local alluvial sand, Jackson-upper Claiborne confining unit, and the upper part of the Memphis Sand). More than half of the loess, by weight, consisted of coarse silt sized particles between 0.016 and 0.062 mm in diameter. Most of the rest of the loess consisted of fine silt or fine clay. Trace amounts of fine sand- sized particles also were present in the loess sampling. Fluvial deposits and local alluvial sand consisted mostly of fine- to medium-grain sand-sized particles between 0.125 and 0.5 mm in diameter. Trace amounts of coarse silt were typical in the fluvial deposits and local alluvial sand. Samples from the top of the Jackson-upper Claiborne confining unit consisted of mostly fine clay-sized particles less than 0.002 mm in diameter. The upper part of the Memphis Sand had a grain-size distribution very similar to the fluvial deposits and local alluvial sand consisting mostly of fine- to medium-grain sand-sized particles with trace amounts of coarse silt and very fine sand.

Organic-carbon content in sediment varied with lithologic unit (tables 1-6 through 1-9). The loess had the greatest concentrations of organic carbon of the four lithologic units (median concentration of 0.8 g/kg). Split spoons samples of the loess were collected at depths ranging from 8 to 18 ft below land surface. Split spoons samples of the deeper lithologic units were collected at depths ranging from 28 to 112 ft below land surface. Inorganic carbon content indicated the presence of carbonate minerals. Only four split spoon samples, three from the loess and one from the Memphis Sand, had detectable amounts of inorganic carbon.

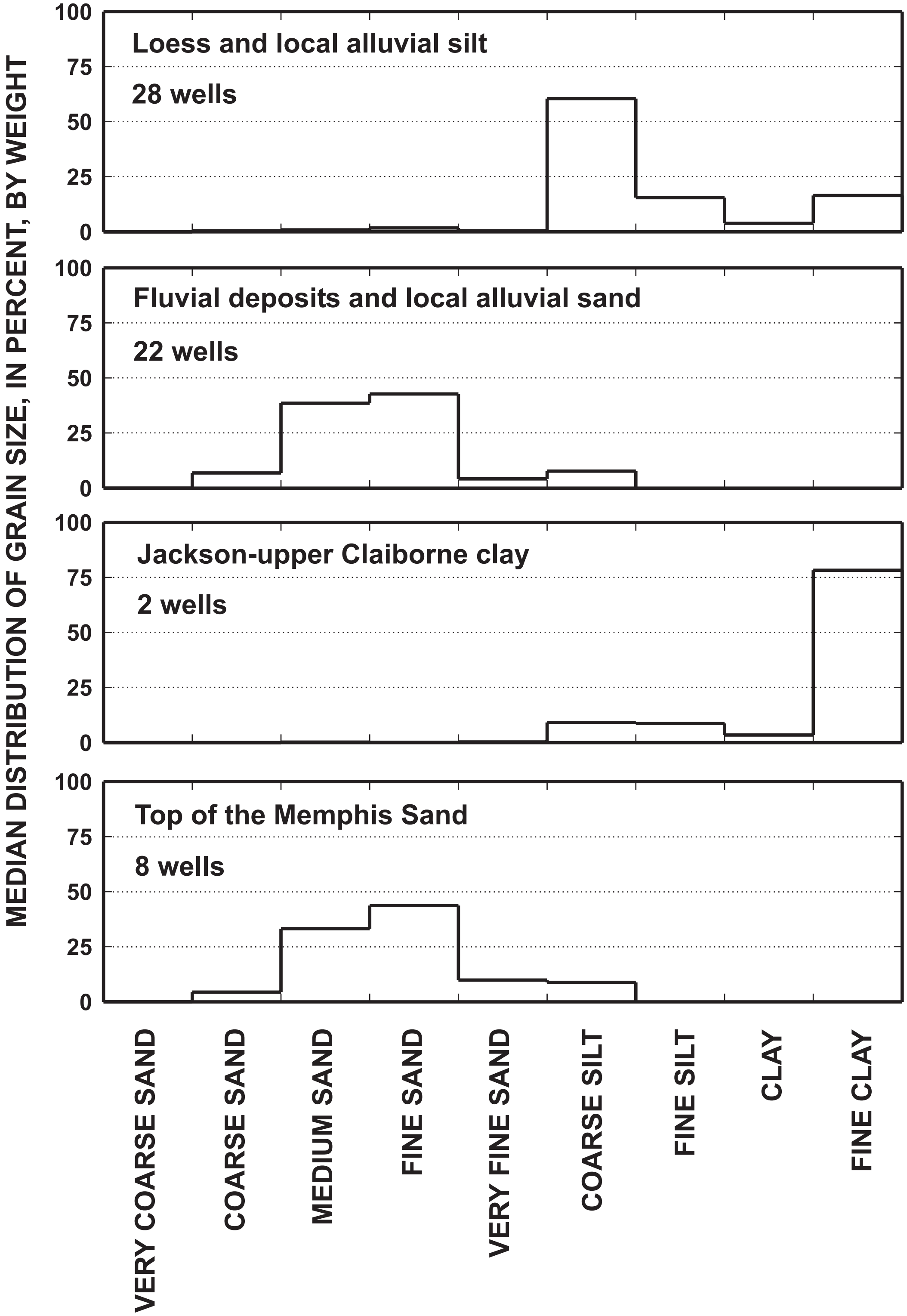

Figure 1-1. Median grain size distribution of sediment in the loess and local alluvial silt, fluvial deposits and local alluvial sand, Jackson-upper Claiborne clay, and the top of the Memphis Sand, Memphis, Tennessee, 1996.

Table 1-1. Depth below land surface to top of major lithologic units, Memphis vicinity, Tennessee, 1996.

[--, well hole did not reach the top of unit]

Well name	Surfical deposit	Fluvial deposits or local alluvial sand (feet)	Jackson-upper Claiborne clay (feet)	Memphis Sand (feet)
UR-01	Loess	34	--	--
UR-02	Loess	38	--	--
UR-03	Loess	35	68	--
UR-04	Loess	21	28	--
UR-05	Loess	31	--	--
UR-06	Loess	23	--	--
UR-07	Loess	33	52	--
UR-08	Loess	28	48	--
UR-09	Loess	21	38	--
UR-10	Loess	25	42	--
UR-11	Loess	18	46	--
UR-12	Loess	17	32	42
UR-13M	Local alluvium	14	29	58
UR-13S	Local alluvium	17	26	--
UR-16	Loess	23	78	--
UR-17	Loess	23	48	--
UR-18	Loess	26	--	--
UR-19	Loess	27	--	--
UR-20	Loess	12	41	63
UR-21	Local alluvium	22	40	63
UR-22	Loess	15	Absent	39
UR-23	Loess	15	47	--
UR-24	Local alluvium	15	Absent	21
UR-25M	Local alluvium	14	24	58
UR-25S	Local alluvium	14	24	--
UR-26	Loess	16	55	89
UR-27	Loess	15	26	--
UR-28	Loess	5	36	--
UR-29	Loess	21	--	--
UR-30	Loess	19	--	--
UR-31	Local alluvium	20	--	--

Table 1-2. Grain-size distribution of sediment in the loess and local alluvial silt, Memphis vicinity, Tennessee, 1996

[In weight percent of sediment smaller than diameter specified; the sieve and/or VA tube analyses were used to determine the weight percent smaller than 1 mm diameter; ft; feet; mm, millimeters; mm, micrometers]

Site	Depth to top of sample (ft)	Depth to bottom of sample (ft)	Sieve analysis (mm)				(mm)	VA tube analysis (µm)				3-point split (mm)		
			16	8	4	2	1	500	250	125	62	16	4	2
UR-1	16	18	100	100	100	100	100	99	99	99	98	36	23	21
UR-2	13	15	100	100	100	100	100	100	100	100	100	36	20	16
UR-3	13	15	100	100	100	100	100	100	100	99	99	--	--	--
UR-4	10	12	100	100	100	99	99	98	96	86	82	29	17	14
UR-5	10	12	100	100	100	100	100	100	100	99	99	34	20	16
UR-6	13	15	100	100	100	99	98	95	92	89	87	--	--	--
UR-7	10	12	100	100	100	100	100	99	98	80	61	--	--	--
UR-8	10	12	100	100	100	99	99	99	99	98	98	--	--	--
UR-9	10	12	100	100	100	100	100	100	99	98	98	37	20	17
UR-10	8	10	100	100	100	100	100	100	100	100	100	--	--	--
UR-11	8	10	100	100	99	98	98	98	98	97	97	47	21	19
UR-12	10	12	100	100	99	98	98	96	93	92	91	--	--	--
UR-13M	10	12	100	100	100	100	100	100	99	99	99	37	19	16
UR-16	8	10	100	100	100	100	100	100	100	99	99	--	--	--
UR-17	10	12	100	100	100	100	100	100	99	96	95	--	--	--
UR-18	10	12	100	100	100	100	100	100	99	98	98	--	--	--
UR-19	10	12	100	100	100	99	99	98	97	96	95	35	21	17
UR-20	7	8	100	100	100	97	97	94	91	89	88	--	--	--
UR-21	10	12	100	100	100	100	100	100	99	96	96	--	--	--
UR-22	10	12	100	100	100	100	100	99	96	87	78	25	16	16
UR-23	10	12	100	100	100	100	99	98	96	95	94	42	27	23
UR-24	10	12	100	100	100	99	99	95	89	86	85	--	--	--

Table 1-2. Grain-size distribution of sediment in the loess and local alluvial silt, Memphis vicinity, Tennessee, 1996

Site	Depth to top of sample (ft)	Depth to bottom of sample (ft)	Sieve analysis (mm)				(mm)	VA tube analysis (µm)				3-point split (mm)		
			16	8	4	2	1	500	250	125	62	16	4	2
UR-25M	10	12	100	100	100	100	100	99	97	88	84	24	14	11
UR-26	10	12	100	100	100	100	100	100	100	99	99	--	--	--
UR-27	10	12	100	100	97	97	96	90	85	80	79	--	--	--
UR-29	10	12	100	100	100	100	100	100	99	99	98	39	25	22
UR-30	8	10	100	100	100	100	100	100	100	99	98	--	--	--
UR-31	8	10	100	100	100	100	100	100	95	81	79	--	--	--

Table 1-3. Grain size distribution of sediment in the fluvial deposits and local alluvial sand, Memphis, Tennessee, 1996
[In weight percent of sediment smaller than diameter specified; the sieve and/or VA tube analyses were used to determine the weight percent smaller than 1 mm diameter; *, sediment sample collected from the auger bit; ft, feet; mm, millimeters; mm, micrometers]

Site	Depth to top of sample (ft)	Depth to bottom of sample (ft)	Sieve analysis (mm)				(mm)	VA tube analysis (µm)				3-point split (µm)		
			16	8	4	2	1	500	250	125	62	16	4	2
UR-1	70	72	100	100	94	82	78	52	14	5	2	--	--	--
UR-2	68	70	100	100	100	100	100	96	85	10	7	--	--	--
UR-3	63	65	100	100	100	100	100	89	53	14.3	6.8	--	--	--
UR-4	*40	*40	100	100	100	100	99	89	58	37	35	--	--	--
UR-5	45	47	100	100	100	100	100	100	100	76	13	--	--	--
UR-6	40	42	100	100	100	100	100	100	94	68	13	--	--	--
UR-7	*50	*50	100	100	100	100	100	99	97	39	17	--	--	--
UR-8	46	48	100	100	100	100	100	98	93	47	20	--	--	--
UR-9	45	47	100	100	100	99	99	85	56	34	29	--	--	--
UR-10	48	50	100	100	100	100	100	98	97	82	48	--	--	--
UR-11	28	30	100	100	100	99	96	62	33	27	27	--		
UR-16	33	35	100	49	39	37	35	24	14	7	4	--	--	--
UR-17	33	35	100	74	69	60	57	29	12	6	4	--	--	--
UR-18	68	70	100	100	98	93	90	62	10	1	1	--	--	--
UR-19	67	69	100	100	100	100	100	97	49	5	3	--	--	--
UR-20	50	52	100	100	100	100	100	99	98	83	22	--	--	--
UR-27	28	30	100	100	100	100	100	99	96	72	63	--	--	--
UR-28	10	12	52	39	31	25	22	18	11	6	4	--	--	--
UR-28	28	32	100	100	100	95	95	91	21	7	4	--	--	--
UR-29	73	75	65	45	40	33	29	23	7	3	2	--	--	--
UR-30	33	35	100	100	100	100	100	97	69	9	9	--	--	--
UR-31	28	30	100	100	100	100	100	95	44	5	3	--	--	--

Table 1-4. Grain size distribution of sediment in the Jackson-upper Claiborne clay, Memphis, Tennessee, 1996

[In weight percent of sediment smaller than diameter specified; the sieve and/or VA tube analyses were used to determine the weight percent smaller than 1 mm diameter; ft, feet; mm, millimeters; mm, micrometers]

Site	Depth to top of sample (ft)	Depth to bottom of sample (ft)	Sieve analysis (mm)				(mm)	VA tube analysis (µm)				3-point split (mm)		
			16	8	4	2	1	500	250	125	62	16	4	2
UR-11	53	55	100	100	100	100	100	100	100	100	100	97	97	93
UR-23	47	49	100	100	100	100	100	100	100	100	99	83	66	64

Table 1-5. Grain-size distribution of sediment in the top of the Memphis Sand, Memphis, Tennessee, Mississippi Embayment, 1996
[In weight percent of sediment smaller than diameter specified; the sieve and/or VA tube analyses were used to determine the weight percent smaller than 1 mm diameter; *, sediment sample collected from the auger bit; ft, feet; mm, millimeters; mm, micrometers]

Site	Depth to top of sample (ft)	Depth to bottom of sample (ft)	Sieve analysis (mm)				(mm)	VA tube analysis (µm)				3-point split (mm)		
			16	8	4	2	1	500	250	125	62	16	4	2
UR-12	108	110	100	100	100	100	100	100	99	77	56	--	--	--
UR-13M	*97	*97	100	100	100	100	100	83	37	23	19	--	--	--
UR-20	*73	*73	100	100	100	100	100	98	97	24	10	--	--	--
UR-21	87	89	100	100	100	100	100	93	44	5	3	--	--	--
UR-22	*105	*110	100	100	100	100	100	67	22	5	2	--	--	--
UR-24	105	107	100	100	100	100	100	100	99	85	58	--	--	--
UR-25M	93	95	100	56	47	40	34	24	16	11	8	--	--	--
UR-26	110	112	100	100	100	100	100	98	81	15	5	--	--	--

Table 1-6. Organic carbon and inorganic carbon content in sediment from the loess and local alluvial silt, Memphis vicinity, Tennessee, 1996

[FT, feet; G/KG, grams per kilogram; <, less than]

SITE	DATE	DEPTH TO TOP OF SAMPLE INTER-VAL (FT)	DEPTH TO BOT-TOM OF SAMPLE INTER-VAL (FT)	CARBON, INORG, SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORGANIC SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORG + INORG SEDIMENT WS,<2MM DW, REC (G/KG)
UR-01	07-08-96	16	18	<.100	2.30	2.30
UR-02	07-09-96	13	15	.400	2.00	2.40
UR-03	07-09-96	13	15	23.0	3.00	26.0
UR-04	07-25-96	10	12	<.100	.800	.800
UR-05	07-26-96	10	12	<.100	.600	.600
UR-06	07-26-96	13	15	.200	.900	1.10
UR-07	07-25-96	10	12	<.100	.400	.400
UR-08	07-20-96	10	12	<.100	1.90	1.90
UR-09	07-27-96	10	12	<.100	.800	.800
UR-10	09-24-96	8.0	10	<.100	1.00	1.00
UR-11	07-01-96	8.0	10	<.100	2.00	2.10
UR-12	06-21-96	10	12	<.100	1.30	1.40
UR-13M	06-20-96	10	12	<.100	.600	.600
UR-16	07-17-96	8.0	10	<.100	1.90	1.90
UR-17	07-16-96	10	12	<.100	.600	.600
UR-18	07-12-96	10	12	<.100	.400	.500
UR-19	07-19-96	10	12	<.100	.500	.500
UR-20	06-10-96	8.0	10	<.100	.400	.400
UR-21	06-17-96	10	12	<.100	.900	.900
UR-22	06-19-96	10	12	<.100	.500	.500
UR-23	07-11-96	10	12	<.100	1.60	.600
UR-24	06-14-96	10	12	<.100	.600	.600
UR-25M	06-12-96	10	12	<.100	.700	.800
UR-26	06-11-96	10	12	<.100	1.60	1.60
UR-27	07-10-96	10	12	<.100	.800	.800
UR-29	07-18-96	10	12	<.100	1.90	1.90
UR-30	09-24-96	8.0	10	<.100	.900	.900
UR-31	09-23-96	8.0	10	<.100	.300	.300

Table 1-7. Organic carbon and inorganic carbon content in sediment from the fluvial deposits and local alluvial sand, Memphis vicinity, Tennessee, 1996

[*, sediment sample collected from the auger bit. UR-F1 is a failed hole for UR-10; FT, feet; G/KG, grams per kilogram; <, less than]

SITE	DATE	DEPTH TO TOP OF SAMPLE INTER-VAL (FT)	DEPTH TO BOT-TOM OF SAMPLE INTER-VAL (FT)	CARBON, INORG, SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORGANIC SEDIMENTS WS,<2MM DW, REC (G/KG)	CARBON, ORG + INORG SEDIMENT WS,<2MM DW, REC (G/KG)
UR-01	07-08-96	70	72	<.100	.100	.100
UR-02	07-09-96	68	70	<.100	.100	.100
UR-03	07-09-96	63	65	<.100	<.100	<.100
UR-04	07-25-96	40	40	<.100	2.80	2.80
UR-05	07-26-96	45	47	<.100	<.100	<.100
UR-06	07-26-96	40	42	<.100	<.100	<.100
UR-07	07-25-96	*50	*50	<.100	2.80	2.80
UR-08	07-20-96	*46	*48	<.100	.800	.800
UR-09	07-27-96	45	47	<.100	1.30	1.30
UR-F1	07-02-96	28	30	<.100	<.100	<.100
UR-10	09-24-96	48	50	<.100	6.30	6.30
UR-11	07-01-96	28	30	<.100	.200	.200
UR-16	07-17-96	33	35	<.100	.200	.200
UR-17	07-16-96	33	35	<.100	<.100	<.100
UR-18	07-12-96	68	70	<.100	<.100	<.100
UR-19	07-19-96	67	69	<.100	<.100	<.100
UR-20	06-10-96	50	52	<.100	.700	.700
UR-27	07-10-96	28	30	<.100	.400	.400
UR-28	07-15-96	10	12	<.100	.200	.200
UR-28	07-15-96	28	32	<.100	<.100	<.100
UR-29	07-18-96	73	75	<.100	<.100	<.100
UR-30	09-24-96	33	35	<.100	<.100	<.100
UR-31	09-23-96	28	30	<.100	<.100	<.100

Table 1-8. Organic carbon and inorganic carbon content in sediment from the Jackson-upper Claiborne clay, Memphis vicinity, Tennessee, 1996

[FT, feet; G/KG, grams per kilogram; <, less than; *, sediment sample collected from the auger bit. UR-F1 is a failed hole for UR-10.]

SITE	DATE	DEPTH TO TOP OF SAMPLE INTER-VAL (FT)	DEPTH TO BOT-TOM OF SAMPLE INTER-VAL (FT)	CARBON, INORG, SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORGANIC SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORG + INORG SEDIMENT WS,<2MM DW, REC (G/KG)
UR-11	07-01-96	53	55	<.100	2.00	2.0-
UR-23	07-11-96	47	49	<.100	.200	<.100

Table 1-9. Organic carbon and inorganic carbon content in sediment from the Jackson-upper Claiborne clay, Memphis vicinity, Tennessee, 1996

[FT, feet; G/KG, grams per kilogram; <, less than; *, sediment sample collected from the auger bit.]

SITE	DATE	DEPTH TO TOP OF SAMPLE INTER-VAL (FT)	DEPTH TO BOT-TOM OF SAMPLE INTER-VAL (FT)	CARBON, INORG, SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORGANIC SEDIMENT WS,<2MM DW, REC (G/KG)	CARBON, ORG + INORG SEDIMENT WS,<2MM DW, REC (G/KG)
UR-12	06-21-96	108	110	<.100	<.100	.200
UR-13M	06-20-96	*97	*97	<.100	1.00	1.00
UR-21	06-17-96	*87	*89	<.100	<.100	<.100
UR-22	06-19-96	*105	*108	<.100	<.100	<.100
UR-24	06-14-96	105	107	<.100	2.90	2.90
UR-25M	06-12-96	93	95	<.100	.800	.800
UR-26	06-11-96	110	112	.200	.400	.600

Appendix 2. Water-Quality Data

Table 2-1. Field-parameter data for water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[NTU, Nephelometric turbidity units; DEG C, degrees Celsius; US/CM, microsiemens per centimeter; MG/L, milligrams per liter; CACO3, calcium carbonate; >, greater than; E, Estimated value]

SITE	STATION NUMBER	DATE	TIME	WATER-LEVEL BELOW LAND SURFACE (FEET)	TUR-BID-ITY (NTU)	TEMPER-ATURE WATER (DEG C)	PH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	OXYGEN, DIS-SOLVED (MG/L)	ALKA-lINITY FIELD MG/L AS CACO3
UR-01	350149090063801	05-22-97	1000	19.6	1.9	17.7	6.6	462	5.1	248
UR-02	350245090035501	05-06-97	1400	25.4	11	18.4	6.5	374	2.8	206
UR-03	350242090052901	05-06-97	1000	14.9	7.8	19.2	6.8	526	3.5	287
UR-04	351217089560501	05-13-97	1300	22.3	>1000	18.8	6.8	347	4.3	146
UR-05	351324089560101	04-29-97	1500	36.1	130	20.6	6.1	190	3.5	72
UR-06	351403089552601	05-01-97	0900	28.0	3.1	20.2	6.0	378	3.7	128
UR-07	351246089553701	05-13-97	0900	26.7	90	18.4	6.7	237	.3	115
UR-08	351201089525501	04-22-97	1500	8.3	1.7	17.8	5.7	187	1.1	65
UR-09	351136089532801	04-30-97	0800	13.1	35	17.5	5.7	240	4.5	43
UR-10	351137089542501	04-23-97	0900	17.5	35	19.3	6.1	179	.1	87
UR-11	350229089525601	05-20-97	1500	12.9	17	18.6	5.8	1000	.4	95
UR-12	350308089525001	05-28-97	1300	99.8	40.4	18.8	6.4	194	3.1	79
UR-13M	350443089524801	05-14-97	0900	64.9	28	17.0	6.7	369	5.8	104
UR-13S	350443089524802	05-14-97	1300	13.5	10	17.6	6.3	287	.2	84
UR-14	351111089512501	04-30-97	1300	71.6	5.6	18.9	6.1	165	5.5	51
UR-15	351155089514201	05-22-97	1500	25.0	.94	19.2	5.7	110	.5	29
UR-16	351245089505001	04-22-97	1000	63.6	6.4	18.7	5.9	220	2.3	43
UR-17	351319089504401	04-24-97	0900	18.5	7.5	16.3	5.7	232	2.0	41
UR-18	351153089494201	04-24-97	1300	62.0	3.6	19.9	6.3	452	.2	140
UR-19	351057089495601	04-29-97	1000	42.6	.75	19.3	6.1	313	2.4	75
UR-20	350643089502001	05-15-97	0900	53.7	16	19.0	6.3	162	.0	72
UR-21	350348089501101	05-07-97	0900	74.9	4.7	22.2	5.6	200	.2	36
UR-22	350320089502901	05-07-97	1500	79.4	3.0	20.5	5.6	76	3.4	19
UR-23	350152089482901	05-08-97	0900	34.2	1.6	18.9	6.3	112	5.4	39
UR-24	350224089485501	05-08-97	1300	66.2	35	21.9	6.0	238	.2	83
UR-25M	350259089490501	05-21-97	1100	73.2	140	17.3	6.2	177	2.5	E60
UR-25S	350259089490502	05-21-97	1500	15.3	25	E17	6.3	418	E3.5	193
UR-26	350543089473901	05-29-97	1000	69.7	31	19.3	6.4	185	1.5	77
UR-28	351108089463201	04-23-97	1600	18.9	180	20.5	5.7	630	4.9	34
UR-29	351147089482701	04-21-97	1700	70.2	2.7	18.6	6.1	225	5.7	60
UR-30	351343089491901	05-01-97	1400	73.1	4.2	21.1	5.8	97	4.8	36
UR-31	350424089593901	05-05-97	1300	27.7	2.1	21.6	6.2	336	.1	161

Table 2-2. Major-cation and silica concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[MG/L, milligrams per liter; UG/L, micrograms per liter; <, less than]

SITE	STATION NUMBER	DATE	TIME	SODIUM, DIS- SOLVED (MG/L AS NA)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	IRON, DIS- SOLVED (UG/L AS FE)	SILICA, DIS- SOLVED (MG/L AS SIO2)
UR-01	350149090063801	05-22-97	1000	9.2	54	28	.51	2.8	11	20
UR-02	350245090035501	05-06-97	1400	16	36	20	.34	9.0	<3.0	31
UR-03	350242090052901	05-06-97	1000	10	53	30	.75	139	5.7	21
UR-04	351217089560501	05-13-97	1300	12	30	14	4.5	667	3900	23
UR-05	351324089560101	04-29-97	1500	23	7.5	4.1	.21	2.1	52	52
UR-06	351403089552601	05-01-97	0900	36	22	14	.23	26	45	59
UR-07	351246089553701	05-13-97	0900	7.8	24	11	1.4	83	710	22
UR-08	351201089525501	04-22-97	1500	23	8.4	3.7	.44	1.7	5.5	39
UR-09	351136089532801	04-30-97	0800	23	12	5.8	.46	21	19	31
UR-10	351137089542501	04-23-97	0900	8.5	15	6.6	2.6	191	2100	25
UR-11	350229089525601	05-20-97	1500	122	38	19	2.4	305	42	34
UR-12	350308089525001	05-22-97	1300	11	14	7.9	2.6	95	120	38
UR-13M	350443089524801	05-14-97	0900	53	10	5.9	.68	107	16	34
UR-13S	350443089524802	05-14-97	1300	34	14	7.6	1.3	296	1400	31
UR-14	351111089512501	04-30-97	1300	19	8.6	2.8	.58	2.3	8.4	23
UR-15	351155089514201	05-22-97	1500	13	4.5	2.7	.19	7.8	9.3	43
UR-16	351245089505001	04-22-97	1000	25	10	4.6	1.4	3.4	17	28
UR-17	351319089504401	04-24-97	0900	17	15	7.3	.39	229	10	32
UR-18	351153089494201	04-24-97	1300	28	34	17	1.1	32	27	12
UR-19	351057089495601	04-29-97	1000	40	13	5.2	.56	9.3	5.6	22
UR-20	350643089502001	05-15-97	0900	17	9.3	4.5	1.5	12	12	19
UR-21	350348089501101	05-07-97	0900	24	6.7	3.0	1.2	199	2700	22
UR-22	350320089502901	05-07-97	1500	10	2.4	.92	.48	1.3	8.8	27
UR-23	350152089482901	05-08-97	0900	18	2.8	1.2	.29	3.8	8.9	35
UR-24	350224089485501	05-08-97	1300	11	17	8.4	3.2	198	4800	64
UR-25M	350259089490501	05-21-97	1100	13	13	5.1	2.2	364	5300	28
UR-25S	350259089490502	05-21-97	1500	23	39	15	4.6	977	4.3	24
UR-26	350543089473901	05-29-97	1000	8.7	13	7.0	3.9	251	2300	13
UR-28	351108089463201	04-23-97	1600	53	37	15	1.5	791	13	18
UR-29	351147089482701	04-21-97	1700	29	8.8	4.3	1.1	1.7	5.5	14
UR-30	351343089491901	05-01-97	1400	11	5.0	2.3	.24	20	37	31
UR-31	350424089593901	05-05-97	1300	6.4	40	12	1.9	6670	120	32

Table 2-3. Major-anion and dissolved-solids concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[MG/L, milligrams per liter; <, less than]

STATION	NUMBER	DATE	TIME	BICARBONATE WATER DIS-SOLVED MG/L AS HCO3	CHLORIDE, DIS-SOLVED (MG/L AS CL)	SULFATE DIS-SOLVED (MG/L AS SO4)	BROMIDE DIS-SOLVED (MG/L AS BR)	FLUORIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
UR-01	350149090063801	05-22-97	1000	296	3.0	5.7	.058	.22	270
UR-02	350245090035501	05-06-97	1400	230	3.3	9.6	.046	.19	220
UR-03	350242090052901	05-06-97	1000	335	7.2	2.4	.074	.25	291
UR-04	351217089560501	05-13-97	1300	168	9.9	12	.091	.12	180
UR-05	351324089560101	04-29-97	1500	84	8.5	5.7	.13	<.10	137
UR-06	351403089552601	05-01-97	0900	157	30	13	.28	.20	248
UR-07	351246089553701	05-13-97	0900	148	2.6	1.5	.035	.20	130
UR-08	351201089525501	04-22-97	1500	90	8.7	6.4	.18	<.10	139
UR-09	351136089532801	04-30-97	0800	54	24	9.4	.060	<.10	155
UR-10	351137089542501	04-23-97	0900	104	2.8	1.8	.055	<.10	108
UR-11	350229089525601	05-20-97	1500	118	240	21	2.2	<.10	577
UR-12	350308089525001	05-22-97	1300	99	8.5	4.2	.15	.16	137
UR-13M	350443089524801	05-14-97	0900	140	12	37	.16	.32	216
UR-13S	350443089524802	05-14-97	1300	115	11	31	.17	.23	184
UR-14	351111089512501	04-30-97	1300	56	13	.81	.13	<.10	104
UR-15	351155089514201	05-22-97	1500	38	6.6	3.6	.050	<.10	107
UR-16	351245089505001	04-22-97	1000	62	26	7.6	.30	<.10	139
UR-17	351319089504401	04-24-97	0900	57	6.8	44	.030	<.10	161
UR-18	351153089494201	04-24-97	1300	179	40	26	.38	<.10	243
UR-19	351057089495601	04-29-97	1000	87	43	.89	.42	<.10	173
UR-20	350643089502001	05-15-97	0900	87	5.6	4.0	.11	.18	104
UR-21	350348089501101	05-07-97	0900	37	11	40	.17	<.10	125
UR-22	350320089502901	05-07-97	1500	27	5.7	2.9	.051	<.10	64
UR-23	350152089482901	05-08-97	0900	50	10	.43	.021	<.10	91
UR-24	350224089485501	05-08-97	1300	105	4.2	20	.087	<.10	186
UR-25M	350259089490501	05-21-97	1100	73	9.2	10	.25	.20	129
UR-25S	350259089490502	05-21-97	1500	234	8.5	16	.088	.16	254
UR-26	350543089473901	05-29-97	1000	91	4.6	7.2	.056	.17	105
UR-28	351108089463201	04-23-97	1600	39	170	7.7	1.5	<.10	358
UR-29	351147089482701	04-21-97	1700	79	15	9.5	.14	<.10	138
UR-30	351343089491901	05-01-97	1400	43	5.9	2.9	.051	<.10	83
UR-31	350424089593901	05-05-97	1300	188	6.0	14	.022	<.10	208

Table 2-4. Nutrient concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[*, field-equipment blank data (Appendix 3) was used to set a reporting limit for dissolved organic carbon of 5 MG/L (milligrams per liter); <, less than; M, deep well; S, shallow well]

SITE	STATION NUMBER	DATE	TIME	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC DIS. (MG/L AS N)	PHOS-PHORUS DIS-SOLVED (MG/L AS P)	PHOS-PHORUS ORTHO, DIS-SOLVED (MG/L AS P)	*CARBON, ORGANIC DIS-SOLVED (MG/L AS C)
UR-01	350149090063801	05-22-97	1000	<.010	.887	<.015	<.20	<.010	.018	<5
UR-02	350245090035501	05-06-97	1400	<.010	.355	<.015	<.20	<.010	.010	<5
UR-03	350242090052901	05-06-97	1000	.012	1.83	<.015	<.20	.012	.011	<5
UR-04	351217089560501	05-13-97	1300	<.010	<.050	.188	.21	<.010	<.010	<5
UR-05	351324089560101	04-29-97	1500	<.010	1.01	<.015	<.20	<.010	<.010	<5
UR-06	351403089552601	05-01-97	0900	<.010	1.55	<.015	<.20	<.010	<.010	<5
UR-07	351246089553701	05-13-97	0900	<.010	<.050	<.015	<.20	<.010	<.010	<5
UR-08	351201089525501	04-22-97	1500	<.010	.660	.090	<.20	<.010	<.010	<5
UR-09	351136089532801	04-30-97	0800	<.010	6.18	<.015	<.20	<.010	<.010	<5
UR-10	351137089542501	04-23-97	0900	<.010	<.050	.043	<.20	.011	<.010	<5
UR-11	350229089525601	05-20-97	1500	<.010	.076	<.015	<.20	.024	.028	<5
UR-12	350308089525001	05-22-97	1300	<.010	<.050	<.015	<.20	<.010	<.010	<5
UR-13M	350443089524801	05-14-97	0900	<.010	.136	<.015	<.20	.074	.082	<5
UR-13S	350443089524802	05-14-97	1300	<.010	<.050	.015	<.20	.045	.046	<5
UR-14	351111089512501	04-30-97	1300	<.010	2.67	<.015	<.20	.010	.013	<5
UR-15	351155089514201	05-22-97	1500	<.010	2.13	<.015	<.20	<.010	.014	<5
UR-16	351245089505001	04-22-97	1000	<.010	1.90	.090	<.20	<.010	<.010	<5
UR-17	351319089504401	04-24-97	0900	.013	2.01	.030	<.20	<.010	.013	<5
UR-18	351153089494201	04-24-97	1300	<.010	<.050	.200	<.20	<.010	<.010	<5
UR-19	351057089495601	04-29-97	1000	<.010	3.10	<.015	<.20	<.010	<.010	<5
UR-20	350643089502001	05-15-97	0900	<.010	<.050	<.015	<.20	<.010	<.010	<5
UR-21	350348089501101	05-07-97	0900	<.010	<.050	<.015	<.20	.067	.085	<5
UR-22	350320089502901	05-07-97	1500	<.010	1.10	<.015	<.20	<.010	<.010	<5
UR-23	350152089482901	05-08-97	0900	<.010	.299	<.015	<.20	<.010	<.010	<5
UR-24	350224089485501	05-08-97	1300	<.010	<.050	.023	<.20	.040	.051	<5
UR-25M	350259089490501	05-21-97	1100	<.010	<.050	.214	.35	.029	.042	<5
UR-25S	350259089490502	05-21-97	1500	<.010	<.050	.234	.54	.012	<.010	<5
UR-26	350543089473901	05-29-97	1000	<.010	<.050	.160	.22	<.010	<.010	<5
UR-28	351108089463201	04-23-97	1600	<.010	.802	<.015	<.20	<.010	<.010	<5
UR-29	351147089482701	04-21-97	1700	<.010	4.20	.090	<.20	<.010	<.010	<5
UR-30	351343089491901	05-01-97	1400	<.010	.514	<.015	<.20	<.010	<.010	<5
UR-31	350424089593901	05-05-97	1300	<.010	<.050	.938	.88	.083	.016	<5

Table 2-5. Trace-element concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[*, field-equipment blank results (Appendix 3) were used to set reporting limits (in micrograms per liter) for: aluminum (5), cobalt (2), and copper (2); **, field-equipment blank results (Appendix 3) were used to set a reporting limit for zinc at 6 micrograms per liter; <, less than; M, deep well; S, shallow well]

STATION	NUMBER	DATE	TIME	ARSENIC DIS-SOLVED (UG/L AS AS)	*ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ANTI-MONY, DIS-SOLVED (UG/L AS SB)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	*COBALT, DIS-SOLVED (UG/L AS CO)	*COPPER, DIS-SOLVED (UG/L AS CU)
UR-01	350149090063801	05-22-97	1000	<1	<5	<1.0	44	<1.0	<1.0	7.0	<2	<2
UR-02	350245090035501	05-06-97	1400	<1	<5	<1.0	63	<1.0	<1.0	4.7	<2	<2
UR-03	350242090052901	05-06-97	1000	<1	<5	<1.0	156	<1.0	<1.0	6.2	3.7	<2
UR-04	351217089560501	05-13-97	1300	1	<5	<1.0	266	<1.0	<1.0	2.3	<2	<2
UR-05	351324089560101	04-29-97	1500	<1	<5	<1.0	20	<1.0	<1.0	5.1	<2	<2
UR-06	351403089552601	05-01-97	0900	<1	<5	<1.0	43	<1.0	<1.0	7.4	<2	<2
UR-07	351246089553701	05-13-97	0900	<1	<5	<1.0	428	<1.0	<1.0	3.2	<2	<2
UR-08	351201089525501	04-22-97	1500	<1	<5	<1.0	30	<1.0	<1.0	5.8	<2	<2
UR-09	351136089532801	04-30-97	0800	<1	<5	<1.0	26	<1.0	<1.0	4.8	<2	<2
UR-10	351137089542501	04-23-97	0900	2	<5	<1.0	205	<1.0	<1.0	2.7	<2	<2
UR-11	350229089525601	05-20-97	1500	<1	<5	<1.0	474	<1.0	<1.0	7.9	2.7	<2
UR-12	350308089525001	05-22-97	1300	<1	<5	<1.0	225	<1.0	<1.0	2.0	4.1	<2
UR-13M	350443089524801	05-14-97	0900	<1	<5	<1.0	40	<1.0	<1.0	2.5	<2	<2
UR-13S	350443089524802	05-14-97	1300	2	<5	<1.0	166	<1.0	<1.0	3.6	2.7	<2
UR-14	351111089512501	04-30-97	1300	<1	<5	<1.0	23	<1.0	<1.0	4.0	<2	<2
UR-15	351155089514201	05-22-97	1500	<1	<5	<1.0	20	<1.0	<1.0	4.3	3.2	<2
UR-16	351245089505001	04-22-97	1000	<1	<5	<1.0	178	<1.0	<1.0	3.6	<2	<2
UR-17	351319089504401	04-24-97	0900	<1	<5	<1.0	60	<1.0	<1.0	4.0	<2	<2
UR-18	351153089494201	04-24-97	1300	<1	<5	<1.0	105	<1.0	<1.0	5.0	<2	<2
UR-19	351057089495601	04-29-97	1000	<1	<5	<1.0	46	<1.0	<1.0	4.0	<2	<2
UR-20	350643089502001	05-15-97	0900	<1	<5	<1.0	122	<1.0	<1.0	4.1	<2	<2
UR-21	350348089501101	05-07-97	0900	1	5.1	<1.0	45	<1.0	<1.0	4.1	2.1	<2
UR-22	350320089502901	05-07-97	1500	<1	<5	<1.0	9.3	<1.0	<1.0	2.9	<2	<2
UR-23	350152089482901	05-08-97	0900	<1	5.0	<1.0	23	<1.0	<1.0	2.9	<2	<2
UR-24	350224089485501	05-08-97	1300	<1	<5	<1.0	368	<1.0	<1.0	4.9	<2	<2
UR-25M	350259089490501	05-21-97	1100	2	<5	<1.0	114	<1.0	<1.0	3.2	<2	<2
UR-25S	350259089490502	05-21-97	1500	<1	<5	<1.0	472	<1.0	<1.0	6.4	<2	<2
UR-26	350543089473901	05-29-97	1000	2	<5	<1.0	234	<1.0	<1.0	<1.0	<2	<2
UR-28	351108089463201	04-23-97	1600	<1	<5	<1.0	310	<1.0	<1.0	1.9	7.5	<2
UR-29	351147089482701	04-21-97	1700	<1	<5	<1.0	27	<1.0	<1.0	3.5	<2	<2
UR-30	351343089491901	05-01-97	1400	<1	5.1	<1.0	9.3	<1.0	<1.0	3.5	<2	<2
UR-31	350424089593901	05-05-97	1300	<1	5.2	<1.0	157	<1.0	<1.0	6.5	6.9	<2

Table 2-5. Trace-element concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997--Continued

	IRON DIS- SOLVED (UG/L AS FE)	LEAD, DIS- SOLVED (UG/L AS PB)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	MOLYB- DENUM, DIS- SOLVED (UG/L AS MO)	NICKEL, DIS- SOLVED (UG/L AS NI)	SELE- NIUM, DIS- SOLVED (UG/L AS SE)	SILVER, DIS- SOLVED (UG/L AS AG)	URANIUM NATURAL DIS- SOLVED (UG/L AS U)	**ZINC, DIS- SOLVED (UG/L AS ZN)
UR-01	11	<1.0	2.8	<1.0	2.6	<1	<1.0	<1.0	<6
UR-02	<5.0	<1.0	9.0	<1.0	1.5	<1	<1.0	<1.0	<6
UR-03	5.7	<1.0	139	1.2	4.8	<1	<1.0	<1.0	<6
UR-04	3900	<1.0	667	<1.0	<1.0	<1	<1.0	<1.0	20
UR-05	52	<1.0	2.1	1.6	8.8	<1	<1.0	<1.0	<6
UR-06	45	<1.0	26	<1.0	3.5	<1	<1.0	<1.0	<6
UR-07	710	<1.0	83	<1.0	1.8	<1	<1.0	<1.0	59
UR-08	5.5	<1.0	1.7	<1.0	<1.0	<1	<1.0	<1.0	<6
UR-09	19	<1.0	21	<1.0	3.7	1	<1.0	<1.0	<6
UR-10	2100	<1.0	190	<1.0	1.1	<1	<1.0	<1.0	<6
UR-11	42	<1.0	305	<1.0	3.2	<1	<1.0	<1.0	<6
UR-12	120	<1.0	95	<1.0	2.8	<1	<1.0	<1.0	34
UR-13M	16	<1.0	107	<1.0	1.6	4	<1.0	<1.0	16
UR-13S	1400	<1.0	296	<1.0	1.9	<1	<1.0	<1.0	7.1
UR-14	8.4	<1.0	2.3	<1.0	1.2	<1	<1.0	<1.0	<6
UR-15	9.3	<1.0	7.8	<1.0	2.3	<1	<1.0	<1.0	<6
UR-16	17	<1.0	3.4	<1.0	3.4	<1	<1.0	<1.0	<6
UR-17	10	<1.0	229	<1.0	2.7	<1	<1.0	<1.0	<6
UR-18	27	<1.0	32	<1.0	1.3	<1	<1.0	<1.0	<6
UR-19	5.6	<1.0	9.3	<1.0	1.8	<1	<1.0	<1.0	<6
UR-20	12	<1.0	12	<1.0	2.0	<1	<1.0	<1.0	<6
UR-21	2700	<1.0	199	<1.0	6.2	<1	<1.0	<1.0	8.2
UR-22	8.8	<1.0	1.2	<1.0	2.0	2	<1.0	<1.0	<6
UR-23	8.9	<1.0	3.8	<1.0	2.0	<1	<1.0	<1.0	6.9
UR-24	4800	<1.0	198	<1.0	1.6	<1	<1.0	<1.0	<6
UR-25M	5300	<1.0	364	<1.0	<1.0	<1	<1.0	<1.0	29
UR-25S	<5.0	<1.0	977	<1.0	2.2	<1	<1.0	<1.0	36
UR-26	2300	<1.0	251	<1.0	1.0	<1	<1.0	<1.0	18
UR-28	13	<1.0	791	<1.0	3.3	<1	<1.0	<1.0	<6
UR-29	5.5	<1.0	1.7	<1.0	1.3	1	<1.0	<1.0	11
UR-30	37	<1.0	20	<1.0	4.9	1	<1.0	<1.0	9.2
UR-31	120	<1.0	6670	<1.0	2.0	<1	<1.0	<1.0	<6

Table 2-6. Trace elements that were analyzed for but were not detected in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997
[UG/L, micrograms per liter]

CONSTITUENT	MINIMUM REPORTING LEVEL (UG/L)
ANTIMONY, DISSOLVED AS SB	1.0
BERYLLIUM, DISSOLVED AS BE	1.0
CADMIUM, DISSOLVED AS CD	1.0
COPPER, DISSOLVED AS CU	2
LEAD, DISSOLVED AS PB	1.0
SILVER, DISSOLVED AS AG	1.0
URANIUM NATURAL, DISSOLVED AS U	1.0

Table 2-7. Pesticide concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997, analyzed by using gas chromatography mass spectrometry

[E, Estimated value; UG/L, micrograms per liter; <, less than; M, deep well; S, shallow well]

SITE	STATION NUMBER	DATE	TIME	ALA-CHLOR, WATER, DISS, REC, (UG/L)	ATRA-ZINE, WATER, DISS, REC (UG/L)	CYANA-ZINE, WATER, DISS, REC (UG/L)	DCPA WATER FLTRD 0.7 U GF, REC (UG/L)	DI-ELDRIN DIS-SOLVED (UG/L)	EPTC WATER FLTRD 0.7 U F, REC UG/L)	METO-LACHLOR WATER DISSOLV (UG/L)	METRI-BUZIN SENCOR WATER DISSOLV (UG/L)	PENDI-METH-ALIN WAT FLT 0.7 U GF, REC (UG/L)	PRO-METON, WATER, DISS, REC (UG/L)	PRO-PANIL WATER FLTRD 0.7 U GF, REC (UG/L)	SI-MAZINE, WATER, DISS, REC (UG/L)
UR-01	350149090063801	05-22-97	1000	<0.002	E0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-02	350245090035501	05-06-97	1400	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-03	350242090052901	05-06-97	1000	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-04	351217089560501	05-13-97	1300	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-05	351324089560101	04-29-97	1500	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-06	351403089552601	05-01-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-07	351246089553701	05-13-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	E0.000	<0.004	<0.004	<0.018	<0.004	<0.005
UR-08	351201089525501	04-22-97	1500	<0.002	0.005	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.006
UR-09	351136089532801	04-30-97	0800	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-10	351137089542501	04-23-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-11	350229089525601	05-20-97	1500	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	E0.003	<0.004	<0.004	<0.018	<0.004	<0.005
UR-12	350308089525001	05-22-97	1300	<0.002	0.007	<0.004	<0.002	<0.001	<0.002	E0.004	<0.004	E0.016	<0.018	<0.004	<0.005
UR-13M	350443089524801	05-14-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.010
UR-13S	350443089524802	05-14-97	1300	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	0.010	<0.004	<0.018	<0.004	0.058
UR-14	351111089512501	04-30-97	1300	<0.002	<0.001	<0.004	<0.002	0.008	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-15	351155089514201	05-22-97	1500	<0.002	<0.001	<0.004	<0.002	3.20	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-16	351245089505001	04-22-97	1000	<0.002	0.015	<0.004	<0.002	<0.001	<0.002	E0.003	<0.004	<0.004	<0.018	<0.004	0.008
UR-17	351319089504401	04-24-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.007
UR-18	351153089494201	04-24-97	1300	<0.002	0.072	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.233
UR-19	351057089495601	04-29-97	1000	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-20	350643089502001	05-15-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	0.007	<0.004	<0.018	<0.004	<0.005
UR-21	350348089501101	05-07-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.048
UR-22	350320089502901	05-07-97	1500	<0.002	0.021	<0.004	<0.002	<0.001	<0.002	E0.003	<0.004	<0.004	<0.018	<0.004	0.113
UR-23	350152089482901	05-08-97	0900	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-24	350224089485501	05-08-97	1300	0.146	3.14	0.089	<0.002	<0.001	<0.002	2.09	0.490	0.084	<0.018	<0.004	0.061
UR-25M	350259089490501	05-21-97	1100	<0.002	0.008	<0.004	<0.002	<0.001	<0.002	0.008	<0.004	<0.004	<0.018	<0.004	<0.005
UR-25S	350259089490502	05-21-97	1500	<0.002	<0.005	<0.004	<0.002	<0.001	0.020	0.006	<0.004	<0.004	<0.018	<0.004	<0.005
UR-26	350543089473901	05-29-97	1000	<0.002	0.007	<0.004	<0.002	<0.001	<0.002	0.006	0.006	<0.040	<0.018	0.005	0.384
UR-28	351108089463201	04-23-97	1600	<0.002	0.070	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	0.009
UR-29	351147089482701	04-21-97	1700	<0.002	0.007	<0.004	E0.001	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-30	351343089491901	05-01-97	1400	<0.002	<0.001	<0.004	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.018	<0.004	<0.005
UR-31	350424089593901	05-05-97	1300	<0.002	0.048	<0.004	<0.002	<0.001	<0.002	0.013	<0.004	<0.004	0.051	<0.004	0.413

Table 2-7. Pesticide concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, analyzed by using gas chromatography mass spectrometry--Continued

SITE	TEBU-THIURON WATER FLTRD 0.7 U GF, REC (UG/L)	THIO-BENCARB WATER FLTRD 0.7 U GF, REC (UG/L)	TRI-FLUR-ALIN WAT FLT 0.7 U GF, REC (UG/L)	DEETHYL ATRA-ZINE, WATER, DISS, REC (UG/L)	CARBO-FURAN WATER FLTRD 0.7 U GF, REC (UG/L)	ACETO-CHLOR, WATER FLTRD REC (UG/L)	DIAZ-INON D10 SRG WAT FLT 0.7 U GF, REC PERCENT	HCH ALPHA D6 SRG WAT FLT 0.7 U GF, REC PERCENT	TERBUTH YLAZINE SURROGT WAT FLT 0.7 U GF, REC PERCENT
UR-01	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	106	104	122
UR-02	<0.010	<0.002	<0.002	E0.004	<0.003	<0.002	83.6	94.1	109
UR-03	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	85.1	87.8	102
UR-04	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	98.2	92.7	115
UR-05	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	102	98.1	112
UR-06	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	109	106	116
UR-07	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	97.3	98.2	114
UR-08	<0.010	<0.002	<0.002	E0.004	<0.003	<0.002	103	107	116
UR-09	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	110	106	124
UR-10	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	101	104	122
UR-11	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	102	94.7	109
UR-12	<0.010	<0.002	<0.002	<0.002	<0.003	0.023	118	104	119
UR-13M	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	106	98.2	121
UR-13S	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	95.4	100	120
UR-14	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	110	105	120
UR-15	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	108	91.5	114
UR-16	0.103	<0.002	<0.002	E0.009	<0.003	<0.002	106	106	117
UR-17	1.76	<0.002	<0.002	<0.002	<0.003	<0.002	107	105	128
UR-18	<0.010	<0.002	<0.002	E0.014	<0.003	<0.002	109	103	128
UR-19	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	106	100	115
UR-20	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	103	95.9	126
UR-21	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	89.3	87.2	103
UR-22	0.014	<0.002	<0.002	E0.006	<0.003	<0.002	92.6	84.6	105
UR-23	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	94.8	92.0	110
UR-24	<0.010	0.036	0.014	E0.114	E0.093	0.122	95.4	95.4	112
UR-25M	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	104	89.7	118
UR-25S	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	102	90.0	105
UR-26	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	111	108	120
UR-28	<0.010	<0.002	<0.002	E0.046	<0.003	<0.002	99.7	108	114
UR-29	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	98.3	76.4	96.6
UR-30	<0.010	<0.002	<0.002	<0.002	<0.003	<0.002	112	101	123
UR-31	0.021	<0.002	<0.002	E0.005	<0.003	<0.002	93.2	93.0	92.8

Table 2-8. Pesticides that were analyzed by using gas chromatography mass spectrometry, but were not detected in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[*, the minimum reporting level for well UR-26 was 0.007]

CONSTITUENT	MIMINUM REPORTING LEVEL (UG/L)
BENFLURALIN	0.002
BUTYLATE	0.002
CHLORPYRIFOS	0.004
P,P' DDE	0.006
DIAZINON*	0.002
2,6-DIETHYL ANILINE	0.003
DISULFOTON	0.017
ETHALFLURALIN	0.004
ETHOPROP	0.003
FONOFOS	0.003
ALPHA BHC	0.002
LINDANE	0.004
LINURON	0.002
MALATHION	0.005
MOLINATE	0.004
NAPROPAMIDE	0.003
PARATHION	0.004
METHYL PARATHION	0.006
PEBULATE	0.004
PERMETHRIN, CIS	0.005
PHORATE	0.002
PRONAMIDE	0.003
PROPACHLOR	0.007
PROPARGITE	0.013
TERBACIL	0.007
TRIALLATE	0.001
METHYL AZINPHOS	0.001
CARBARYL	0.003
TERBUFOS	0.013

Table 2-9. Pesticide concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, analyzed by using high performance liquid chromatography

[E, Estimated value; UG/L, micrograms per liter; <, less than; M, deep well; S, shallow well]

SITE	STATION NUMBER	DATE	TIME	2,4-D, DIS-SOLVED (UG/L)	BENTA-ZON, WATER, FLTRD, GF 0.7U REC (UG/L)	BRO-MACIL, WATER, DISS, REC (UG/L)	DICAMBA WATER, FLTRD, GF 0.7U REC (UG/L)	DIURON, WATER, FLTRD, GF 0.7U REC (UG/L)	FEN-URON, WATER, FLTRD, GF 0.7U REC (UG/L)	FLUO-METURON WATER, FLTRD, GF 0.7U REC (UG/L)	PIC-LORAM, WATER, FLTRD, GF 0.7U REC (UG/L)	BDMC, SURROG, WATER, UNFLTRD REC PERCENT
UR-01	350149090063801	05-22-97	1000	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	58.0
UR-02	350245090035501	05-06-97	1400	<0.035	<0.014	<0.035	<0.035	<0.020	0.570	<0.035	<0.050	65.0
UR-03	350242090052901	05-06-97	1000	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	70.0
UR-04	351217089560501	05-13-97	1300	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	74.0
UR-05	351324089560101	04-29-97	1500	<0.035	<0.014	0.150	<0.035	<0.020	<0.013	<0.035	E3.91	89.0
UR-06	351403089552601	05-01-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	79.0
UR-07	351246089553701	05-13-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	79.0
UR-08	351201089525501	04-22-97	1500	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	94.0
UR-09	351136089532801	04-30-97	0800	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	87.0
UR-10	351137089542501	04-23-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	91.0
UR-11	350229089525601	05-20-97	1500	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	69.0
UR-12	350308089525001	05-22-97	1300	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	66.0
UR-13M	350443089524801	05-14-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	74.0
UR-13S	350443089524802	05-14-97	1300	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	73.0
UR-14	351111089512501	04-30-97	1300	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	83.0
UR-15	351155089514201	05-22-97	1500	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	67.0
UR-16	351245089505001	04-22-97	1000	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	0.170	99.0
UR-17	351319089504401	04-24-97	0900	<0.035	<0.014	0.270	<0.035	<0.020	<0.013	<0.035	0.340	96.0
UR-18	351153089494201	05-27-97	1700	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	71.0
UR-19	351057089495601	04-29-97	1000	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	78.0
UR-20	350643089502001	05-15-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	77.0
UR-21	350348089501101	05-07-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	77.0
UR-22	350320089502901	05-07-97	1500	<0.035	0.120	<0.035	<0.035	E0.001	<0.013	<0.035	<0.050	79.0
UR-23	350152089482901	05-08-97	0900	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	74.0
UR-24	350224089485501	05-08-97	1300	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	74.0
UR-25M	350259089490501	05-28-97	1500	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	90.0
UR-25S	350259089490502	05-21-97	1500	<0.035	0.050	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	73.0
UR-26	350543089473901	05-29-97	1000	E14.8	0.060	<0.035	E1.46	<0.020	<0.013	<0.035	<0.050	47.0
UR-28	351108089463201	04-23-97	1600	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	78.0
UR-29	351147089482701	04-21-97	1700	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	84.0
UR-30	351343089491901	05-01-97	1400	<0.035	<0.014	<0.035	<0.035	<0.020	<0.013	<0.035	<0.050	81.0
UR-31	350424089593901	05-05-97	1300	<0.035	0.080	<0.035	<0.035	0.190	0.050	0.110	<0.050	64.0

Table 2-10. Pesticides that were analyzed using high performance liquid chromatography but were not detected in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[UG/L, micrograms per liter]

CONSTITUENT	MIMIMUM REPORTING LEVEL (UG/L)
2,4,5-T	0.035
2,4-DB	0.035
ACIFLUORFEN	0.035
ALDICARB	0.016
ALDICARB SULFONE	0.016
ALDICARB SULFOXIDE	0.021
BROXYNIL	0.035
CARBARYL	0.008
CARBOFURAN	0.028
3-HYDROXY CARBOFURAN	0.014
CHLORAMBEN	0.011
CHLOROTHALONIL	0.035
CLOPYRALID	0.050
DACTHAL	0.017
DICHLOBENIL	0.020
DICHLORPROP	0.032
DINOSEB	0.035
DNOC	0.035
LINURON	0.018
MCPA	0.050
MCPB	0.035
METHIOCARB	0.026
METHOMYL	0.017
NEBURON	0.015
NORFLURAZON	0.024
ORYZALIN	0.019
OXAMYL	0.018
PROPHAM	0.035
PROPOXUR	0.035
SILVEX	0.021
TRICLOPYR	0.050

Table 2-11. Volatile-organic-compound concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997

[E, Estimated value; UG/L, micrograms per liter; <, less than; M, deep well; S, shallow well]

SITE	STATION NUMBER	DATE	TIME	DI-CHLORO-DI-FLUORO-METHANE TOTAL (UG/L)	TRI-CHLORO-FLUORO-METHANE TOTAL (UG/L)	CHLORO-FORM TOTAL (UG/L)	DI-CHLORO-BROMO-METHANE TOTAL (UG/L)	METHYL-CHLO-RIDE TOTAL (UG/L)	1,1-DI-CHLORO-ETHANE TOTAL (UG/L)	1,1,1-TRI-CHLORO-ETHANE TOTAL (UG/L)	CHLORO-ETHANE TOTAL (UG/L)	TETRA-CHLORO-ETHYL-ENE TOTAL (UG/L)	TRI-CHLORO-ETHYL-ENE TOTAL (UG/L)	1,1-DI-CHLORO-ETHYL-ENE TOTAL (UG/L)	1,2-TRANSDI CHLORO-ETHENE TOTAL (UG/L)	CIS-1,2 -DI-CHLORO-ETHENE WATER TOTAL (UG/L)
UR-01	350149090063801	05-22-97	0959	<0.200	<0.100	<0.050	<0.100	E0.030	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-02	350245090035501	05-06-97	1359	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-03	350242090052901	05-06-97	0959	<0.200	<0.100	E0.010	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-04	351217089560501	05-13-97	1259	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.05
UR-05	351324089560101	04-29-97	1459	<0.200	<0.100	E0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-06	351403089552601	05-01-97	0859	E0.100	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	E0.010	<0.050	<0.100	<0.050	<0.050
UR-07	351246089553701	05-13-97	0859	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-08	351201089525501	04-22-97	1459	E0.040	<0.100	E0.010	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-09	351136089532801	04-30-97	0759	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-10	351137089542501	04-23-97	0859	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-11	350229089525601	05-20-97	1459	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-12	350308089525001	05-22-97	1259	<0.200	<0.100	E0.020	<0.100	E0.040	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-13M	350443089524801	05-14-97	0859	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-13S	350443089524802	05-14-97	1259	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-14	351111089512501	04-30-97	1259	<0.200	<0.100	E0.080	<0.100	<0.200	E0.030	E0.020	<0.100	E0.009	E0.004	<0.100	<0.050	<0.050
UR-15	351155089514201	05-22-97	1459	<0.200	<0.100	E0.060	<0.100	<0.200	E0.040	E0.030	<0.100	E0.030	<0.050	E0.070	<0.050	<0.050
UR-16	351245089505001	04-22-97	0959	<0.200	<0.100	E0.020	<0.100	<0.200	<0.050	<0.050	<0.100	E0.005	<0.050	<0.100	<0.050	<0.050
UR-17	351319089504401	04-24-97	0859	<0.200	<0.100	2.06	E0.010	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-18	351153089494201	04-24-97	1259	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-19	351057089495601	04-29-97	0959	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-20	350643089502001	05-15-97	0859	<0.200	<0.100	<0.050	<0.100	E0.030	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-21	350348089501101	05-07-97	0859	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-22	350320089502901	05-07-97	1459	<0.200	<0.100	E0.020	<0.100	<0.200	<0.050	<0.050	<0.100	E0.030	<0.050	<0.100	<0.050	<0.050
UR-23	350152089482901	05-08-97	0859	<0.200	<0.100	E0.010	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-24	350224089485501	05-08-97	1259	<0.200	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-25M	350259089490501	05-21-97	1059	<0.200	<0.100	E0.009	<0.100	E0.060	<0.050	<0.050	E0.020	E0.010	<0.050	<0.100	<0.050	<0.050
UR-25S	350259089490502	05-21-97	1459	<0.200	<0.100	<0.050	<0.100	E0.040	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-26	350543089473901	05-29-97	0959	<0.200	<0.100	<0.050	<0.100	E0.050	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-28	351108089463201	04-23-97	1559	<0.200	<0.100	<0.050	<0.100	<0.200	0.201	<0.050	<0.100	0.443	E0.050	E0.030	E0.010	0.566
UR-29	351147089482701	04-21-97	1659	<0.200	0.233	E0.010	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-30	351343089491901	05-01-97	1359	E0.300	<0.100	<0.050	<0.100	<0.200	<0.050	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050
UR-31	350424089593901	05-05-97	1259	<0.200	<0.100	<0.050	<0.100	<0.200	0.101	<0.050	<0.100	<0.050	<0.050	<0.100	<0.050	<0.050

Table 2-11. Volatile-organic-compound concentrations in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997--Continued

SITE	META/ PARA- XYLENE WATER UNFLTRD REC (UG/L)	TOLUENE TOTAL (UG/L)	BENZENE 124-TRI METHYL UNFILT RECOVER (UG/L)	BENZENE 135-TRI METHYL WATER UNFLTRD REC (UG/L)	BENZENE TOTAL (UG/L)	BENZENE 123-TRI METHYL- WATER UNFLTRD RECOVER (UG/L)	O- XYLENE WATER WHOLE TOTAL (UG/L)	ETHYL- BENZENE TOTAL (UG/L)	METHYL TERT- BUTYL ETHER WAT UNF REC (UG/L)	DI-ISO- PROPYL- ETHER, WATER, UNFLTRD RECOVER (UG/L)	ACETONE WATER WHOLE TOTAL UG/L)	CARBON DI. SULFIDE WATER WHOLE TOTAL (UG/L)	BENZENE 1,4-DI- CHLORO- WATER UNFLTRD REC (UG/L)	CHLORO- BENZENE TOTAL (UG/L)
UR-01	E0.010	<0.050	<0.050	<0.050	E0.009	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-02	E0.010	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-03	E0.020	<0.050	E0.010	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-04	<0.050	0.274	<0.050	<0.050	E0.010	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.040	<0.050	<0.050
UR-05	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-06	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-07	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.020	<0.050	<0.050
UR-08	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-09	<0.050	E0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-10	<0.050	E0.020	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.010	<0.050	<0.050
UR-11	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-12	<0.050	E0.010	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.030	<0.050	<0.050
UR-13M	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.010	<0.050	<0.050
UR-13S	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.020	<0.050	<0.050
UR-14	E0.010	<0.050	E0.010	E0.005	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-15	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-16	E0.030	<0.050	E0.010	E0.010	<0.050	E0.009	E0.010	<0.050	<0.100	<0.100	<5.00	<0.050	E0.006	<0.050
UR-17	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.080	<0.050	<0.050
UR-18	E0.040	<0.050	E0.020	E0.010	<0.050	E0.010	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-19	E0.030	<0.050	<0.050	E0.010	<0.050	<0.050	E0.009	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-20	<0.050	<0.050	<0.050	<0.050	E0.007	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.010	<0.050	<0.050
UR-21	E0.010	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.010	<0.050	<0.050
UR-22	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	E0.030	<5.00	<0.050	<0.050	<0.050
UR-23	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-24	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	E0.60	E0.010	<0.050	<0.050
UR-25M	E0.040	0.282	<0.050	<0.050	<0.050	<0.050	<0.050	E0.010	<0.100	<0.100	<5.00	0.120	<0.050	<0.050
UR-25S	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.080	<0.050	<0.050
UR-26	E0.010	0.106	<0.050	<0.050	E0.010	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	0.157	<0.050	<0.050
UR-28	<0.050	E0.030	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	E0.060	<0.050	<0.050
UR-29	E0.040	<0.050	E0.020	E0.010	<0.050	E0.010	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	E0.010	<0.050
UR-30	E0.050	<0.050	E0.020	E0.010	E0.010	<0.050	<0.050	<0.050	<0.100	<0.100	<5.00	<0.050	<0.050	<0.050
UR-31	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	E0.020	<0.100	<5.00	<0.050	<0.050	E0.003

Table 2-12. Volatile organic compounds that were analyzed for but were not detected in water from 32 monitor wells, Memphis vicinity, Tennessee, 1997
[UG/L, micrograms per liter]

CONSTITUENT	MINIMUM REPORTING LEVEL (UG/L)
FREON-113	0.050
HEXACHLOROETHANE	0.050
CHLORODIBROMOMETHANE	0.100
BROMOFORM	0.200
1,2-DIBROMOETHANE	0.100
1,2-DICHLOROETHANE	0.050
1,1,2-TRICHLOROETHANE	0.100
1,1,1,2-TETRACHLOROETHANE	0.050
1,1,2,2-TETRACHLOROETHANE	0.100
METHYL BROMIDE	0.100
METHYL IODIDE	0.050
CHLOROBROMOMETHANE	0.100
DIBROMOMETHANE	0.100
METHYLENE CHLORIDE	0.100
CARBON TETRACHLORIDE	0.050
1,3-DICHLOROPROPANE	0.050
1,2-DICHLOROPROPANE	0.050
2,2-DICHLOROPROPANE	0.050
1,2,3-TRICHLOROPROPANE	0.200
CHLORDIBROMOPROPANE	0.500
STYRENE	0.050
NAPHTHALENE	0.200
VINYL CHLORIDE	0.100
BROMOETHENE	0.100
3-CHLOROPORPENE	0.100
1,1-DICHLOROPROPENE	0.050
CIS-1,3-DICHLOROPROPENE	0.100
TRANS-1,3-DICHLOROPROPENE	0.100
TRANS-1,4-DICHLOR,2-BUTENE	5.00
HEXACHLOROBUTADIENE	0.200
ISOPROPYLBENZENE	0.050
N-PROPY BENZENE	0.050
TERT BUTYL BENZENE	0.050
SEC BUTYL BENZENE	0.050
N-BUTYL BENZENE	0.050
ISODURENE	0.050
PREHNITENE	0.050
O-ETHYL EOLUENE	0.050
P-ISOPROPYLTOLUENE	0.050
ETHYL ETHER	0.100
ETHYL TERT BUYTL ETHER	0.100
METHYL THER PENTYL ETHER	0.100
METHYL ETHYL KETONE	5.00
METHYL ISOBUTYL KETONE	5.00
2-HEXANONE	5.00
ACROLEIN	2.00
TETRAHYDROGURAN	5.00
ACRYLONITRILE	2.00
METHARCYLONITRITE	2.00
METHYL ACRYLATE	2.00
METHYL METHACRYLATE	1.00
ETHYL METHACRYLATE	1.00
ACETATE VINYL	5.00
O-DICHLOROBENZENE	0.050
1,3-DICHLORBENZENE	0.050
1,2,3-TRICHLOROBENZENE	0.200
1,2,4-TRICHLOROBENZENE	0.200
BROMOBENZENE	0.050
O-CHLOROTOLUENE	0.050
P-CHLOROTOLUENE	0.050

Table 2-13. Radioisotope concentrations and relative stable-isotope ratios in water from 32 monitor wells,Memphis vicinity, Tennessee, 1997

[PCI/L, picoCuries per liter; TU, tritium units; --, no data; <, less than; M, deep well; S, shallow welloxygen and hydrogen stable isotope ratio values are reported relative to Vienna Standard Mean Ocean Water.]

SITE	STATION NUMBER	DATE	TIME	RADIUM 226, DIS- SOLVED, RADON METHOD (PCI/L)	RADON 222 TOTAL (PCI/L)	TRITIUM TOTAL (PCI/L)	TRITIUM TOTAL (TU)	O-18 / O-16 STABLE ISOTOPE RATIO PER MIL	H-2 / H-1 STABLE ISOTOPE RATIO PER MIL
UR-01	350149090063801	05-22-97	1000	--	363	32	10	--	--
UR-02	350245090035501	05-06-97	1400	--	391	46	14.4	--	--
UR-03	350242090052901	05-06-97	1000	.34	161	13	3.8	-5.42	-30.8
UR-04	351217089560501	05-13-97	1300	--	--	8.0	2.5	--	--
UR-05	351324089560101	04-29-97	1500	--	269	38	11.0	--	--
UR-06	351403089552601	05-01-97	0900	.29	331	18	5.6	-5.40	-29.0
UR-07	351246089553701	05-13-97	0900	--	177	3.2	1	--	--
UR-08	351201089525501	04-22-97	1500	--	292	32	10	--	--
UR-09	351136089532801	04-30-97	0800	.09	928	19	5.9	-5.28	-28.8
UR-10	351137089542501	04-23-97	0900	--	208	1.3	0.41	--	--
UR-11	350229089525601	05-20-97	1500	.88	144	7.4	2.3	-5.26	-29.2
UR-12	350308089525001	05-22-97	1300	--	--	1.0	<0.31	--	--
UR-13M	350443089524801	05-14-97	0900	.09	--	16	5	-5.27	-28.6
UR-13S	350443089524802	05-14-97	1300	.33	641	24	7.5	-5.13	-28.9
UR-14	351111089512501	04-30-97	1300	--	172	25	7.8	--	--
UR-15	351155089514201	05-22-97	1500	--	316	20	6.3	--	--
UR-16	351245089505001	04-22-97	1000	.40	266	28	8.8	--	--
UR-17	351319089504401	04-24-97	0900	--	405	26	8.1	--	--
UR-18	351153089494201	04-24-97	1300	--	120	29	9.1	--	--
UR-19	351057089495601	04-29-97	1000	.19	151	10	3.1	-5.28	-31.6
UR-20	350643089502001	05-15-97	0900	.52	133	<1.0	<0.31	-5.34	-29.6
UR-21	350348089501101	05-07-97	0900	--	97	28	8.8	--	--
UR-22	350320089502901	05-07-97	1500	.09	88	23	7.2	-5.22	-29.2
UR-23	350152089482901	05-08-97	0900	--	267	27	8.4	--	--
UR-24	350224089485501	05-08-97	1300	.73	689	<1.0	<0.31	-5.13	-28.3
UR-25M	350259089490501	05-21-97	1100	--	--	2.2	0.69	--	--
UR-25S	350259089490502	05-21-97	1500	--	--	15	4.7	--	--
UR-26	350543089473901	05-29-97	1000	.47	--	2.2	0.69	-5.17	-27.8
UR-28	351108089463201	04-23-97	1600	--	595	13	3.8	--	--
UR-29	351147089482701	04-21-97	1700	.06	<80	35	10.9	-5.26	-27.6
UR-30	351343089491901	05-01-97	1400	--	247	30	9.4	--	--
UR-31	350424089593901	05-05-97	1300	--	173	17	5.3	--	--

Appendix 3. Quality-Assurance Data

Table 3-1. Quality-assurance data for major cations and silica in water from monitor wells, Memphis vicinity, Tennessee, 1997
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot; EQ.BLK, equipment blank; REPLCT, replicate; NORMAL, regular sample from Appendix table 2-2; MG/L, milligrams per liter; UG/L, micrograms per liter; <, less than]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	SODIUM, DIS- SOLVED (MG/L AS NA)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	MANGA- NESE, DIS- SOLVED (UG/ L AS MN)	IRON, DIS- SOLVED (UG/L AS FE)	SILICA, DIS- SOLVED (MG/L AS SIO2)
OFFICE	344459092235201	04-16-97	1306	EQ.BLK	<.20	.069	.013	<.10	1.4	5.9	.016
UR-02	350245090035501	05-06-97	1401	REPLCT	16	36	20	.34	12	3.8	31
			1400	NORMAL	16	36	20	.34	9.0	<3.0	31
UR-06	351403089552601	05-01-97	1206	EQ.BLK	<.20	.058	<.010	<.10	<1.0	3.8	.014
UR-11	350229089525601	05-20-97	1501	REPLCT	122	38	19	2.5	302	43	34
			1500	NORMAL	122	38	19	2.4	305	42	34
UR-20	350643089502001	05-15-97	0906	EQ.BLK	<.20	.021	<.010	<.10	<1.0	<3.0	.035
UR-26	350543089473901	05-29-97	1006	EQ.BLK	<.20	.056	<.010	<.10	<1.0	<3.0	.030

Table 3-2. Quality-assurance data for major anions and dissolved solids in water from monitor wells, Memphis vicinity, Tennessee, 1997
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot; EQ.BLK, equipment blank; REPLCT, replicate; NORMAL, regular sample from appendix 2, table 2-3; MG/L, milligrams per liter; <, less than]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	CHLORIDE, DIS-SOLVED (MG/L AS CL)	SULFATE DIS-SOLVED (MG/L AS SO4)	BROMIDE DIS-SOLVED (MG/L AS BR)	FLUORIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
OFFICE	344459092235201	04-16-97	1306	EQ.BLK	<.10	<.10	<.010	<.10	2
UR-02	350245090035501	05-06-97	1401	REPLCT	3.4	9.5	.048	.19	217
			1400	NORMAL	3.3	9.6	.046	.19	220
UR-06	351403089552601	05-01-97	1206	EQ.BLK	<.10	<.10	<.010	<.10	1
UR-11	350229089525601	05-20-97	1501	REPLCT	230	21	2.1	<.10	570
			1500	NORMAL	240	21	2.2	<.10	577
UR-20	350643089502001	05-15-97	0906	EQ.BLK	<.10	<.10	<.010	<.10	2
UR-26	350543089473901	05-29-97	1006	EQ.BLK	<.10	<.10	<.010	<.10	1

Table 3-3. Quality-assurance data for nutrients in water from monitor wells, Memphis vicinity, Tennessee, 1997
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. MG/L, milligrams per liter; EQ.BLK, equipment blank; SC.BLK, source solution blank; REPLCT, replicate; NORMAL, regular sample from appendix 2, table 2-4; <, less than; --, no data]

STATION	NUMBER	DATE	TIME	QA SAMPLE TYPE	NITROGEN, NITRITE DISSOLVED (MG/L AS N)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	PHOSPHORUS DISSOLVED (MG/L AS P)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)
OFFICE	344459092235201	06-02-97	1414	SC.BLK	--	--	--	--	--	--	.50
		04-16-97	1114	SC.BLK	--	--	--	--	--	--	.20
		04-16-97	1305	EQ.BLK	--	--	--	--	--	--	.50
		04-16-97	1306	EQ.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--
		04-16-97	1314	SC.BLK	<.010	<.050	<.015	<.20	.010	<.010	--
		04-16-97	1414	SC.BLK	--	--	--	--	--	--	.50
UR-02	350245090035501	05-06-97	1401	REPLCT	<.010	.374	<.015	<.20	<.010	.010	1.5
			1400	NORMAL	<.010	.355	<.015	<.20	<.010	.010	2.2
UR-06	351403089552601	05-01-97	1205	EQ.BLK	--	--	--	--	--	--	15
		05-01-97	1206	EQ.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--
		05-01-97	1214	SC.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--
UR-11	350229089525601	05-20-97	1501	REPLCT	<.010	.097	.029	<.20	.024	.029	--
			1500	NORMAL	<.010	.076	.015	<.20	.024	.028	--
UR-20	350643089502001	05-15-97	0905	EQ.BLK	--	--	--	--	--	--	2.5
		05-15-97	0906	EQ.BLK	.013	<.050	.018	<.20	<.010	<.010	--
		05-15-97	0914	SC.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--
UR-25M	350259089490501	05-21-97	1101	REPLCT	--	--	--	--	--	--	3.1
			1100	NORMAL	--	--	--	--	--	--	1.9
UR-26	350543089473901	05-29-97	1005	EQ.BLK	--	--	--	--	--	--	1.1
		05-29-97	1006	EQ.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--
		05-29-97	1014	SC.BLK	<.010	<.050	<.015	<.20	<.010	<.010	--

Table 3-4. Quality-assurance data for trace elements in water from monitor wells, Memphis vicinity, Tennessee, 1997
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; REPLCT, replicate; NORMAL, regular sample from appendix 2, table 2-5; UG/L, micrograms per liter; <, less than]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	ARSENIC DIS-SOLVED (UG/L AS AS)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ANTI-MONY, DIS-SOLVED (UG/L AS SB)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, DIS-SOLVED (UG/L AS CU)
OFFICE	344459092235201	04-16-97	1311	EQ.BLK	<1	4.1	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0
UR-02	350245090035501	05-06-97	1410	REPLCT	<1	3.4	<1.0	62	<1.0	<1.0	6.6	<1.0	<1.0
			1400	NORMAL	<1	3.1	<1.0	63	<1.0	<1.0	4.7	<2	<2
UR-06	351403089552601	05-01-97	1211	EQ.BLK	<1	3.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
UR-11	350229089525601	05-20-97	1510	REPLCT	<1	3.9	<1.0	475	<1.0	<1.0	8.5	2.6	<1.0
			1500	NORMAL	<1	4.0	<1.0	474	<1.0	<1.0	7.9	2.7	<2
UR-20	350643089502001	05-15-97	0911	EQ.BLK	<1	4.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.5	1.3
UR-26	350543089473901	05-29-97	1011	EQ.BLK	<1	3.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.2

Table 3-5. Quality-assurance data for trace elements in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; REPLCT, replicate; NORMAL, regular sample from appendix 2, table 2-6; UG/L, micrograms per liter; <, less than; --, no data]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	NICKEL, DIS-SOLVED (UG/L AS NI)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	SILVER, DIS-SOLVED (UG/L AS AG)	URANIUM NATURAL DIS-SOLVED (UG/L AS U)	ZINC, DIS-SOLVED (UG/L AS ZN)
OFFICE	344459092235201	04-16-97	1306	EQ.BLK	5.9	--	1.4	--	--	--	--	--	--
		04-16-97	1311	EQ.BLK	--	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	6.5
UR-02	350245090035501	05-06-97	1401	REPLCT	3.8	--	12	--	--	--	--	--	--
			1410	REPLCT	--	<1.0	8.1	<1.0	1.9	<1	<1.0	<1.0	4.6
			1400	NORMAL	<5.0	<1.0	9.0	<1.0	1.5	<1	<1.0	<1.0	1.8
UR-06	351403089552601	05-01-97	1206	EQ.BLK	3.8	--	<1.0	--	--	--	--	--	--
		05-01-97	1211	EQ.BLK	--	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	6.3
UR-11	350229089525601	05-20-97	1501	REPLCT	43	--	302	--	--	--	--	--	--
		05-20-97	1510	REPLCT	--	<1.0	299	<1.0	3.0	<1	<1.0	<1.0	5.1
			1500	NORMAL	42	<1.0	305	<1.0	3.2	<1	<1.0	<1.0	5.4
UR-20	350643089502001	05-15-97	0906	EQ.BLK	<3.0	--	<1.0	--	--	--	--	--	--
		05-15-97	0911	EQ.BLK	--	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	4.9
UR-26	350543089473901	05-29-97	1006	EQ.BLK	<3.0	--	<1.0	--	--	--	--	--	--
		05-29-97	1011	EQ.BLK	--	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<1.0	4.4

Table 3-6. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate; E estimated value. NWQL Lab Schedule 2010; UG/L, micrograms per liter; <, less than; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	ALA-CHLOR, WATER, DISS, REC, (UG/L)	ATRA-ZINE, WATER, DISS, REC (UG/L)	BEN-FLUR-ALIN WAT FLD 0.7 U GF, REC (UG/L)	BUTYL-ATE, WATER, DISS, REC (UG/L)	CHLOR-PYRIFOS DIS-SOLVED (UG/L)	CYANA-ZINE, WATER, DISS, REC (UG/L)	DCPA WATER FLTRD 0.7 U GF, REC (UG/L)	P,P' DDE DISSOLV (UG/L)	DI-AZINON, DIS-SOLVED (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	E0.002	<0.006	<0.002
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.002	<0.006	<0.002
UR-10	351137089542501	04-23-97	0902	FS	0.123	0.141	0.103	0.125	0.111	0.153	0.134	0.092	0.121
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.002	<0.006	<0.002
UR-22	350320089502901	05-07-97	1502	FS	0.107	0.143	0.097	0.102	0.100	0.126	0.111	0.067	0.095
		05-07-97	1503	FSR	0.109	0.140	0.103	0.103	0.106	0.126	0.114	0.077	0.095
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.002	<0.001	<0.002	<0.002	<0.004	<0.004	<0.002	<0.006	<0.002
		05-29-97	1002	FS	0.124	0.130	0.112	0.108	0.111	0.130	0.116	0.072	0.114
		05-29-97	1003	FSR	0.110	0.114	0.107	0.126	0.080	0.134	0.107	0.113	0.113
Sample fortification concentration (water)					0.1	0.1	0.1	0.09	0.1	0.1	0.09	0.1	0.1

Table 3-7. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2010; UG/L, micrograms per liter; <, less than; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	DI-ELDRIN DIS-SOLVED (UG/L)	2,6-DI-ETHYL ANILINE WAT FLT 0.7 U GF, REC (UG/L)	DISUL-FOTON WATER FLTRD 0.7 U GF, REC (UG/L)	EPTC WATER FLTRD 0.7 U GF, REC (UG/L)	ETHAL-FLUR-ALIN WAT FLT 0.7 U GF, REC (UG/L)	ETHO-PROP WATER FLTRD 0.7 U GF, REC (UG/L)	FONOFOS WATER DISS REC (UG/L)	ALPHA BHC DIS-SOLVED (UG/L)	LINDANE DIS-SOLVED (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.001	<0.003	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.001	<0.003	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004
UR-10	351137089542501	04-23-97	0902	FS	0.100	0.110	0.098	0.119	0.116	0.129	0.112	0.127	0.135
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.001	<0.003	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004
UR-22	350320089502901	05-07-97	1502	FS	0.077	0.083	0.074	0.095	0.102	0.102	0.092	0.091	0.068
		05-07-97	1503	FSR	0.082	0.093	0.072	0.107	0.102	0.096	0.095	0.088	0.069
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.001	<0.003	<0.017	<0.002	<0.004	<0.003	<0.003	<0.002	<0.004
		05-29-97	1002	FS	0.093	0.101	0.111	0.108	0.133	0.116	0.101	0.092	0.100
		05-29-97	1003	FSR	0.152	0.112	0.089	0.104	0.145	0.134	0.108	0.108	0.107
Sample fortification concentration (water)					0.09	0.1	0.09	0.09	0.09	0.09	0.1	0.1	0.09

Table 3-8. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2010; UG/L, micrograms per liter; <, less than; E, Estimated value; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	LIN-URON WATER FLTRD 0.7 U GF, REC (UG/L)	MALA-THION, DIS-SOLVED (UG/L)	METO-LACHLOR WATER DISSOLV (UG/L)	METRI-BUZIN SENCOR WATER DISSOLV (UG/L)	MOL-INATE WATER FLTRD 0.7 U GF, REC (UG/L)	NAPROP-AMIDE WATER FLTRD 0.7 U GF, REC (UG/L)	PARA-THION, DIS-SOLVED (UG/L)	METHYL PARA-THION WAT FLT 0.7 U GF, REC (UG/L)	PEB-ULATE WATER FILTRD 0.7 U GF, REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.002	<0.005	<0.002	<0.004	<0.004	<0.003	<0.004	<0.006	<0.004
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.002	<0.005	<0.002	<0.004	<0.004	<0.003	<0.004	<0.006	<0.004
UR-10	351137089542501	04-23-97	0902	FS	0.139	0.122	0.155	0.122	0.124	0.114	0.126	0.116	0.121
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.002	<0.005	<0.002	<0.004	<0.004	<0.003	<0.004	<0.006	<0.004
UR-22	350320089502901	05-07-97	1502	FS	0.104	0.100	0.123	0.105	0.103	0.083	0.110	0.099	0.099
		05-07-97	1503	FSR	0.106	0.097	0.122	0.108	0.102	0.091	0.118	0.099	0.103
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.002	<0.005	<0.002	<0.004	<0.004	<0.003	<0.004	<0.006	<0.004
		05-29-97	1002	FS	0.158	0.126	0.136	0.138	0.122	0.102	0.069	0.178	0.117
		05-29-97	1003	FSR	0.135	0.117	0.123	0.099	0.110	E0.164	0.170	0.169	0.113
Sample fortification concentration (water)					0.09	0.1	0.09	0.10	0.10	0.10	0.1	0.1	0.09

Table 3-9. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2010; UG/L, micrograms per liter; <, less than; E, Estimated value; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	PENDI- METH- ALIN WAT FLT 0.7 U GF, REC (UG/L)	PER- METHRIN CIS WAT FLT 0.7 U GF, REC (UG/L)	PHORATE WATER FLTRD 0.7 U GF, REC (UG/L)	PRO- METON, WATER, DISS, REC (UG/L)	PRON- AMIDE WATER FLTRD 0.7 U GF, REC (UG/L)	PROP- CHLOR, WATER, DISS, REC (UG/L)	PRO- PANIL WATER FLTRD 0.7 U GF, REC (UG/L)	PRO- PARGITE WATER FLTRD 0.7 U GF, REC (UG/L)	SI- MAZINE, WATER, DISS, REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005
UR-10	351137089542501	04-23-97	0902	FS	0.114	0.019	0.085	0.138	0.124	0.133	0.128	0.114	0.138
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005
UR-22	350320089502901	05-07-97	1502	FS	0.061	0.016	0.077	0.120	0.097	0.112	0.107	0.091	0.238
		05-07-97	1503	FSR	0.068	0.018	0.070	0.123	0.104	0.112	0.117	0.100	0.238
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.004	<0.005	<0.002	<0.018	<0.003	<0.007	<0.004	<0.013	<0.005
		05-29-97	1002	FS	0.103	0.020	0.090	0.136	0.112	0.131	0.127	0.108	0.540
		05-29-97	1003	FSR	E0.210	0.026	0.100	0.116	0.113	0.116	0.134	E0.154	0.478
Sample fortification concentration (water)					0.1	0.03	0.1	0.1	0.1	0.1	0.1	0.09	0.1

Table 3-10. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2010; UG/L, micrograms per liter; <, less than; E, Estimated value; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	TEBU-THIURON WATER FLTRD 0.7 U GF, REC (UG/L)	TER-BACIL WATER FLTRD 0.7 U GF, REC (UG/L)	THIO-BENCARB WATER FLTRD 0.7 U GF, REC (UG/L)	TRIAL-LATE WATER FLTRD 0.7 U GF, REC (UG/L)	TRI-FLUR-ALIN WAT FLT 0.7 U GF, REC (UG/L)	DEETHYL ATRA-ZINE, WATER, DISS, REC (UG/L)	METHYL AZIN-PHOS WAT FLT 0.7 U GF, REC (UG/L)	CAR-BARYL WATER FLTRD 0.7 U GF, REC (UG/L)	CARBO-FURAN WATER FLTRD 0.7 U GF, REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.010	<0.007	<0.002	<0.001	<0.002	<0.002	<0.001	<0.003	<0.003
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.010	<0.007	<0.002	<0.001	<0.002	<0.002	<0.001	<0.003	<0.003
UR-10	351137089542501	04-23-97	0902	FS	0.171	E0.110	0.125	0.113	0.110	E0.095	E0.220	E0.035	E0.208
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.010	<0.007	<0.002	<0.001	<0.002	<0.002	<0.001	<0.003	<0.003
UR-22	350320089502901	05-07-97	1502	FS	0.169	E0.121	0.110	0.097	0.101	E0.082	E0.103	E0.135	E0.122
		05-07-97	1503	FSR	0.172	E0.122	0.102	0.091	0.102	E0.071	E0.104	E0.116	E0.126
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.010	<0.007	<0.002	<0.001	<0.002	<0.002	<0.001	<0.003	<0.003
		05-29-97	1002	FS	0.197	E0.143	0.118	0.108	0.114	E0.089	E0.222	E0.212	E0.168
		05-29-97	1003	FSR	0.160	E0.140	0.126	0.107	0.120	E0.086	E0.239	E0.280	E0.190
Sample fortification concentration (water)					0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 3-11. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2010; UG/L, micrograms per liter; ML, milliliters; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	TER-BUFOS WATER FLTRD 0.7 U GF, REC (UG/L)	ACETO-CHLOR, WATER FLTRD REC (UG/L)	DIAZ-INON D10 SRG WAT FLT 0.7 U GF, REC PERCENT	HCH ALPHA D6 SRG WAT FLT 0.7 U GF, REC PERCENT	TERBUTH YLAZINE SURROGT WAT FLT 0.7 U GF, REC PERCENT	SAMPLE OR SPIKE VOLUME SCHED-ULE 2010 (ML)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.013	<0.002	84.1	65.5	84.7	854
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.013	<0.002	99.4	94.8	119	884
UR-10	351137089542501	04-23-97	0902	FS	0.096	0.125	109	110	125	806
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.013	<0.002	93.5	90.5	117	934
UR-22	350320089502901	05-07-97	1502	FS	0.093	0.113	99.5	90.2	120	952
		05-07-97	1503	FSR	0.087	0.104	97.1	82.0	109	892
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.013	<0.002	105	100	114	961
		05-29-97	1002	FS	0.088	0.129	110	92.9	120	892
		05-29-97	1003	FSR	0.108	0.120	126	111	120	934
Sample fortification concentration (water)					0.1	0.1	--	--	--	0.1

Table 3-12. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2051; UG/L, micrograms per liter; <, less than; E, Estimated value, --, no data; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	2,4,5-T DIS-SOLVED (UG/L)	2,4-D, DIS-SOLVED (UG/L)	2,4-DB WATER, FLTRD, GF 0.7U REC (UG/L)	ACIFL-UORFEN WATER, FLTRD, GF 0.7U REC (UG/L)	ALDI-CARB, WATER, FLTRD, GF 0.7U REC (UG/L)	ALDI-CARB SULFONE WAT,FLT GF 0.7U REC (UG/L)	ALDICA-RB SUL-FOXIDE, WAT,FLT GF 0.7U REC (UG/L)	BENTA-ZON, WATER, FLTRD, GF 0.7U REC (UG/L)	BRO-MACIL, WATER, DISS, REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.035	<0.035	<0.035	<0.035	<0.016	<0.016	<0.021	<0.014	<0.035
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.035	<0.035	<0.035	<0.035	<0.016	<0.016	<0.021	<0.014	<0.035
UR-10	351137089542501	04-24-97	1002	FS	0.880	0.870	0.720	1.01	--	0.280	0.720	0.840	0.920
		04-23-97	1003	FSR	0.980	0.980	0.820	1.18	--	0.280	0.730	0.940	0.950
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.035	<0.035	<0.035	<0.035	<0.016	<0.016	<0.021	<0.014	<0.035
UR-22	350320089502901	05-07-97	1402	FS	0.900	0.900	0.820	0.990	--	0.330	0.830	E0.970	--
		05-07-97	1403	FSR	0.890	0.900	0.910	0.980	--	0.360	0.830	0.990	1.13
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.035	<0.035	<0.035	<0.035	<0.016	<0.016	<0.021	<0.014	<0.035
		05-29-97	1102	FS	0.830	--	0.530	0.930	<0.016	0.240	0.530	0.900	--
		05-29-97	1103	FSR	0.900	E16.2	0.780	0.900	--	0.170	0.690	0.860	E1.86
Sample fortification concentration (water)					0.909	0.934	0.924	1.10	1.15	1.18	1.17	0.949	1.09

Table 3-13. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2051; UG/L, micrograms per liter; <, less than; E, Estimated value; --, no data; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	BRO-MOXYNIL WATER, FLTRD, GF 0.7U REC (UG/L)	CAR-BARYL, WATER, FLTRD, GF 0.7U REC (UG/L)	CARBO-FURAN, WATER, FLTRD, GF 0.7U REC (UG/L)	3HYDRXY CARBO-FURAN WAT,FLT GF 0.7U REC (UG/L)	CHLOR-AMBEN, WATER, FLTRD, GF 0.7U REC (UG/L)	CHLORO-THALO-NIL, WAT,FLT GF 0.7U REC (UG/L)	CLOPYR-ALID, WATER, FLTRD, GF 0.7U REC (UG/L)	DACTHAL MONO-ACID, WAT,FLT GF 0.7U REC (UG/L)	DICAMBA WATER, FLTRD, GF 0.7U REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.035	<0.008	<0.028	<0.014	<0.011	<0.035	<0.050	<0.017	<0.035
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.035	<0.008	<0.028	<0.014	<0.011	<0.035	<0.050	<0.017	<0.035
UR-10	351137089542501	04-24-97	1002	FS	0.970	1.03	1.08	0.950	<0.011	E0.740	0.440	0.930	0.820
		04-23-97	1003	FSR	1.04	1.07	1.00	0.920	<0.011	E0.510	0.900	1.04	0.970
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.035	<0.008	<0.028	<0.014	<0.011	<0.035	<0.050	<0.017	<0.035
UR-22	350320089502901	05-07-97	1402	FS	0.920	E1.00	0.860	0.800	<0.011	E0.670	E0.550	0.930	0.830
		05-07-97	1403	FSR	0.890	1.02	E0.790	0.780	<0.011	E0.400	0.680	0.920	0.860
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.035	<0.008	<0.028	<0.014	<0.011	<0.035	<0.050	<0.017	<0.035
		05-29-97	1102	FS	0.870	0.940	0.920	0.910	<0.011	E0.080	<0.050	--	--
		05-29-97	1103	FSR	0.870	E1.11	0.960	0.920	<0.011	E0.610	<0.050	0.860	E2.26
Sample fortification concentration (water)					0.948	1.07	1.05	1.12	0.001	0.10	0.898	0.966	0.918

Table 3-14. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2051; UG/L, micrograms per liter; <, less than; E, Estimated value; --, no data; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	DICHLO-BENIL, WATER, FLTRD, GF 0.7U REC (UG/L)	DICHLOR PROP, WATER, FLTRD, GF 0.7U REC (UG/L)	DINOSEB WATER, FLTRD, GF 0.7U REC (UG/L)	DIURON, WATER, FLTRD, GF 0.7U REC (UG/L)	DNOC WAT,FLT GF 0.7U REC (UG/L)	ESFEN-VAL-ERATE, WAT,FLT GF 0.7U REC (UG/L)	FEN-URON, WATER, FLTRD, GF 0.7U REC (UG/L)	FLUO-METURON WATER, FLTRD, GF 0.7U REC (UG/L)	LINURON WATER, FLTRD, GF 0.7U REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.020	<0.032	<0.035	<0.020	<0.035	<0.019	<0.013	<0.035	<0.018
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.020	<0.032	<0.035	<0.020	<0.035	<0.019	<0.013	<0.035	<0.018
UR-10	351137089542501	04-24-97	1002	FS	E0.320	0.860	0.820	0.990	E0.570	E0.130	1.06	1.04	0.890
		04-23-97	1003	FSR	E0.330	0.940	0.950	1.02	E0.730	E0.320	1.13	1.10	0.890
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.020	<0.032	<0.035	<0.020	<0.035	<0.019	<0.013	<0.035	<0.018
UR-22	350320089502901	05-07-97	1402	FS	E0.380	0.860	0.820	0.930	E0.640	E0.190	0.900	0.940	0.730
		05-07-97	1403	FSR	E0.390	0.860	0.790	0.950	E0.460	E0.250	0.900	0.910	0.750
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.020	<0.032	<0.035	<0.020	<0.035	<0.019	<0.013	<0.035	<0.018
		05-29-97	1102	FS	E0.490	--	0.790	0.990	E0.810	<0.019	1.14	0.940	0.900
		05-29-97	1103	FSR	E0.550	0.530	0.820	0.850	E0.790	<0.019	1.01	0.930	0.860
Sample fortification concentration (water)					1.01	0.953	0.938	1.07	0.992	1.06	1.18	1.05	1.08

Table 3-15. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)
[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2051; UG/L, micrograms per liter; <, less than; E, Estimated value; --, concentration not reported; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	MCPA, WATER, FLTRD, GF 0.7U REC (UG/L)	MCPB, WATER, FLTRD, GF 0.7U REC (UG/L)	METHIO-CARB, WATER, FLTRD, GF 0.7U REC (UG/L)	METH-OMYL, WATER, FLTRD, GF 0.7U REC (UG/L)	1-NAPH THOL, WATER, FLTRD, GF 0.7U REC (UG/L)	NEB-URON, WATER, FLTRD, GF 0.7U REC (UG/L)	NORFLUR AZON, WATER, FLTRD, GF 0.7U REC (UG/L)	ORY-ZALIN, WATER, FLTRD, GF 0.7U REC (UG/L)	OXAMYL, WATER, FLTRD, GF 0.7U REC (UG/L)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.050	<0.035	<0.026	<0.017	<0.007	<0.015	<0.024	<0.019	<0.018
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.050	<0.035	<0.026	<0.017	<0.007	<0.015	<0.024	<0.019	<0.018
UR-10	351137089542501	04-24-97	1002	FS	0.860	0.690	0.920	0.990	<0.007	0.930	1.00	0.850	0.790
		04-23-97	1003	FSR	0.980	0.760	0.940	0.990	<0.007	E0.920	1.03	0.840	0.840
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.050	<0.035	<0.026	<0.017	<0.007	<0.015	<0.024	<0.019	<0.018
UR-22	350320089502901	05-07-97	1402	FS	0.880	E0.730	0.780	0.800	<0.007	0.760	0.840	0.730	0.720
		05-07-97	1403	FSR	0.860	0.750	0.800	0.820	<0.007	0.800	0.880	0.820	0.730
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.050	<0.035	<0.026	<0.017	<0.007	<0.015	<0.024	<0.019	<0.018
		05-29-97	1102	FS	0.660	0.470	0.850	0.910	<0.007	0.820	1.00	0.650	0.770
		05-29-97	1103	FSR	1.01	0.640	0.870	0.790	<0.007	0.730	0.870	0.550	0.800
Sample fortification concentration (water)					0.935	0.939	1.06	1.04	--	1.09	1.04	1.14	0.990

Table 3-16. Quality-assurance data for pesticides in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; FS, field spike; FSR, field spike replicate. NWQL Lab Schedule 2051; UG/L, micrograms per liter; <, less than; E, Estimated value; --, concentration not reported sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 1 liter]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	PICLORAM, WATER, FLTRD, GF 0.7U REC (UG/L)	PROPHAM, WATER, FLTRD, GF 0.7U REC (UG/L)	PROPOXUR, WATER, FLTRD, GF 0.7U REC (UG/L)	SILVEX, DISSOLVED (UG/L)	TRICLOPYR, WATER, FLTRD, GF 0.7U REC (UG/L)	BDMC, SURROG, WATER, UNFLTRD REC PERCENT	SAMPLE OR SPIKE VOLUME, SCHEDULE 2051 (ML)
OFFICE	344459092235201	04-16-97	1305	EQ.BLK	<0.050	<0.035	<0.035	<0.021	<0.050	80.0	873
UR-06	351403089552601	05-01-97	1205	EQ.BLK	<0.050	<0.035	<0.035	<0.021	<0.050	E0.00	911
UR-10	351137089542501	04-24-97	1002	FS	0.870	0.780	0.990	0.910	0.960	94.0	887
		04-23-97	1003	FSR	1.01	0.850	0.980	1.03	1.12	97.0	830
UR-20	350643089502001	05-15-97	0905	EQ.BLK	<0.050	<0.035	<0.035	<0.021	<0.050	74.0	986
UR-22	350320089502901	05-07-97	1402	FS	E0.910	0.750	0.810	0.920	0.940	70.0	924
		05-07-97	1403	FSR	0.910	0.740	0.820	0.880	0.930	75.0	942
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<0.050	<0.035	<0.035	<0.021	<0.050	93.0	958
		05-29-97	1102	FS	0.780	0.920	0.820	0.870	0.940	100	897
		05-29-97	1103	FSR	0.740	0.730	0.950	0.830	1.06	75.0	926
Sample fortification concentration (water)					1.0	1.08	1.07	0.945	0.976	--	0.1

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997

[OFFICE, equipment blank collected prior to the start of the season in the USGS Arkansas District office parking lot. EQ.BLK, equipment blank; TR.BLK, trip blank; sample fortification concentration is the theoretical concentration when 100 microliters of the spike mixture is added to a water volume of 40 milliliters; --, concentration not reported; FS, field spike; FSR, field spike replicate; UG/L, micrograms per liter; <, less than; E, estimated value; SFC, sample fortification concentration (water)]

SITE	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	DI-CHLORO-DI-FLUORO-METHANE TOTAL (UG/L)	TRI-CHLORO-FLUORO-METHANE TOTAL (UG/L)	FREON-113 WATER UNFLTRD REC (UG/L)	ETHANE HEXA-CHLORO-WATER UNFLTRD RECOVER (UG/L)	CHLORO-FORM TOTAL (UG/L)	BROMO-DI-CHLORO-METHANE TOTAL (UG/L)	CHLORO-DI-BROMO-METHANE TOTAL (UG/L)	BROMO-FORM TOTAL (UG/L)
OFFICE	344459092235201	04-16-97	1205	EQ.BLK	<.200	<.100	<.050	<.050	.188	<.100	<.100	<.200
UR-01	350149090063801	05-22-97	1005	EQ.BLK	<.200	<.100	<.050	<.050	<.050	<.100	<.100	<.200
UR-10	351137089542501	04-23-97	0908	TR.BLK	<.200	<.100	<.050	<.050	<.050	<.100	<.100	<.200
		04-23-97	0902	FS	<.200	<.100	E.030	<.050	E.020	2.52	2.26	2.48
		04-23-97	0903	FSR	<.200	<.100	E.030	<.050	E.020	2.54	2.25	2.44
UR-17	351319089504401	04-29-97	1205	EQ.BLK	<.200	<.100	<.050	<.050	E.020	<.100	<.100	<.200
UR-22	350320089502901	05-07-97	1502	FS	<.200	<.100	E.030	<.050	E.040	2.42	2.30	2.35
		05-07-97	1503	FSR	<.200	<.100	E.030	<.050	E.040	2.28	2.17	2.20
UR-26	350543089473901	05-29-97	1005	EQ.BLK	<.200	<.100	<.050	<.050	<.050	<.100	<.100	<.200
		05-29-97	1002	FS	<.200	<.100	E.050	<.050	E.020	2.34	2.13	1.98
		05-29-97	1003	FSR	<.200	<.100	E.040	<.050	E.020	2.21	1.97	1.88
UR-31	350424089593901	05-05-97	1305	EQ.BLK	<.200	<.100	<.050	<.050	E.030	<.100	<.100	<.200
SFC					--	--	--	--	E.02	2.5	2.4	2.5

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997--(continued)

SITE	METHYL-CHLO-RIDE TOTAL (UG/L)	1,1-DI-CHLORO-ETHANE TOTAL (UG/L)	1,1,1-TRI-CHLORO-ETHANE TOTAL (UG/L)	CHLORO-ETHANE TOTAL (UG/L)	1,2-DIBROMO ETHANE WATER WHOLE TOTAL (UG/L)	1,2-DI-CHLORO-ETHANE TOTAL (UG/L)	1,1,2-TRI-CHLORO-ETHANE TOTAL (UG/L)	ETHANE, 1112-TETRA-CHLORO-WAT UNF REC (UG/L)	ETHANE, 1,1,2,2 TETRA-CHLORO-WAT UNF REC (UG/L)	METHYL-BROMIDE TOTAL (UG/L)	METHYL IODIDE WATER UNFLTRD RECOVER (UG/L)	METHANE BROMO CHLORO-WAT UNFLTRD REC (UG/L)	DI-BROMO-METHANE WATER WHOLE RECOVER (UG/L)	METHYL ENE CHLO-RIDE TOTAL (UG/L)	CARBON TETRA-CHLO-RIDE TOTAL (UG/L)
OFFICE	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	<.100	<.050
UR-01	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	<.104	<.050
UR-10	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	E.040	<.050
	<.200	<.050	2.45	<.100	<.100	2.36	<.100	<.050	<.100	<.100	<.050	<.100	E.010	E.090	2.48
	<.200	E.010	2.46	<.100	<.100	2.37	<.100	<.050	<.100	<.100	<.050	<.100	E.010	E.090	2.46
UR-17	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	<.200	<.050
UR-22	E.070	E.010	2.30	<.100	<.100	2.38	<.100	<.050	<.100	<.100	E.010	<.100	<.100	<.108	2.28
	.134	<.050	2.21	<.100	<.100	2.20	<.100	<.050	<.100	<.100	E.020	<.100	<.100	<.100	2.19
UR-26	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	<.100	<.050
	E.060	<.050	2.50	<.100	<.100	2.43	<.100	<.050	<.100	<.100	<.050	<.100	<.100	<.118	2.54
	E.070	<.050	2.26	<.100	<.100	2.25	<.100	<.050	<.100	<.100	<.050	<.100	E.030	<.114	2.24
UR-31	<.200	<.050	<.050	<.100	<.100	<.050	<.100	<.050	<.100	<.100	<.050	<.100	<.100	.259	<.050
SFC	.01	E0.02	--	--	--	2.5	--	--	--	E0.02	E0.03	--	--	0.1	2.5

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

SITE	1,3-DI-CHLORO-PROPANE WAT. WH TOTAL (UG/L)	1,2-DI-CHLORO-PROPANE TOTAL (UG/L)	2,2-DI CHLORO-PRO-PANE WAT, WH TOTAL (UG/L)	123-TRI CHLORO-PROPANE WATER WHOLE TOTAL (UG/L)	DIBROMO CHLORO-PROPANE WATER WHOLE TOT.REC (UG/L)	STYRENE TOTAL (UG/L)	NAPHTH-ALENE TOTAL (UG/L)	TETRA-CHLORO-ETHYL-ENE TOTAL (UG/L)	TRI-CHLORO-ETHYL-ENE TOTAL (UG/L)	1,1-DI-CHLORO-ETHYL-ENE TOTAL (UG/L)	TRANS-1,2-DI-CHLORO-ETHENE TOTAL (UG/L)	CIS-1,2 -DI-CHLORO-ETHENE WATER TOTAL (UG/L)	VINYL CHLO-RIDE TOTAL (UG/L)	BROMO-ETHENE WATER UNFLTRD RECOVER (UG/L)
OFFICE	<.050	<.050	<.050	<.200	<.500	E.030	E.020	<.050	<.050	<.100	<.050	<.050	<.100	<.100
UR-01	<.050	<.050	<.050	<.200	<.500	<.050	<.200	<.050	<.050	<.100	<.050	<.050	<.100	<.100
UR-10	<.050	<.050	<.050	<.200	<.500	<.050	<.200	<.050	<.050	<.100	<.050	<.050	<.100	<.100
	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.08	2.37	2.95	<.050	<.050	2.97	<.100
	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.10	2.40	2.95	<.050	<.050	2.87	<.100
UR-17	<.050	<.050	<.050	<.200	<.500	<.050	<.200	<.050	E.010	<.100	<.050	<.050	<.100	<.100
UR-22	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.06	2.27	2.48	<.050	E.004	2.26	<.100
	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.02	2.19	2.38	<.050	E.006	1.98	<.100
UR-26	<.050	<.050	<.050	<.200	<.500	<.050	<.200	<.050	<.050	<.100	<.050	<.050	<.100	<.100
	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.25	2.46	2.80	<.050	<.050	2.63	<.100
	<.050	<.050	<.050	<.200	<.500	<.050	<.200	2.07	2.20	2.46	<.050	<.050	2.14	<.100
UR-31	<.050	<.050	<.050	<.200	<.500	<.050	<.200	<.050	<.050	<.100	<.050	<.050	<.100	<.100
SFC	--	--	--	--	--	--	--	2.3	2.4	3.0	--	--	3.8	--

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997--(continued)

SITE	PROPENE 3- CHLORO- WATER UNFLTRD RECOVER (UG/L)	1,1-DI CHLORO- PRO- PENE, WAT, WH TOTAL (UG/L)	CIS 1,3-DI- CHLORO- PROPENE TOTAL (UG/L)	TRANS- 1,3-DI- CHLORO- PROPENE TOTAL (UG/L)	2BUTENE TRANS-1 4-DI- CHLORO UNFLTRD RECOVER (UG/L)	HEXA- CHLORO- BUT- ADIENE TOTAL (UG/L)	META/ PARA- XYLENE WATER UNFLTRD REC (UG/L)	TOLUENE TOTAL (UG/L)	BENZENE 124-TRI METHYL UNFILT RECOVER (UG/L)	BENZENE 135-TRI METHYL WATER UNFLTRD REC (UG/L)	BENZENE TOTAL (UG/L)	BENZENE 123-TRI METHYL- WATER UNFLTRD RECOVER (UG/L)	O- XYLENE WATER WHOLE TOTAL (UG/L)	ETHYL- BENZENE TOTAL (UG/L)
OFFICE	<.100	<.050	<.100	<.100	<5.00	<.200	E.100	.140	E.080	E.040	<.050	E.030	E.050	E.010
UR-01	<.100	<.050	<.100	<.100	<5.00	<.200	E.030	<.050	E.020	<.050	<.050	<.050	<.050	<.050
UR-10	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	E.007	<.050	<.050	<.050	<.050	<.050	<.050
	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	E.020	<.050	<.050	E.010	<.050	<.050	2.31
	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	E.030	<.050	<.050	E.020	<.050	<.050	2.37
UR-17	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
UR-22	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	<.050	E.010	<.050	<.050	<.050	<.050	2.27
	<.100	<.050	<.100	<.100	<5.00	<.200	E.020	<.050	E.010	<.050	<.050	<.050	<.050	2.15
UR-26	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
	<.100	<.050	<.100	<.100	<5.00	<.200	E.010	.103	<.050	<.050	E.030	<.050	<.050	2.42
	<.100	<.050	<.100	<.100	<5.00	<.200	E.010	.100	<.050	<.050	E.020	<.050	<.050	2.19
UR-31	<.100	<.050	<.100	<.100	<5.00	<.200	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050
SFC	--	--	--	--	--	--	--	--	--	--	--	--	--	2.4

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

SITE	ISO-PROPYL-BENZENE WATER WHOLE REC (UG/L)	BENZENE N-PROPY WATER UNFLTRD REC (UG/L)	BENZENE TERT-BUTYL-WATER UNFLTRD REC (UG/L)	BENZENE SEC BUTYL-WATER UNFLTRD REC (UG/L)	BENZENE N-BUTYL WATER UNFLTRD REC (UG/L)	ISO-DURENE WATER UNFLTRD RECOVER (UG/L)	PREH-NITENE WATER UNFLTRD RECOVER (UG/L)	TOLUENE O-ETHYL WATER UNFLTRD RECOVER (UG/L)	P-ISO-PROPYL-TOLUENE WATER WHOLE REC (UG/L)	METHYL TERT-BUTYL ETHER WAT UNF REC (UG/L)	DI-ISO-PROPYL-ETHER, WATER, UNFLTRD RECOVER (UG/L)	ETHER ETHYL WATER UNFLTRD RECOVER (UG/L)	ETHER TERT-BUTYL ETHYL UNFLTRD RECOVER (UG/L)	ETHER TERT-PENTYL METHYL UNFLTRD RECOVER (UG/L)	ACETONE WATER WHOLE TOTAL (UG/L)
OFFICE	<.050	<.050	<.050	<.050	<.050	E.007	E.006	E.010	<.050	<.100	<.100	<.100	<.100	<.100	4.99
UR-01	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.100	<.100	<.100	<.100	<.100	<5.00
UR-10	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.100	<.100	<.100	<.100	<.100	<5.00
	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.79	<.100	<.100	<.100	<.100	E1.00
	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.76	<.100	<.100	<.100	<.100	E1.00
UR-17	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.100	<.100	<.100	<.100	<.100	16.2
UR-22	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.53	E.030	<.100	<.100	<.100	E1.00
	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.35	E.020	<.100	<.100	<.100	E1.00
UR-26	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.100	<.100	<.100	<.100	<.100	<5.00
	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.49	<.100	<.100	<.100	<.100	2.29
	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	2.38	<.100	<.100	<.100	<.100	2.13
UR-31	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.050	<.100	<.100	<.100	<.100	<.100	19.1
SFC	--	--	--	--	--	--	--	--	--	2.8	--	--	--	--	2.8

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

SITE	METHYL-ETHYL-KETONE WATER WHOLE TOTAL (UG/L)	METHYL ISO-BUTYL KETONE WAT.WH. TOTAL (UG/L)	2-HEXA-NONE WATER WHOLE TOTAL (UG/L)	CARBON DI-SULFIDE WATER WHOLE TOTAL (UG/L)	ACRO-LEIN TOTAL (UG/L)	FURAN, TETRA-HYDRO- WATER UNFLTRD RECOVER (UG/L)	ACRYLO-NITRILE TOTAL (UG/L)	METH-ACRYLO-NITRITE WATER UNFLTRD RECOVER (UG/L)	METHYL ACRY-LATE WATER UNFLTRD RECOVER (UG/L)	METHAC-RYLATE METHYL WATER UNFLTRD RECOVER (UG/L)	METHAC-RYLATE ETHYL- WATER UNFLTRD RECOVER (UG/L)	ACETATE VINYL WATER UNFLTRD RECOVER (UG/L)	BENZENE 1,4-DI-CHLORO- WATER UNFLTRD REC (UG/L)	CHLORO-BENZENE TOTAL (UG/L)	BENZENE O-DI-CHLORO- WATER UNFLTRD REC (UG/L)	BENZENE 1,3-DI-CHLORO- WATER UNFLTRD REC (UG/L)
OFFICE	<5.00	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	E.010	<.050	<.050	<.050
UR-01	<5.00	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	<.050	<.050	<.050	<.050
UR-10	<5.00	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	<.050	<.050	<.050	<.050
	E.900	<5.00	<5.00	E.040	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.22	<.050	<.050	<.050
	E.900	<5.00	<5.00	E.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.25	<.050	<.050	<.050
UR-17	<5.00	<5.00	<5.00	E.010	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	<.050	<.050	<.050	<.050
UR-22	1.04	<5.00	<5.00	E.040	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.15	<.050	<.050	<.050
	E.700	<5.00	<5.00	E.030	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.04	<.050	<.050	<.050
UR-26	<5.00	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	<.050	<.050	<.050	<.050
	1.07	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.18	<.050	<.050	<.050
	1.14	<5.00	<5.00	.171	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	2.04	<.050	<.050	<.050
UR-31	<5.00	<5.00	<5.00	<.050	<2.00	<5.00	<2.00	<2.00	<2.00	<1.00	<1.00	<5.00	<.050	<.050	<.050	<.050
SFC	1.4	--	--	E0.05	--	--	--	--	--	--	--	--	2.4	--	--	--

Table 3-17. Quality-assurance data for volatile organic compounds in water from monitor wells, Memphis vicinity, Tennessee, 1997 (continued)

SITE	1,2,3-TRI-CHLORO BENZENE WAT, WH REC (UG/L)	BENZENE 1,2,4-TRI-CHLORO-WAT UNF REC (UG/L)	BROMO-BENZENE WATER, WHOLE, TOTAL (UG/L)	O-CHLORO-TOLUENE WATER WHOLE TOTAL (UG/L)	TOLUENE P-CHLOR WATER UNFLTRD REC (UG/L)
OFFICE	<.200	<.200	<.050	<.050	<.050
UR-01	<.200	<.200	<.050	<.050	<.050
UR-10	<.200	<.200	<.050	<.050	<.050
	<.200	<.200	<.050	<.050	<.050
	<.200	<.200	<.050	<.050	<.050
UR-17	<.200	<.200	<.050	<.050	<.050
UR-22	<.200	<.200	<.050	<.050	<.050
	<.200	<.200	<.050	<.050	<.050
UR-26	<.200	<.200	<.050	<.050	<.050
	<.200	<.200	<.050	<.050	<.050
	<.200	<.200	<.050	<.050	<.050
UR-31	<.200	<.200	<.050	<.050	<.050
SFC	--	--	--	--	--

Table 3-18. Quality-assurance data for isotopes in water from monitor wells, Memphis vicinity, Tennessee, 1997

[REPLCT, replicate; NORMAL, regular sample from Appendix 2, table 2-13; PCI/L, picoCuries per liter]

	STATION NUMBER	DATE	TIME	QA SAMPLE TYPE	RADON 222 TOTAL (PCI/L)
UR-02	350245090035501	05-06-97	1401	RPLCT	328
			1400	NORMAL	391
UR-11	350229089525601	05-20-97	1501	RPLCT	178
			1500	NORMAL	144

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