# Water-Resources Investigations in Tennessee: Programs and Activities of the U.S. Geological Survey, 1995-96

Compiled by BARBARA H. BALTHROP and KIMBERLY A. CARNEY

U.S. Geological Survey

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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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## A Message from the District Chief

This report is the most recent in a series published about every 2 years that describes the programs and activities of the Tennessee District of the U.S. Geological Survey (USGS), Water Resources Division. The report summarizes the objectives and status of projects conducted during 1995-96 as part of the cooperative and Federal programs of the USGS in Tennessee.

Tennessee is fortunate in that it has an abundance of surface and ground water, but the quality and availability of water resources throughout the State are not uniform. The water resources of Tennessee continue to be affected by contamination from point and nonpoint sources, wastewater treatment, and increased demands for water use. The USGS, in partnership with local, State, and Federal agencies, collects data and conducts investigations to address the water-resource issues in Tennessee. These water-resource issues include:

- Nonpoint-source pollution of surface waters from several sources including agriculture and urban storm runoff.
- Acid rain.
- Increased water-supply demands resulting in localized water shortages and the need to develop new sources of supply.
- Point-source pollution of ground water from industrial and domestic waste sites and abandoned mines.
- Point-source pollution of surface water by waste discharges from sewage treatment plants and industrial facilities.

The mission of the Tennessee District of the USGS is to assist local, State, and Federal agencies in collecting needed water-resources data to better understand the problems that affect this important resource, and to provide scientific analyses in the search for solutions. The USGS staff is dedicated to working in partnership with governmental agencies at all levels to meet these goals. I am proud of the dedication, capabilities, and accomplishments of the employees of the Tennessee District as reflected in the summaries provided in this report.

Harold C. Mattraw, Jr.
District Chief
Tennessee District

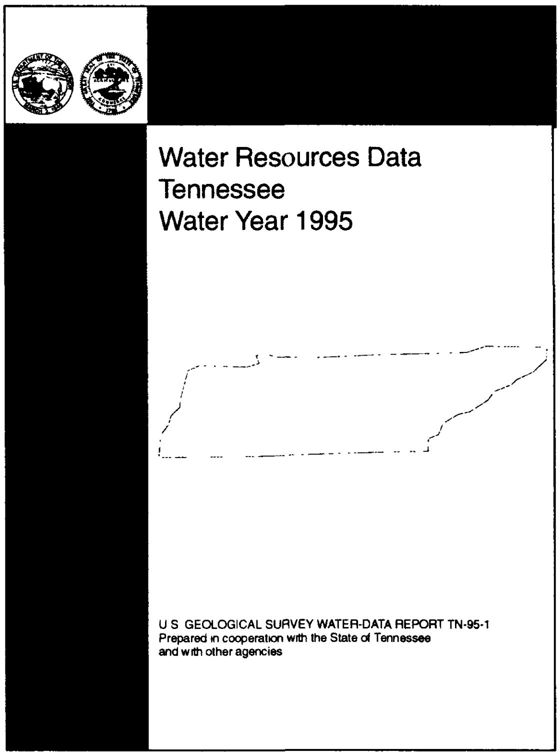
# CONTENTS

# Water-Resources Investigations in Tennessee: Programs and Activities of the U.S. Geological Survey, 1995–96

*Compiled by* Barbara H. Balthrop *and* Kimberly A. Carney

## HYDROLOGIC DATA COLLECTION

Hydrologic data, or basic data as this type of information is commonly known, is the mainstay of the investigations conducted by the Water Resources Division of the U.S. Geological Survey (USGS). The basic-data collection programs carried out by the Tennessee District provide streamflow, quality of water, and ground-water-level information essential to the assessment and management of the State's water resources. Long-term streamflow, quality of water, and ground-water-level networks are operated as part of the function of the Hydrologic Data Section. Field operations are about equally divided among field offices in Nashville, Knoxville, and Memphis. A staff of about 45 hydrologists and hydrologic technicians provide operational support for long-term networks as well as short-term networks established for areal investigations. The data collected from the networks are published in the series of annual data reports titled "Water Resources Data for Tennessee." The data also are readily available from the USGS District office in Nashville.

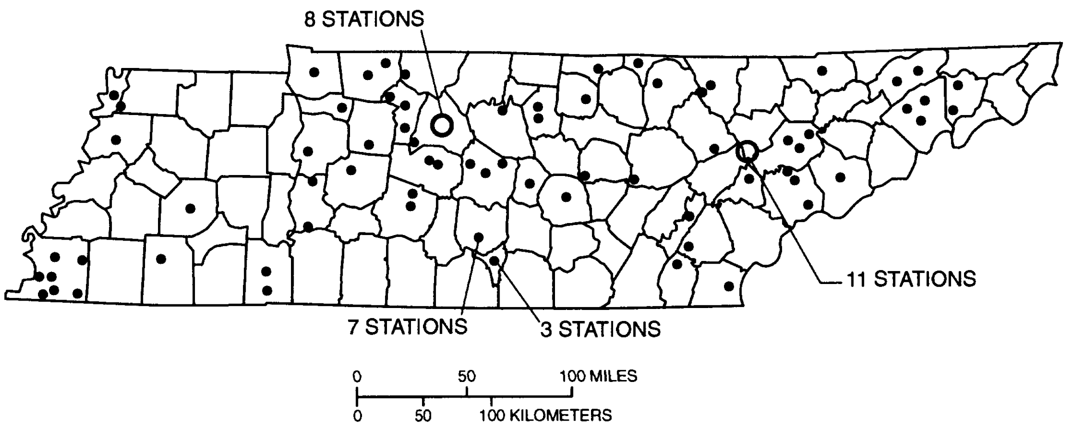


## Surface-Water Monitoring Network

The USGS, Tennessee District, operates a network of continuous streamflow-gaging stations throughout Tennessee. In 1995, the network was made up of 98 stations (Appendix 1). Additionally, crest-stage stations were maintained at 97 locations and rainfall data were collected at about 56 sites. Continuous streamflow data are recorded and disseminated for many purposes, including:

- Assessment of water availability.
- Operation of impoundments and pumping facilities.
- Flood or drought monitoring and forecasting.
- Waste disposal and control.
- Legal requirements and enforcement.
- Research and hydrologic trends or other special studies.

This program is conducted by the USGS in cooperation with the following agencies or municipal governments:
Tennessee Valley Authority
U.S. Army Corps of Engineers, Nashville District
U.S. Department of the Air Force, Arnold Engineering Development Center
U.S. Department of the Army
U.S. Department of Energy, Oak Ridge Operations Office
Tennessee Department of Environment and Conservation
Tennessee Department of Transportation
Tennessee Wildlife Resources Agency
Harpeth Valley Utility District
Duck River Development Agency
the Metropolitan Government of Nashville and Davidson County, Shelby County, the Memphis Light, Gas and Water Division of the City of Memphis, and the cities of Alcoa, Rogersville, Dickson, Franklin, Murfreesboro, Harriman, Sevierville, Camden, Crossville, Red Boiling Springs, Tullahoma, and Wartrace.



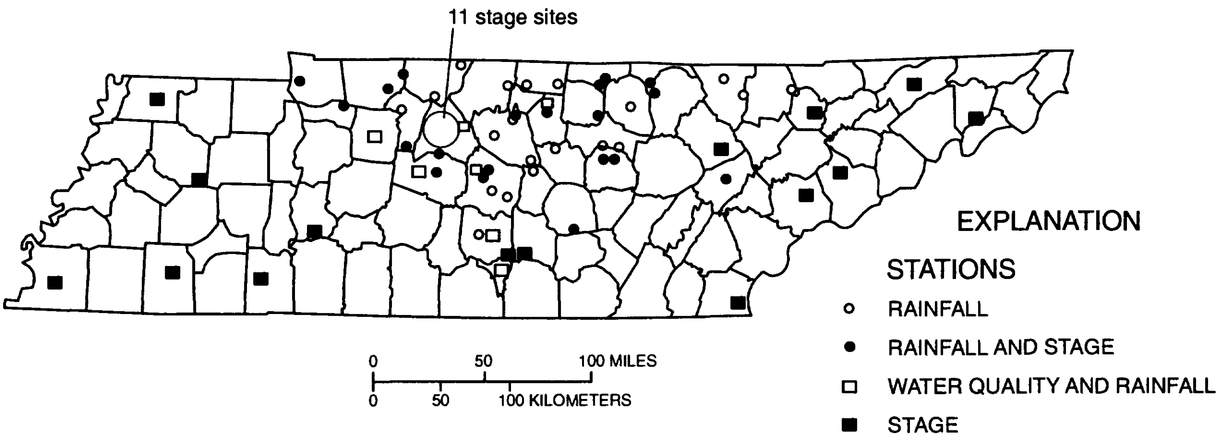

Location of streamflow stations in Tennessee.

## Real-Time Data-Collection Network

The surface-water monitoring network includes about 80 real-time gaging stations that monitor streamflow, rainfall, and, at some locations, water quality and air temperature. Most of these stations are operated in cooperation with the U.S. Army Corps of Engineers (COE). A few stations are operated in cooperation with the Tennessee Valley Authority (TVA) or with local governments.

At each of these stations, data are recorded in digital format and, at 2-, 3-, or 4-hour intervals, are radioed to the Geostationary Orbiting Earth Satellite (GOES). The data are returned to ground stations in South Carolina, Mississippi, or Tennessee, as appropriate, and are transmitted to offices of the USGS, COE, or TVA where the data can be displayed on computer screens or printed in graphic and tabular format. The real-time data-collection network permits the continuous monitoring of conditions at stations many miles away.

The COE and TVA use the data for the management and operation of the reservoir systems on the Cumberland and Tennessee Rivers. The rapid transmission of data describing events taking place in the field enables quick response during extreme hydrologic conditions. Several towns and cities in Tennessee also use real-time data to determine when streamflow is adequate to dispose of waste into the streams. The USGS uses the data to compute discharge and water-quality characteristics. Data transmitted to USGS offices are archived in computer files and included in the annual data reports.



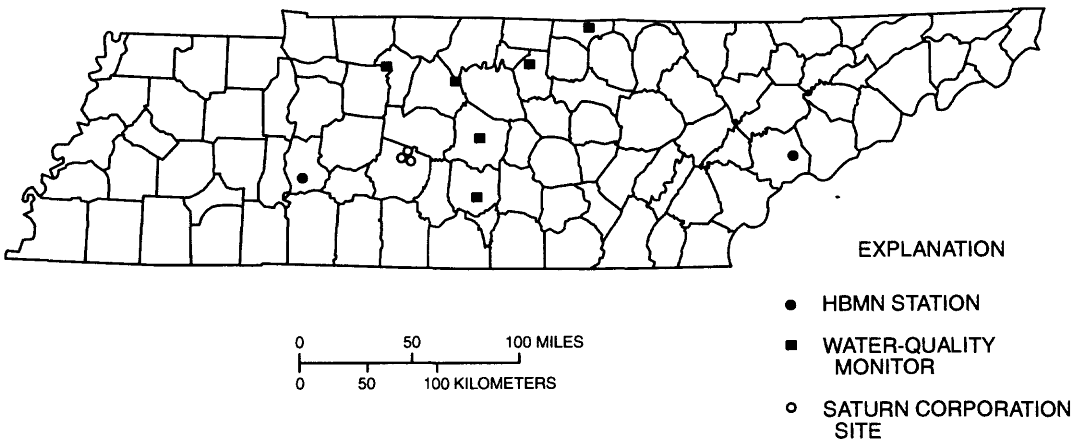

Location of real-time data-collection network stations.

## Water-Quality Network

The USGS monitors water quality at selected surface-water stations in Tennessee (Appendix 2). Two sites within the State were part of the national Hydrologic Bench-Mark Network (HBMN) during 1995. At HBMN sites, the USGS assesses natural streamflow and water quality of river basins that are known to be minimally affected by human activity.

Water-quality monitors are operated by the USGS, in cooperation with the U.S. Army Corps of Engineers, at four stations along the Cumberland River and its tributaries in Middle Tennessee. A fifth monitor is operated in cooperation with the City of Murfreesboro above the wastewater-treatment plant. These instruments record hourly values for water temperature and specific conductance, and in some cases, pH and dissolved-oxygen concentration.

Water quality is assessed quarterly at three stations in Maury County near the Saturn Corporation industrial facility in cooperation with the Tennessee Department of Environment and Conservation. At these sites, concentrations of suspended sediments, bacteria, organic compounds, and priority-pollutant metals are determined. Water quality has also been monitored in the Duck River at Shelbyville in cooperation with the Duck River Development Agency. In addition to the sites shown below, the Upper Tennessee National Water-Quality Assessment Program collects samples periodically for various chemical, physical, and bacteriological determinations at many sites in East Tennessee.

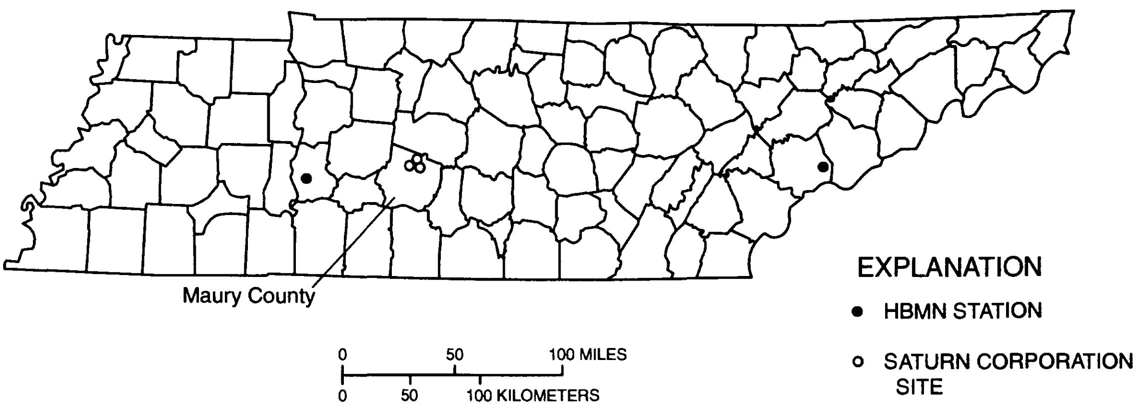



Water-quality data-collection sites in Tennessee.

## Suspended-Sediment Data Collection

Sediment is considered perhaps the most important nonpoint-source pollutant in stream water. The presence of much sediment makes water unsuitable for many purposes. Sediment is also a vehicle for transporting nutrients, pesticides, metals, and other undesirable constituents that are chemically bonded to it. Samples of water are analyzed for sediment content in order to measure and document the amount of material in transport.

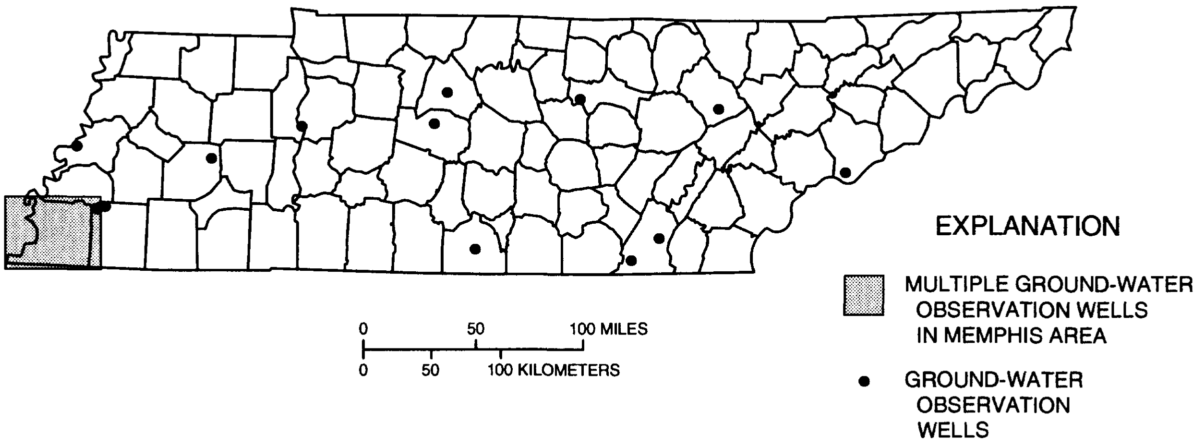
The USGS currently (1996) measures suspended sediment at several sites in Tennessee (Appendix 2). Suspended sediment is measured at two Hydrologic Bench-Mark Network (HBMN) stations, one on the Buffalo River near Flat Woods and the other on the Little River above Townsend. Suspended sediment is also measured at three sites in a project-oriented study in Maury County. Additionally, this constituent is measured at several stations in the Tennessee River drainage basin as part of the Upper Tennessee National Water-Quality Assessment Program.




Location of suspended-sediment stations in Tennessee.

## Ground-Water-Level Network

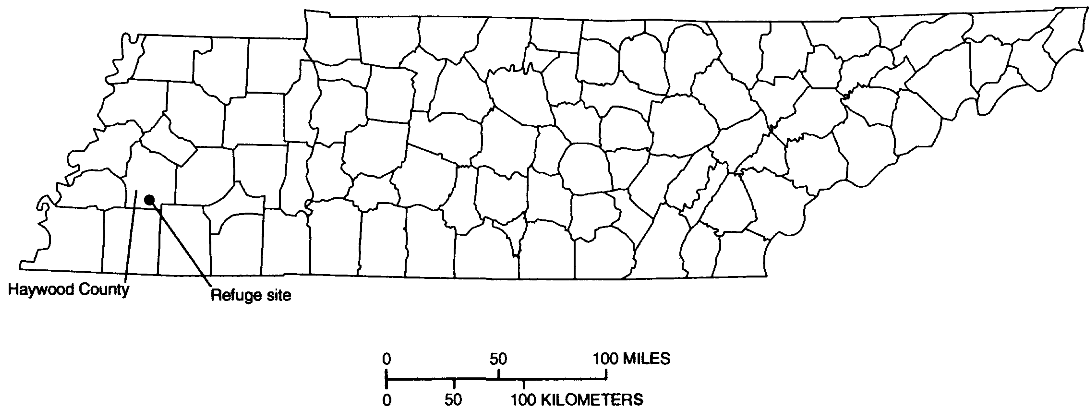
The USGS measures water levels in 48 wells (Appendix 3) throughout Tennessee to determine long-term trends and short-term changes in depth to ground water. These wells constitute the statewide ground-water-level network. The network includes about 35 wells owned by the Memphis Light, Gas and Water Division of the City of Memphis, the single largest user of ground water in the State. Other cooperators are the Savannah Valley Utility District, Lincoln County Board of Public Utilities, and Jackson Utility District.




Location of ground-water observation wells in Tennessee.

## Participation in the National Atmospheric Deposition Program

The USGS, Tennessee District, is sponsoring a station for the collection of data on chemical and physical properties of wet and dry deposition. The monitoring station was established in 1984 at the Hatchie National Wildlife Refuge near Brownsville, Tennessee, as part of the National Atmospheric Deposition Program. This program is assessing acid rain—an environmental problem that is receiving international attention. Each data-collection station in the program is carefully located in an area that typifies a region. The refuge site in Haywood County was selected because it is representative of the western Tennessee region and is relatively free from local sources of atmospheric contamination.



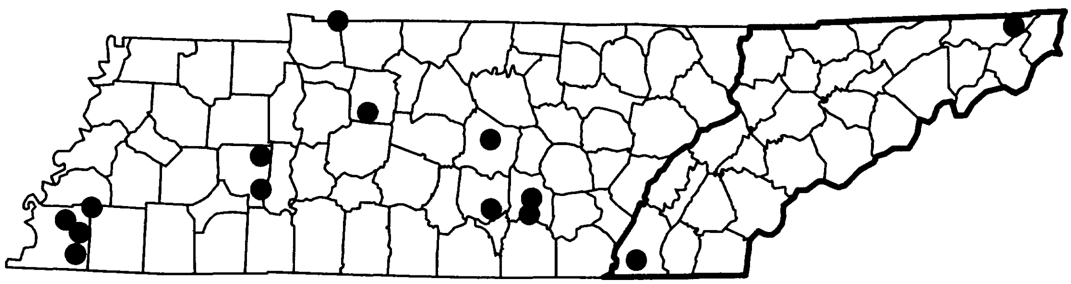

Location of Hatchie National Wildlife Refuge.

# HYDROLOGIC INVESTIGATIONS

The Water Resources Division of the USGS collects hydrologic data for use in understanding the Nation's water resources. Surface-water, ground-water, and quality-of-water investigations are conducted throughout the State in cooperation with Federal, State, and local agencies.

For the 2-year period 1995 through 1996, the Tennessee District conducted investigations in many parts of the State. The scope of the investigations ranged from the study of small sites to the study of multistate areas. Some studies, such as the flood-frequency investigation and the evaluation of water levels, have relied heavily on the long-term record of data produced by the USGS over a period of many years. The USGS studies encompass a broad range of disciplines, such as hydraulic engineering, geology, biology, chemistry, physics, mathematics, and computer science. In addition to the applications of basic data, recent studies include determining water use, ground-water availability, regional water quality, extent of contamination, the effect of agriculture and urban areas on local water quality, hydrology of wetland areas, and potential for debris accumulation in rivers at bridge crossings.

Brief descriptions of investigations conducted in Tennessee during this 2-year period are presented in the following sections of this report.




Generalized locations of the principal areal investigations.

## Low-Flow and Flow-Duration Characteristics for Streams

Low-flow and flow-duration data are critical for the effective management and use of the surface-water resources in Tennessee. Several key regulatory programs within the Tennessee Department of Environment and Conservation depend on these data for day-to-day operations. For example, the lowest 3-day flow with a 20-year recurrence interval (the "3Q20") is used for regulating discharge from wastewater-treatment plants to streams and also for regulating water-use pumpage from streams in order to maintain minimal flows. City and county governments, utility districts, consulting engineers, and many others also use these data.

The USGS, in cooperation with the Tennessee Department of Environment and Conservation and the Tennessee Valley Authority, has continued a study to update the low-flow and flow-duration data for streams in Tennessee. Data were collected at three types of gaged sites: (1) long-term continuous-record sites, (2) short-term continuous-record sites, and (3) partial-record sites.

Low-flow characteristics for long-term continuous-record sites were computed for 1, 3, 7, 14, 30, 60, and 90 consecutive days of low flow with recurrence intervals of 2, 5, 10, and 20 years. Flow-duration characteristics for long-term continuous-record stations were calculated by statistical analysis of the period-of-record daily mean flows.

Low-flow characteristics for short-term continuous-record sites and partial-record sites were estimated by correlating base-flow discharges at these sites with daily-mean discharge values at long-term continuous-record sites with similar basin characteristics. Low-flow values for the short-term continuous-record stations and partial-record stations were estimated for 1, 3, and 7 consecutive days with a recurrence interval of 10 years, and for 3 consecutive days with a recurrence interval of 20 years.

George S. Outlaw of the District office in Nashville was in charge of the study.

PUBLICATION

Outlaw, G.S., and Weaver, J.D., 1996, Flow duration and low flows of Tennessee streams through 1992: U.S. Geological Survey Water-Resources Investigations Report 95-4293, 245 p.

## Flood Investigations

The USGS conducts flood investigations in Tennessee in cooperation with the Tennessee Department of Transportation and the Metropolitan Government of Nashville and Davidson County. A knowledge of flood-frequency characteristics of streams is essential to the design of adequate and economical bridges, culverts, embankments, dams, levees, and other stream-related structures. Information on flood magnitude and frequency also is used by city and county planners for managing development of flood plains and by insurers for establishing flood-insurance rates.

The objective of the flood investigations program is to better define the flood characteristics of Tennessee streams by:

- Investigating and documenting significant floods.
- Operating a network of about 97 peak-stage and crest-stage partial-record gages to provide flood data on small streams and other streams in parts of the State where data are sparse.
- Providing analytical techniques and reports as needed to further understand the flood hydrology of Tennessee.

Several analytical reports, in addition to reports documenting significant floods, have been prepared within the past several years to provide information for use in the proper design of hydraulic structures within the highway system in Tennessee. Information in these reports include:

- Methods to compute depth of floods of various recurrence intervals at ungaged sites.
- Methods to estimate an average flood hydrograph and runoff volume, in inches, for ungaged sites.
- Regional flood-frequency analyses to provide peak discharges for various recurrence intervals at ungaged sites.

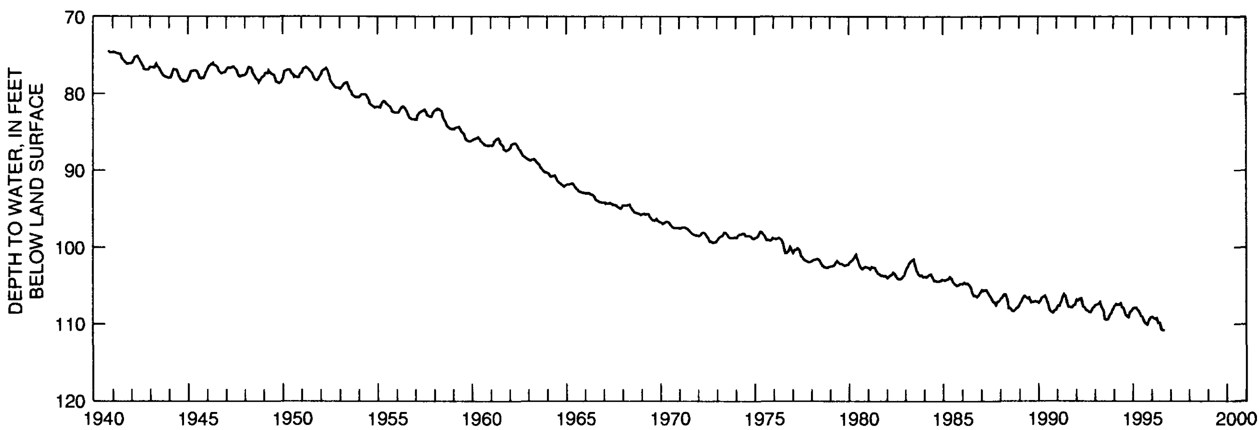
The project is statewide. The project chief is Rodney R. Knight of the District office in Nashville.

## Monitoring of Water Levels and Water Quality in Aquifers in the Memphis Area

Large amounts of water are pumped daily from wells in the metropolitan Memphis area to meet the demand for domestic, commercial, and industrial water supply. The USGS, in cooperation with the Memphis Light, Gas and Water Division (MLGW) of the City of Memphis and the City of Germantown, monitors water levels in the three principal aquifers underlying this area. Water-level data are collected at an observation network consisting of 37 wells. Six of the wells are screened in the shallow water-table aquifer, 21 in the Memphis aquifer, and 10 in the Fort Pillow aquifer. In addition, an extensometer is maintained in the MLGW Mallory well field to measure the compaction of sediments resulting from water-level declines and the reduction of fluid pressure within the sediments.

The largest amounts of water are withdrawn from the Memphis aquifer. During autumn, water levels in about 40 wells in this aquifer are measured over a period of a few days to supplement data from the observation-well network and to record the extent of seasonal water-level decline. These data are used to determine where significant changes in water levels have occurred and for the preparation of potentiometric-surface maps. These maps can show the location of historical changes in the potentiometric surface and identify areas having potential for the transfer of less-desirable-quality water from the water-table aquifer to the underlying Memphis aquifer.

Annually, during times of high pumping stress, 10 wells that draw water from the Memphis aquifer are sampled for water quality. The wells are sampled to document present conditions and long-term changes in the quality of water in the major well fields and in the area of the large cone of depression that has developed in the potentiometric surface of this aquifer. The wells sampled include eight production wells (one in each of MLGW's major well fields) and two wells in the City of Germantown. Water-quality data also are collected from wells in the shallow water-table aquifer below two closed landfills in the Memphis area to monitor any water-quality changes with time.




Depth to water in well Sh:Q-1, 1940-96.

## Statewide Water-Use Information Program

The USGS Tennessee Water-Use Information Program is conducted in cooperation with the Tennessee Department of Environment and Conservation, Division of Water Supply. The need for detailed water-use information for Tennessee has become increasingly important. Competing demands for local sources of surface and ground water continue to increase. Detailed accounting of the rate at which water resources are being used and the location where the demands are greatest is needed in order to develop management strategies necessary to ensure both sufficient water supply and adequate water quality. A statewide survey of water use for 1995 was conducted during 1996. The study is part of a survey conducted once every 5 years to estimate water use in the United States. The first survey of water use was conducted in 1955. Ground- and surface-water withdrawal and ancillary data were collected for the water-use categories of public supply, industrial, commercial, domestic, agriculture (including irrigation), mining, thermoelectric power, and reservoir evaporation. Data were compiled at the county, watershed, and aquifer level.

Susan S. Hutson of the Memphis Subdistrict office is coordinator of the Tennessee Water-Use Information Program.

PUBLICATIONS

Hutson, S.S., 1995a, Estimated use of water in Tennessee, 1990: U.S. Geological Survey Water-Resources Investigations Report 94-4055, 1 sheet.

_______1995b, Ground-water use by public-supply systems in Tennessee, 1990: U.S. Geological Survey Open-File Report 94-483, 1 sheet.

_______1996, Estimates of future water demand for selected water-service areas in the upper Duck River basin, central Tennessee *with a section on* Methodology used to develop population forecasts for Bedford, Marshall, and Maury Counties, Tennessee, from 1993 through 2050: U.S. Geological Survey Water-Resources Investigations Report 96-4140, 58 p.

## Appalachian Valley–Piedmont Regional Aquifer-System Analysis

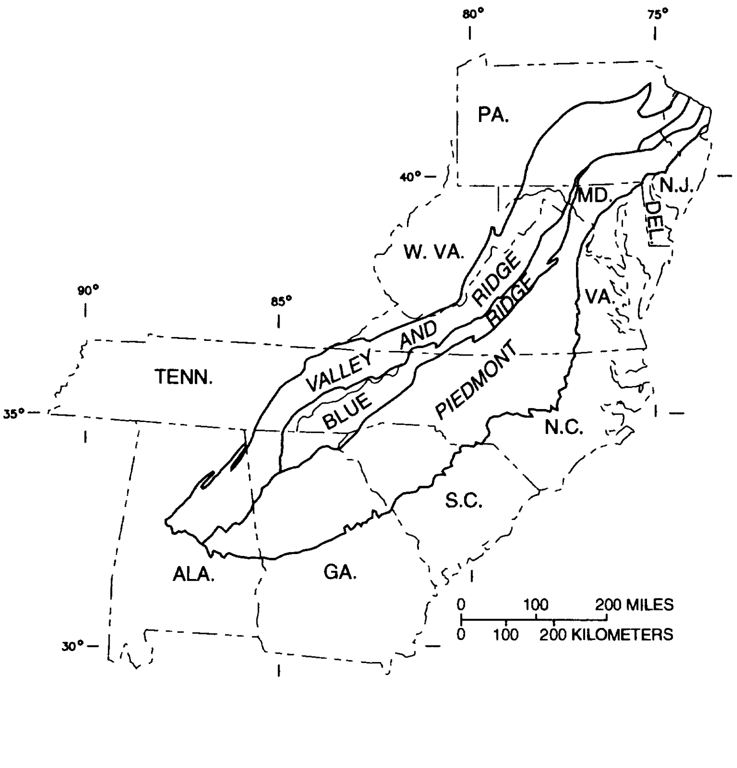
The Regional Aquifer System-Analysis (RASA) Program defined the regional geology and hydrology of the major aquifer systems of the United States. The Valley and Ridge study team of the Appalachian Valley-Piedmont RASA study examined the water-yielding carbonate and siliciclastic rocks in the Valley and Ridge Physiographic Province in parts of eight states from New Jersey to Alabama.

Well records were analyzed to identify and classify rock types into five terranes on the basis of water-yielding characteristics. The extent of each terrane was mapped using geographic information system coverages derived from State geologic maps. Well records were used to estimate ranges in potential yields to wells in each terrane. The middle 50-percent range in estimated potential yield to selected municipal and industrial wells in the eight-state area was 170 to 580 gallons per minute (gal/min) for alluvium of glacial origin; 210 to 1,400 gal/min for dolomite; 80 to 720 gal/min for limestone; 65 to 850 gal/min for argillaceous carbonate rock; and 70 to 280 gal/min for siliciclastic rock. Results of these analyses allow water users to determine the more favorable terranes in which to seek water from wells and provide an estimate of the probable range in yields to wells before drilling is attempted.

The Valley and Ridge team of the study was located at the District office in Nashville; E.F. "Pat" Hollyday was team leader.

PUBLICATION

Hollyday, E.F., Hileman, G.E., Smith, M.A., and Pavlicek, D.J., 1996, Hydrogeologic terranes and potential yield of water to wells in the Valley and Ridge Physiographic Province in Maryland, New Jersey, and Pennsylvania: U.S. Geological Survey Hydrogeologic Investigations Atlas HA-732-A, 2 sheets, scale 1:500,000.




Location of the Appalachian Valley-Piedmont Regional Aquifer-System Analysis study area.

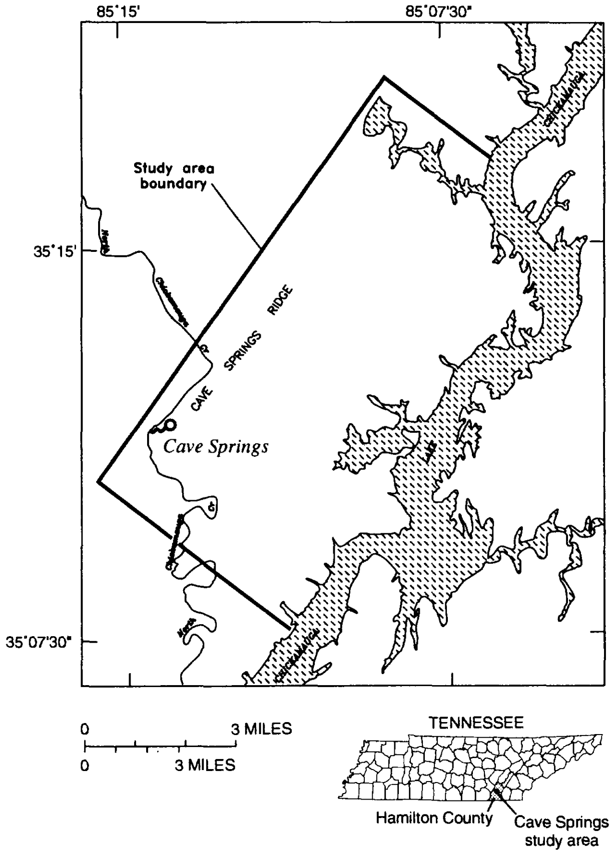
## Hydrogeology of Cave Springs Basin, Near Chattanooga, as Part of the Appalachian Valley–Piedmont Regional Aquifer-System Analysis Study

The Appalachian Valley–Piedmont Regional Aquifer-System Analysis study area is characterized by many local, discontinuous ground-water flow systems. Local systems representative of the region were selected for detailed study. The Cave Springs ground-water basin, located in Hamilton County near Chattanooga, Tennessee, was chosen as a typical karstic spring basin in the Valley and Ridge Physiographic Province. The study was conducted in cooperation with the Hixson Utility District, which obtains its water from wells at Cave Springs, the second-largest spring in Tennessee. Objectives were to define certain hydrogeologic aspects of this highly productive karst terrane.

Important results of the study are:

- The aquifer extends to a depth of at least 350 feet. The flow system is complex because of faulting and the development of solution cavities in the carbonate rock. Two flow types are characteristic. Diffuse flow through thick, clay-rich regolith that serves as a semi-confining layer predominates east of Cave Springs Ridge; conduit-type flow through solution cavities and other openings in bedrock capped only by a veneer of alluvium predominates in the area west of the ridge.
- Analysis of potentiometric maps indicates that the basin has a recharge area of about 7 square miles. Recharge is from precipitation that occurs across the basin. North Chickamauga Creek may contribute significant amounts of recharge along losing reaches of the creek.
- Ground water in the area is of the calcium bicarbonate and calcium magnesium bicarbonate type, whereas surface water is of the calcium bicarbonate and calcium magnesium sulfate type.

The results of this study are applicable to other basins underlain by carbonate rock and contribute to a better understanding of how ground-water flow systems function in karst terrane. The study was performed by Dianne J. Pavlicek with the assistance of Arthur D. Bradfield.




The Cave Springs area near Chattanooga, Tennessee.

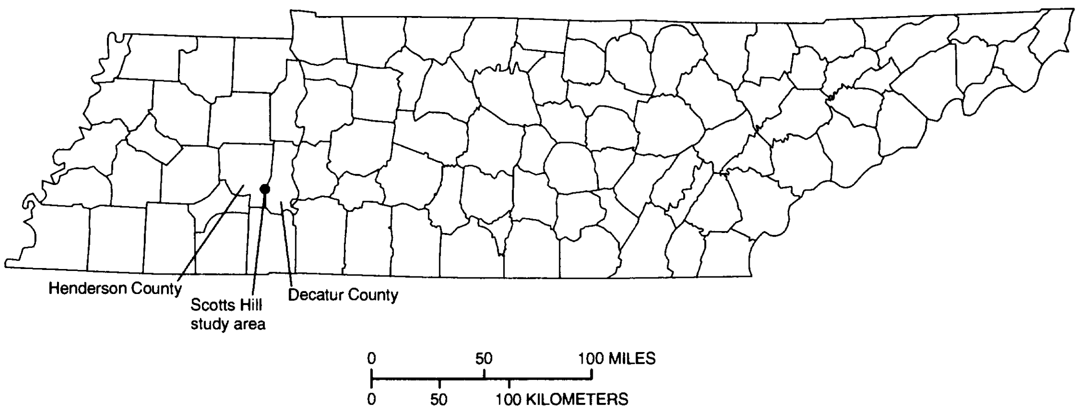
### PUBLICATION

Pavlicek, D.J., 1996, Hydrogeology and hydrochemistry of the Cave Springs basin near Chattanooga, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96-4248, 35 p.

## Ground-Water Data for Scotts Hill

The USGS, in cooperation with the City of Scotts Hill, Henderson County, is investigating the thickness, texture, and water-supply potential of sands in the Coffee Sand and Eutaw Formation. For many years, Scotts Hill has struggled with a short supply of water that needs treatment for dissolved iron. The yield of water to wells completed at a depth of about 200 feet in the Eutaw Formation, and on top of the Paleozoic bedrock, reportedly starts at about 100 gallons per minute, but declines over months to 20 gallons per minute or less. Part of the problem appears to be 100 or more feet of silt and clay that caps the aquifer and limits recharge. Water-level measurements, natural gamma logging, test hole drilling, specific capacity tests, and aquifer tests are being conducted to determine aquifer characteristics and to test both aquifers for yield, drawdown, and water quality.

The investigation is being conducted by E.F. "Pat" Hollyday and Michael W. Bradley, of the District Office in Nashville.




Location of study area, Scotts Hill, Tennessee.

## Hydrogeology of the Area near the J4 Test Cell, Arnold Air Force Base

The USGS, in cooperation with the U.S. Air Force, recently completed an investigation to determine the effects of aquifer dewatering operations at the J4 test cell at the Arnold Engineering Development Center (AEDC), Arnold Air Force Base, Coffee County. The J4 facility is a rocket-motor test cell about 100 feet in diameter and 250 feet deep. The cell penetrates the shallow aquifer, Manchester aquifer, and Fort Payne aquifer. Ground water has been pumped continuously from the test cell since the late 1960's to keep the cell structurally intact.

The investigation showed that ground-water depressions centered on the J4 test cell have developed in the potentiometric surface of each aquifer. Discharge from the test cell and ground-water samples from several Installation Restoration Program (IRP) sites at the AEDC contain contaminants, predominantly volatile organic compounds. Dewatering activity at the J4 test cell has caused ground water containing these contaminants to flow from the nearby IRP sites to the test cell.

The depression in the potentiometric surface of each aquifer is of irregular shape. Irregularity results from high-permeability features such as chert-gravel zones in the regolith and fractures, joints, and bedding planes in the bedrock. These features permit water to move more readily through them than through the surrounding regolith and rock. Because the fracture systems and the test cell provide hydraulic connection between the three aquifers, the depression extends outward from J4, cuts across each aquifer, and is oriented along the most permeable pathways. Resulting ground-water flow patterns near the test cell are complex.

Flow in each aquifer approximates steady-state equilibrium because pumpage at the test cell has been continuous for almost three decades. For 1992-95, the average pumping rate was 105 gallons per minute. The area contributing water from each aquifer to the point of dewatering includes all or part of several nearby IRP sites.

The project chief for this investigation was Connor J. Haugh of the District office in Nashville.

PUBLICATIONS

Haugh, C.J., 1996a, Hydrogeology of the area near the J4 test cell, Arnold Air Force Base, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96-4182, 43 p.

———1996b, Well-construction, water-level, and water-quality data for ground-water monitoring wells for the J4 hydrogeologic study, Arnold Air Force Base, Tennessee: U.S. Geological Survey Open-File Report 95-763, 81 p.


Base from U.S. Geological Survey digital data, 1:100,000, 1983
Universal Transverse Mercator projection,
zone 16

0 1,000 2,000 3,000 FEET
0 250 500 750 METERS

EXPLANATION

CONTRIBUTING AREA--Shows area of the Fort Payne and the lower part of the Manchester aquifers, undifferentiated, in which ground water is captured by the J4 test cell dewatering system

GENERAL AREA OF GROUND-WATER DEPRESSION CAUSED BY DEWATERING J-4 AND ORIENTATION OF HIGH-PERMEABILITY FEATURES

— — — — SURFACE-WATER DRAINAGE DIVIDE

• WELL--Water-level measurement made in July 1994 and used for control

The J4 study area at Arnold Engineering Development Center, July 1994.

## Hydrogeologic Investigation of the Fort Campbell Military Reservation, Kentucky and Tennessee

The USGS, in cooperation with the U.S. Army, Fort Campbell, Directorate of Public Works, Environmental Division, conducted an investigation of the hydrogeology of the Fort Campbell Military Reservation and adjacent parts of Christian and Trigg Counties, Kentucky, and Montgomery and Stewart Counties, Tennessee. The study was conducted to better understand the occurrence and movement of ground water in the Fort Campbell area and to delineate the recharge area of Boiling Spring, the primary source of drinking water for the Reservation. Fort Campbell pumps approximately 5 million gallons of water per day from Boiling Spring. Delineation of the recharge area for ground water pumped from Boiling Spring allows Reservation officials to manage and protect the water supply from potential sources of pollution.

The hydrologic investigation at Fort Campbell involved a multidisciplinary approach. Major components of the investigation included:

- Observation/well installation.
- Dye-trace studies.
- Ground-water level measurements.
- Geophysical studies.
- Stream-discharge measurements.
- Water chemistry analyses.

Well drilling identified the existence of deep, water-bearing openings in bedrock. Five wells drilled into bedrock beneath the alluviated valley near Boiling Spring intercepted water-bearing openings at depths greater than 100 feet below land surface and had yields exceeding 35 gallons per minute. At four of these wells, yields from these deep openings exceeded 200 gallons per minute.

Dye-trace studies and discharge measurements verified the hydraulic connection between surface streams and Boiling Spring during low base flow conditions. Fluorescent dye placed in a stream reach adjacent to Boiling Spring was detected in less than 2 hours in water pumped from the spring. Simultaneous discharge measurements in the stream reach showed decreases in streamflow and confirmed infiltration of surface water into the ground near Boiling Spring.

The area with the potential to recharge Boiling Spring encompasses approximately 126 square miles. This area includes the 50-square-mile ground-water basin directly upgradient of Boiling Spring and the catchment areas of surface-water bodies that provide streamflow recharge to the spring during low-flow conditions.

The multidisciplinary approach of this investigation involved the efforts of personnel from the Tennessee and Kentucky offices of the USGS. Gregg E. Hileman, of the Tennessee District office in Nashville, was project chief. Charles J. Taylor, of the Kentucky District office in Louisville, was responsible for the dye-trace component of the investigation.

### PUBLICATIONS

Ladd, D.E., 1996, Base-flow data for the Little West Fork basin, Fort Campbell, Tennessee and Kentucky, 1993 and 1994: U.S. Geological Survey Open-File Report 96-343, 28 p.

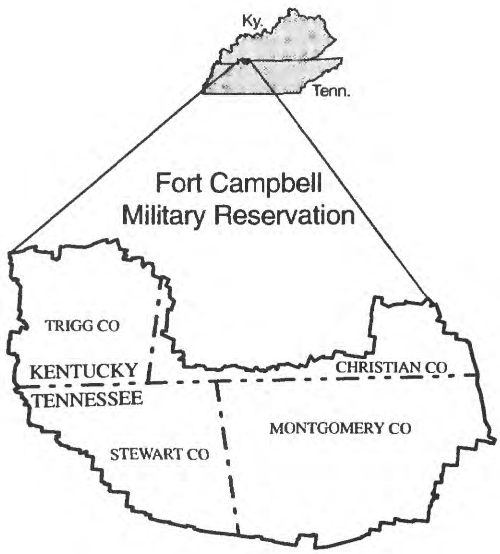
Webbers, Ank, 1995, Ground-water quality protection—Why it's important to you: U.S. Geological Survey Open-File Report 95-376, 1 sheet.

## Ground-Water Protection Plan for Fort Campbell Military Reservation, Kentucky and Tennessee

Residents and employees of the Fort Campbell Military Reservation rely on ground water from Boiling Spring as the primary source for their drinking-water supply. This spring issues from carbonate bedrock and can produce up to 5 million gallons of water per day. The Reservation is underlain by karst terrane that is characterized by sinkholes, disappearing streams, and caves. Dye-trace studies completed at the Reservation have shown that openings in the bedrock provide pathways for potential pollutants spilled at land surface to travel to Boiling Spring and to other springs and wells.

The USGS, in cooperation with the U.S. Army, Fort Campbell, Directorate of Public Works, Environmental Division, developed an up-to-date Ground-Water Protection Plan that describes the hydrology at Fort Campbell and identifies all activities, services, and maintenance procedures at the Reservation where potential pollutants could contaminate the ground water and Boiling Spring. The Plan was prepared as a voluntary compliance response to the 1994 Kentucky Regulatory Statutes that require the protection of the waters of the Commonwealth and the prevention of pollution to all current and future uses of ground-water resources.

Project chief for development of the Ground-Water Protection Plan was Ank Webbers of the District office in Nashville.



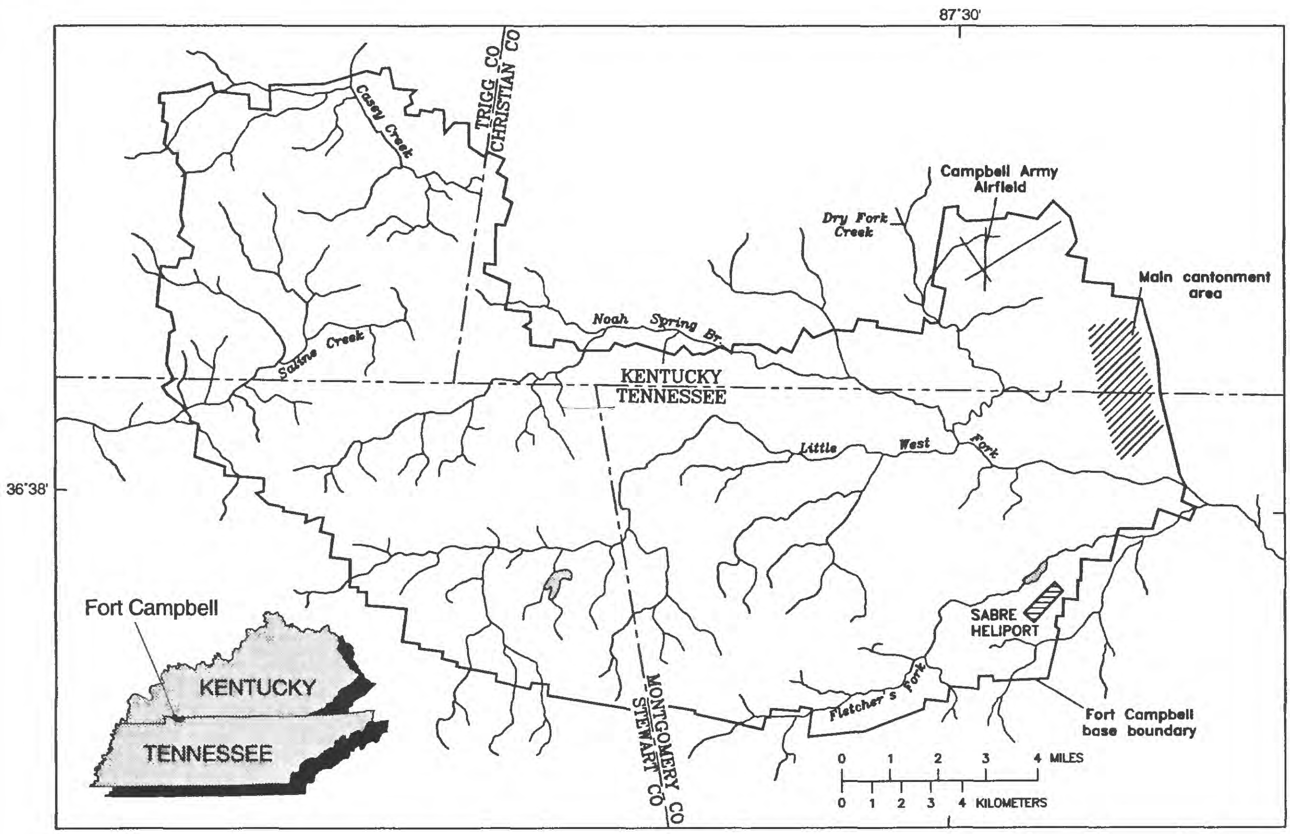
## Stormwater Pollution Prevention, Fort Campbell, Kentucky and Tennessee

Some Federal installations are required under the Clean Water Act to develop stormwater pollution-prevention plans that identify sources of potential pollution, describe best management practices designed to minimize pollution through prevention and control, and provide recommended actions for implementing the plan. The facility may also perform water-quality sampling to determine the quality of stormwater runoff from select land-use categories or industrial activities. In response to these requirements, the U.S. Army Directorate of Public Works (DPW), Fort Campbell, Kentucky, with assistance from the USGS, initiated a program to develop and implement a base-wide stormwater pollution-prevention plan and to collect water-quality samples of runoff draining from selected industrial facilities.

The Fort Campbell stormwater pollution-prevention plan is composed of three primary parts: map of the facilities showing the location of regulated industrial facilities, associated stormwater outfalls, and the stormwater-quality sampling points; site-specific stormwater pollution-prevention plans for 82 regulated industrial facilities located at the base; and two documents for industrial facilities, one within Kentucky and one within Tennessee, that summarize the site-specific plans. These plans are the implementation documents that allow the stormwater program to be implemented at the military unit or facility level.

Stormwater-quality samples are being collected by the USGS at six sites in Fort Campbell. The sites were selected to represent runoff from landfills, motor pool and airfield operations, and recycling/material storage facilities. Samples are collected to document the quality of the stormwater runoff and to determine if any potential contaminants are being transported in the runoff.

The stormwater pollution-prevention plans were completed under the direction of George S. Outlaw of the District office in Nashville. Stormwater-quality sampling is being conducted under the direction of Rodney Knight, also of the District office in Nashville.




Location of Fort Campbell, Kentucky and Tennessee.

## Investigation of the Hydrogeology of the Naval Support Activity-Memphis near Millington in Shelby County

The USGS, in cooperation with the U.S. Department of Navy, Southern Division Naval Facility Engineering Command, Charleston, South Carolina, is providing technical assistance in hydrogeologic investigations at Naval Support Activity (NSA) Memphis near Millington in Shelby County, Tennessee. The work is being done under the Navy's Corrective Action Program. The project currently has two components. The first, and higher priority, component focuses on investigations within the NSA Memphis Northside, which is scheduled to close and be reaccessed by the City of Millington under the Base Closure and Realignment Act of 1990. The second component focuses on the NSA Memphis Southside, which will be retained by the Navy. The objectives of the USGS investigation are to:

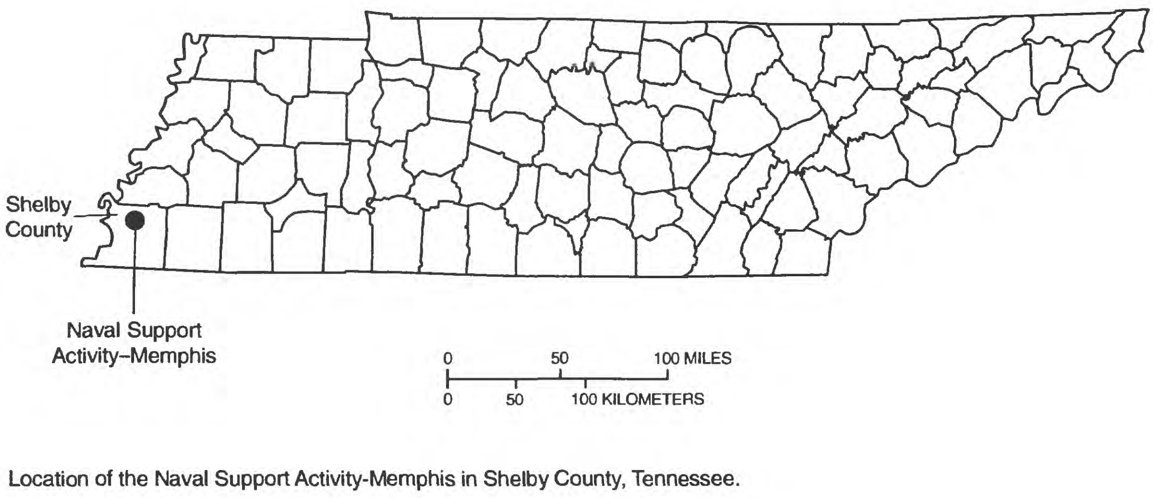
- Assist in the preparation and review of work plans and final reports that describe planned and completed field work, respectively.
- Assist in conducting Resource Conservation and Recovery Act Facility Investigations at several Solid Waste Management Units (SWMU) to determine the possible occurrence and extent of contamination of soil, sediment, and ground water.
- Describe the general hydrogeology of the area.

As part of the work performed at NSA Memphis, the USGS has conducted soil-gas and surface-geophysical investigations at several of the SWMU's, and has conducted a multiple-well aquifer test. The USGS has provided technical oversight of contractors in the use of Direct Push Technology and for the installation of stratigraphic test holes and monitoring wells by Rotosonic and other more-conventional drilling techniques. The USGS has analyzed ground-water samples for natural water quality and for tritium as an aid in determining the contamination potential of the Memphis aquifer, which supplies some of the water used by the NSA Memphis and the City of Millington. The USGS also has developed a series of modular computer programs linking various geographic-information-system coverages for the base.

The USGS investigations are under the direction of John K. Carmichael of the District office in Nashville.

PUBLICATION

Kingsbury, J.A., and Carmichael, J.K., 1995, Hydrology of post-Wilcox Group stratigraphic units in the area of the Naval Air Station Memphis, near Millington, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 95-4011, 1 sheet.




Location of the Naval Support Activity-Memphis in Shelby County, Tennessee.

# Hydrologic Investigation at the Dickson County Landfill, Dickson County

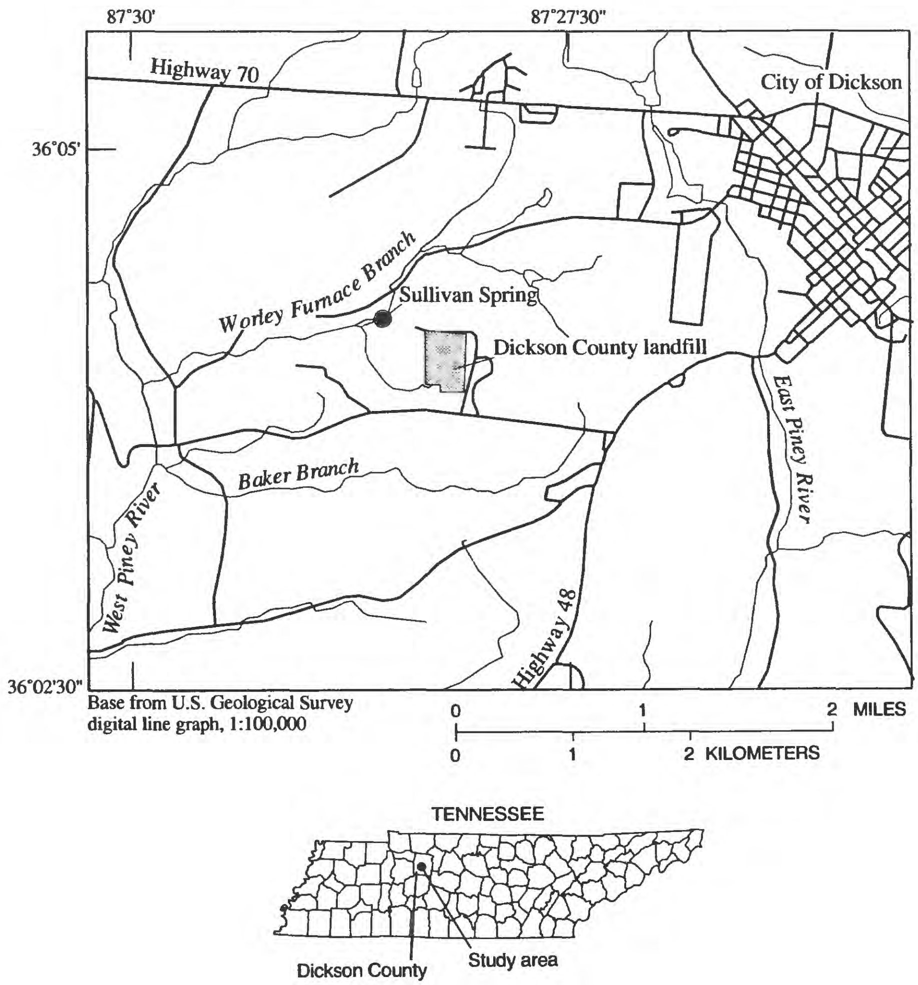
The USGS, as part of an ongoing investigation to better understand the hydrology of landfills along the Highland Rim Physiographic Province, conducted activities at the Dickson County landfill in cooperation with the Dickson County Solid Waste Authority. The purpose was to determine ground-water gradients near the Dickson County landfill and to determine if Sullivan Spring, about 0.3 mile to the northwest, is downgradient of the landfill. As part of a routine sampling event by the Dickson County Solid Waste Authority, low levels of organic compounds were detected at Sullivan Spring. Prior to this, the spring was the drinking-water source for two nearby families.

For this investigation, the USGS installed five monitoring wells near the northwestern corner of the landfill at locations between the landfill and Sullivan Spring. Water-level measurements were made on June 1-2, 1995, in these wells and 13 others near the landfill to determine ground-water altitudes in the area. Water-level altitudes in the five new monitoring wells and three of the existing wells at the landfill were higher than the altitude of Sullivan Spring. In general, wells in topographically higher areas had higher water-level altitudes than wells near streams in lowland areas. The altitudes of the ground-water levels indicate the spring, located in a lowland area, is downgradient of the landfill.

The study was conducted by David E. Ladd of the District office in Nashville.

PUBLICATION


Ladd, D.E., 1996, Construction, lithologic, and water-level data for wells near the Dickson County landfill, Dickson County, Tennessee, 1995: U.S. Geological Survey Open-File Report 96-229, 16 p.


Location of the study area.

## Upper Tennessee River Basin Study Unit of the National Water-Quality Assessment Program

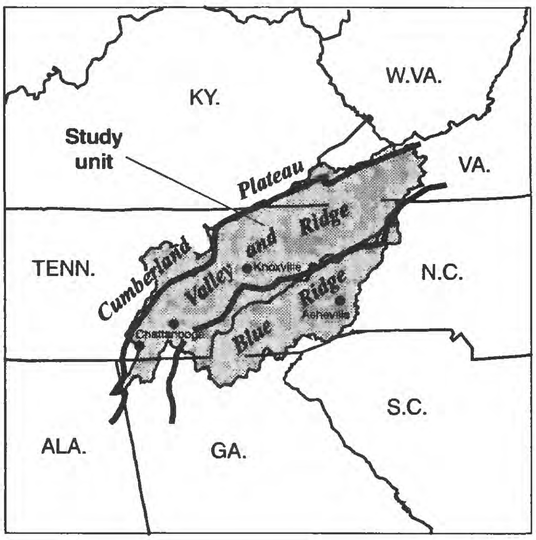
The National Water-Quality Assessment (NAWQA) Program was established (1) to describe, in a nationally consistent manner, the status of and trends in the quality of a large, representative part of the Nation's surface- and ground-water resources and (2) to provide a sound, scientific understanding of the principal natural and human-related factors affecting the quality of these resources. The program is expected to produce water-quality information needed by policymakers and water managers at local, State, and Federal levels.

The Upper Tennessee River Basin study unit is one of 60 NAWQA study units in the Nation. It encompasses the Tennessee River drainage basin upstream of Chattanooga, and includes parts of Tennessee, North Carolina, Virginia, and Georgia. Assessment activities began in 1994 with the identification and prioritization of water-quality issues and sources of water-quality data through meetings and consultation with interested public and private agencies. Intensive data collection, including the operation of monthly and weekly sampling stations and one-time synoptic sampling programs, began in 1996. Synoptic work focused on the Clinch, Powell, and Holston Rivers of Tennessee and Virginia. Assessment activities will continue following completion of the high intensity phase of the project, but at a lower level of effort.

The study unit staff consists of seven scientists and technicians located in the Knoxville Subdistrict office under the direction of Paul S. Hampson.

PUBLICATION

Hampson, Paul S., 1995, National Water-Quality Assessment Program—The upper Tennessee River Basin study unit: U.S. Geological Survey NAWQA Fact Sheet FS-150-95, 1 p.



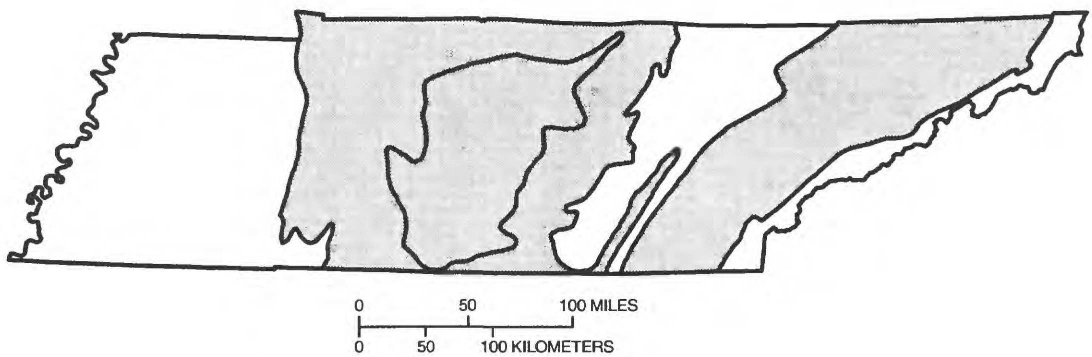

Location of the upper Tennessee River Basin NAWQA study unit.

## Occurrence, Fate, and Transport of Chlorinated Solvents in Carbonate Aquifers

Chlorinated organic solvents, such as tetrachloroethylene (PCE) and trichloroethylene (TCE), are recognized as a significant source of ground-water contamination in the aquifers of Tennessee. More than two thirds of the State's aquifers are composed of carbonate rock that provides significant quantities of water to domestic and municipal supplies in Middle and East Tennessee, and which are particularly susceptible to contamination by these organic compounds.

The USGS, in cooperation with the Tennessee Department of Environment and Conservation, Division of Superfund, is conducting a study of the occurrence, fate, and transport of chlorinated solvents in the carbonate aquifers of Tennessee. The purpose of the study is to develop and test a conceptual model of the physical and chemical factors that affect chlorinated solvents in the carbonate rock settings across the State. The study will have several phases. The first phase includes a review of existing literature on the behavior of chlorinated solvents and an evaluation of data from sites in Tennessee where these contaminants have been released. Of particular importance will be a determination of how hydrogeologic factors influence contaminant behavior in karst terrain.

The project is being conducted under the direction of William J. Wolfe and Connor J. Haugh of the District Office in Nashville.




Location of carbonate aquifers (shaded areas) in Tennessee.

## Development of Guidelines for Evaluating Bioremediation of Chlorinated Solvents, and Demonstration of the Technique

Contamination of ground water with chlorinated solvents has become a concern in Tennessee. State agencies with limited resources are faced with trying to remediate numerous contaminated sites. Conventional remedial methods, such as pumping and treating ground water or removing contaminated soils, may be expensive and ineffective. To cleanup the maximum number of contamination sites, State agencies are considering bioremediation as an alternative method.

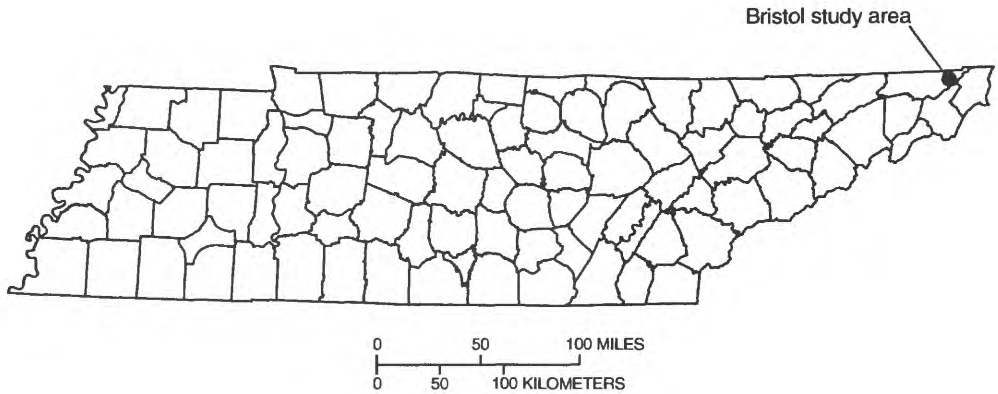
Bioremediation is the biological degradation of contaminants without removing the contaminants. All contaminated sites are not suitable for bioremediation. The USGS, in cooperation with the Tennessee Department of Environment and Conservation, Division of Superfund, is developing a set of guidelines for site-feasibility studies based on past studies by the USGS and other agencies. The USGS, in collaboration with the Division of Superfund, will select demonstration sites for evaluation. Guidelines will be revised, based on data collected during these evaluations.

Tom D. Byl of the District office in Nashville is the project chief.

## Water Quality of an Intermittent Stream near Bristol

The USGS, in cooperation with the U.S. Department of the Navy, conducted a hydrologic investigation of the Hollow Drum Disposal Area (HDDA) at the Naval Weapons Industrial Reserve Plant, Bristol, Tennessee, from 1992 to 1995. Data collected were used to determine the quantity and quality of surface water leaving the HDDA prior to, during, and after a remedial action. The remedial action, performed from April to November 1993, consisted primarily of removing waste material and contaminated soil from the HDDA. Upon completion of the waste removal, the site was filled with clean topsoil, contoured, and seeded to restore it to a nearly natural condition. Of primary concern to Navy officials during the remediation process was the potential for surface runoff and streamflow from the HDDA to transport contaminants off-site.

Several inorganic analytes, notably cadmium, copper, nickel, and zinc, were measured in concentrations exceeding background levels in runoff from the HDDA before and during site remediation. However, concentrations decreased to background-equivalent levels soon after the site remediation was completed. A small number of organic substances were detected in samples during pre-remediation sampling. Although detectable, most of these compounds had smaller concentrations than could be accurately quantified by the analytical procedure used or also were found in the laboratory quality-assurance/quality-control samples submitted. After site remediation, none of these organic substances were detected.




Location of the Bristol, Tennessee, study area.

## Determining the Source of Fecal Contamination Using Ribonucleic Acid Hybridization

Fecal bacteria in drinking and recreational waters is a serious public health concern. Diseases, such as hepatitis, gastroenteritis, dysentery, cholera, and typhoid fever, are associated with fecal contamination. Identifying the source of fecal contamination is the key to correcting the problem. However, the source of contamination is not always apparent, especially in rural areas undergoing development. Potential bacteria sources include feedlots, pastures, natural wildlife, leaky septic tanks, or substandard waste-treatment facilities. The USGS is adapting molecular techniques to identify bacteria sources. Fecal bacteria unique to a host species may be identified using this molecular technique.

The ribonucleic acid (RNA) oligonucleotide probe takes advantage of unique sequences on the RNA contained within a particular bacteria species. A water sample containing unknown bacteria is incubated in a buffer solution containing fluorescent-marked RNA probes. The probes will enter the cells and bind to the bacteria with complimentary RNA sequence. The bacteria are viewed using an epifluorescent microscope to count individual cells that are fluorescing, providing a bacteria count per known quantity of water. Probes targeting different bacteria species can be used simultaneously. For example, a probe for total fecal coliform and a probe for Salmonella can be run simultaneously by tagging the probes with different fluorescent dyes.

This technique is presently being used in medical and veterinarian science and microbial ecology but has not been used for water-quality studies. A variety of control experiments and field experiments are being conducted to determine the full potential of this technique.

Tom D. Byl of the Nashville District office is the project chief.

## Evaluation of Agricultural Nonpoint-Source Pollution in the Beaver Creek Drainage Basin

The USGS began a comprehensive research program in 1990 to assess the effect of agricultural practices on the quality of surface water and ground water in the Beaver Creek watershed, West Tennessee. The program was conducted in cooperation with the Tennessee Department of Agriculture, U.S. Department of Agriculture, Natural Resources Conservation Service, Tennessee Association of Soil Conservation Districts, Shelby County Soil Conservation District, Tennessee Department of Environment and Conservation, Water Environment Federation, Clemson University, The University of Memphis, University of Tennessee Agricultural Extension Service, and the Tennessee Soybean Promotion Board.

Objectives of the program were to:

- Evaluate the nature and extent to which agricultural activities affect the quality of surface and ground water in the Beaver Creek watershed.
- Identify and quantify the processes and factors that control the transport of pollutants from agricultural fields.
- Assess the effectiveness of agricultural conservation practices (commonly referred to as best management practices) at the field and the watershed levels.

The project was completed in 1996. W. Harry Doyle, Jr. of the Memphis Subdistrict office was the project chief. Some of the results of this investigation were published in the following reports.

PUBLICATIONS


Byl, T.D., and Carney, K.A., comps., 1996, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991-95: U.S. Geological Survey Water-Resources Investigations Report 96-4186, 34 p.

Byl, T.D., Jiao, Yun, Hutson, S.S., 1996, Influence of riparian vegetation on the biological structure and processing function of a channelized stream in West Tennessee, *in* Byl, T.D., and Carney, K.A., comps., Instream investigations in the Beaver Creek watershed in West Tennessee, 1991-95: U.S. Geological Survey Water-Resources Investigations Report 96-4186, p. 21-26.

Cochrane, H.H., and Williams, S.D., 1996, Nutrient and sediment loads in a channelized stream and a nonchannelized wetland stream in the Beaver Creek watershed, West Tennessee, *in* Byl, T.D., and Carney, K.A., comps., Instream investigations in the Beaver Creek watershed in West Tennessee, 1991-95: U.S. Geological Survey Water-Resources Investigations Report 96-4186, p. 3-8.

Doyle,W.H., Jr., and Baker, E.G., comps., 1995, Collection of short papers on Beaver Creek watershed studies in West Tennessee, 1989-94: U.S. Geological Survey Open-File Report 95-156, 56 p.

Doyle, W.H., Jr., Whitworth, B.G., Smith, G.F., and Byl, T.D., 1996, The Beaver Creek story: U.S. Geological Survey Open-File Report 96-398, 1 sheet.

Olsen, L.D., 1995, Pesticide movement in soils: a comparison of no-tillage and conventional tillage in the Beaver Creek watershed in West Tennessee: U.S. Geological Survey Open-File Report 95-329, 1 sheet.

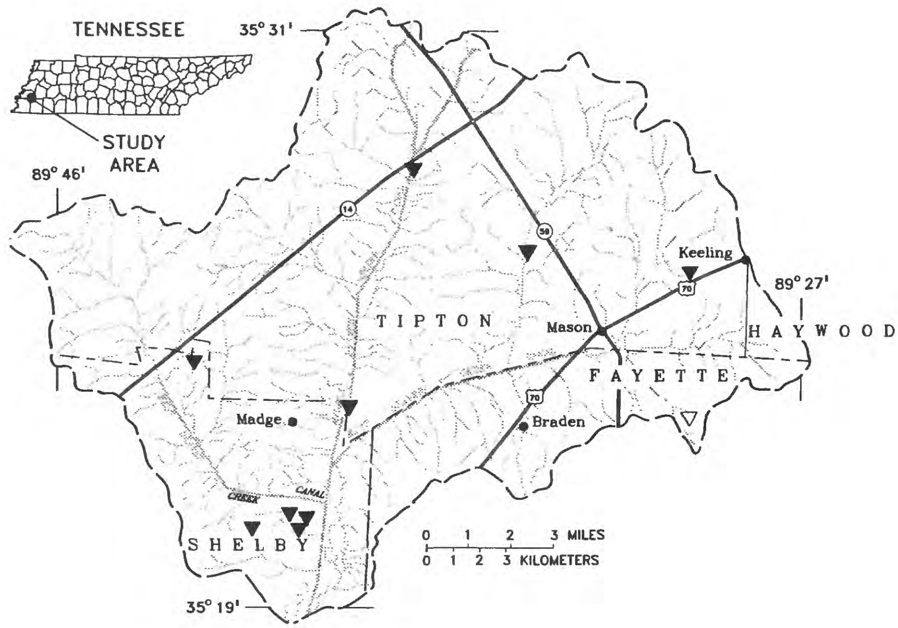
Smink, J.A., and Byl, T.D., 1996, Evaluation of a constructed wetland to control agricultural row-crop nonpoint-source pollution, *in* Byl, T.D., and Carney, K.A., comps., Instream investigations in the Beaver Creek watershed in West Tennessee, 1991-95: U.S. Geological Survey Water-Resources Investigations Report 96-4186, p. 11-17.

U.S. Geological Survey, 1995, An overview of the Beaver Creek study in West Tennessee: U.S. Geological Survey Open-File Report 95-312, 1 sheet.

Williams, S.D., 1996a, Ground-water-quality data for selected wells in the Beaver Creek watershed, West Tennessee: U.S. Geological Survey Open-File Report 95-769, 30 p.

__________1996b, Transport of aldicarb and aldicarb metabolites in runoff from agricultural fields in the Beaver Creek watershed, West Tennessee, *in* Byl, T.D., and Carney, K.A., comps., Instream investigations in the Beaver Creek watershed in West Tennessee, 1991-95: U.S. Geological Survey Water-Resources Investigations Report 96-4186, p. 29-34.

Williams, S.D., and Harris, R.M., 1996, Nutrient, sediment, and pesticide data collected at four small agricultural basins in the Beaver Creek watershed, West Tennessee, 1990-1995: U.S. Geological Survey Open-File Report 96-366, 115 p.




Location of surface-water monitoring stations in the Beaver Creek watershed.

## Hydrogeology of Quail Hollow Landfill

The USGS, in cooperation with the Bedford County Solid Waste Authority, has investigated the effect of the Quail Hollow landfill on ground-water and surface-water quality in the adjacent aquifers and streams. Local landowners were concerned that during the past 22 years, contaminants may have migrated from this regional landfill to nearby waters. The Bedford County Solid Waste Authority needed information on water quality in order to assure a safe environment for county residents.

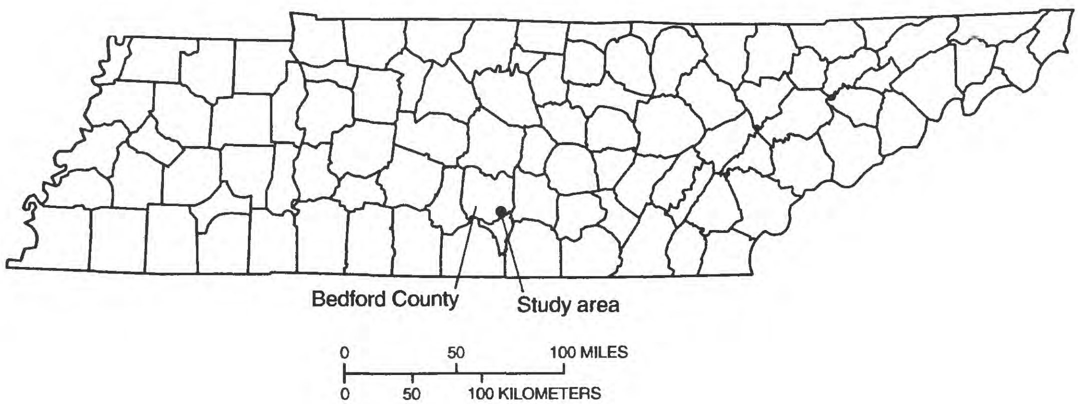
The primary objectives of this USGS study were to measure natural, or background, water-quality conditions in streams, springs, and aquifers in areas unaffected by the landfill and then to compare these measurements with water-quality data collected from streams, springs, and wells adjacent to the landfill.

Water-quality and biologic-diversity data were collected and discharge was estimated at 176 sites along streams in 9 watersheds. Samples of water were collected for complete analysis at 28 sites during a seepage investigation. Conductivity—an indicator of dissolved-solids concentrations in the water—was measured continuously at Sons Spring and on Anderton Branch that drain the landfill. In general, the concentrations of several chemical constituents exceeded maximum contaminant levels recommended for drinking water only at springs or seeps adjacent to the toe of the landfill.

Biologic and bioremediation work was conducted by Tom D. Byl and James Farmer of the District office in Nashville. Hydrogeologic studies were conducted by E.F. "Pat" Hollyday, assisted by James Farmer and Nashville Subdistrict Office personnel.

PUBLICATION

Hollyday, E.F., and Byl, T.D., 1995, Water-quality, discharge, and biologic data for streams and springs in the Highland Rim escarpment of southeastern Bedford County, Tennessee: U.S. Geological Survey Open-File Report 95-732, 36 p.



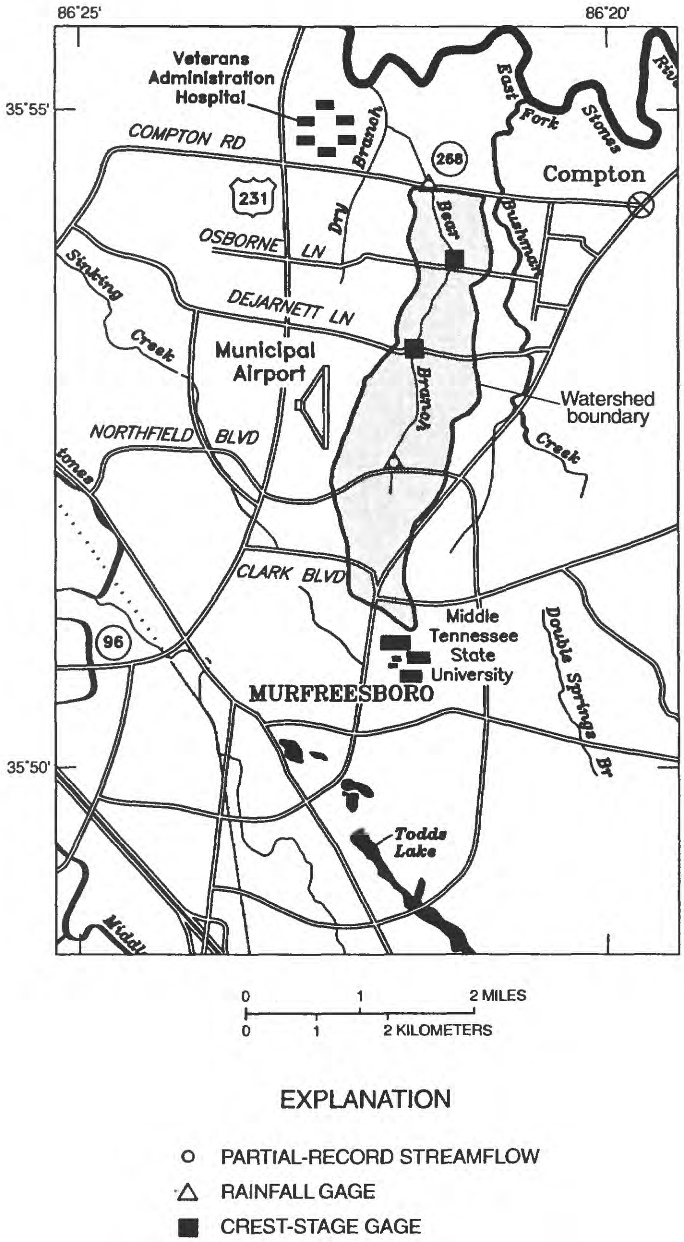

Location of Quail Hollow landfill.

# Application of the Distributed Routing Rainfall Runoff Model, $DR_3M$, to Bear Branch Watershed, Murfreesboro

The USGS, in cooperation with the City of Murfreesboro, calibrated the USGS Distributed Routing Rainfall Runoff Model, $DR_3M$, to the 2.8-square-mile Bear Branch watershed in northern Murfreesboro. $DR_3M$ uses kinematic wave theory to route excess rainfall overland and through a branched system of stream channels. The effect of detention storage also can be simulated. The model was calibrated using information from two rain gages, two stream gages, and two crest-stage gages that were maintained in the watershed from March 1989 through July 1992. The calibrated model was used to define flood characteristics and long-term flood frequencies for conditions in the watershed as of 1993.

The calibrated model provides planners and engineers of the City of Murfreesboro with a valuable tool to study the effects of future changes in land use on the flood characteristics and the flood-frequency relation of the Bear Branch watershed. The ability of the model to simulate detention storage will be important in the development of plans to manage and reduce flood damage in the watershed. The calibrated model applies specifically to the Bear Branch watershed; however, the techniques used in the study are transferable to other watersheds where observed rainfall and streamflow data are available.

The investigation was conducted by George S. Outlaw of the District office in Nashville.




Location of watershed and data-collection points for Bear Branch, Murfreesboro, Tennessee.

## PUBLICATION


Outlaw, G.S., 1996, Flood frequency and detention-storage characteristics of Bear Branch watershed, Murfreesboro, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96-4005, 24 p.

## Hydrology and Tree-Distribution Patterns of Karst Wetlands at Arnold Air Force Base

Arnold Air Force Base, near Manchester, Tennessee, is notable for its diverse ecological resources, including many rare, threatened, or endangered plant and animal species, many of which inhabit the 640 acres of wetlands on the base. Some of the most ecologically distinct wetlands at Arnold Air Force Base are seasonally flooded karst depressions. In the past, management of these karst wetlands was hampered by a lack of knowledge about their basic hydrology and geomorphology, and about how these factors affected species distribution.

In October 1992, the USGS, in cooperation with the U.S. Air Force, began a study of the geomorphology, hydrology, and tree-distribution patterns of selected karst wetlands at Arnold Air Force Base. The study included describing karst features on the base, monitoring flooding patterns, determining ground-water interactions in five karst depressions, and documenting the distribution of tree species in and near three karst wetlands. Two geomorphically distinct types of karst wetlands, shallow karst pans, such as Goose Pond, and compound sinks, such as Sinking Pond and Westall Swamp, were observed. The shallow karst pans have depths less than 3.5 feet, flat bottom topography, and the lack of an internal drain that limits interaction with the local ground water. In contrast, compound sinks have depths greater than 7 feet, complex bottom topography, and visible internal drains. Seasonal floods and recession in the compound sinks were abrupt, with water levels rising as much as 9 feet in 24 hours and falling almost as rapidly. The study demonstrated that the geomorphic characteristics of these karst wetlands largely determined their flooding characteristics and had a pronounced effect on tree-distribution patterns.

The karst pans dry out more slowly than the compound sinks, have longer periods of saturated bottom material, and tend to support more specialized wetlands plants. The transition between vegetation on the pans' periphery and that of the saturated areas is abrupt. Compound sinks may support some specialized wetland trees in some of the deepest areas, but most tree species in the compound sinks are adapted to a wide range of hydrologic conditions. The transition between vegetation in the flooded parts of the compound sinks and adjacent nonflooded areas is much more gradual than in karst pans.

The project was directed by William J. Wolfe of the District office in Nashville.

PUBLICATIONS


Wolfe, W.J., 1996, Hydrology and tree-distribution patterns of karst wetlands at Arnold Engineering Development Center, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4277, 46 p.

Wolfe, W.J., and League, D.E., 1995, Water–surface elevations of wetlands and nearby wells at Arnold Air Force Base, near Manchester, Tennessee: U.S. Geological Survey Open-File Report 95–753, 19 p.

## Debris Accumulation at Bridges

Large woody debris, consisting largely of entire tree trunks with attached root masses, is common in rivers that flow between wooded banks. The accumulation of debris at bridges causes maintenance problems, contraction and local scour, and bridge failures. The USGS, in cooperation with the Federal Highway Administration (FHWA), investigated the causes and effects of debris accumulation at bridges nationwide.

This project incorporated three interdependent approaches to understanding debris accumulation:

- A statistical study of data relevant to debris accumulation.
- A more detailed study of factors contributing to debris accumulation at selected bridges where debris has blocked much of the river channel.
- A descriptive study of debris production, transport, and trapping in one or two study reaches.

Accomplishments during 1992-96 included combining bridge inspection data from several States into a single data base, developing response forms on which highway engineers can describe debris accumulations, identifying several bridges in the Mississippi Valley with large, recurrent debris accumulations, and conducting a pilot study of debris production and transport potential in the West Harpeth River, Tennessee. A report on this investigation, including suggested guidelines for estimating the potential for debris accumulation at a bridge, has been approved and is being published by the FHWA.

Timothy H. Diehl of the District office in Nashville is project chief.

PUBLICATIONS

Bryan, B.A., Simon, Andrew, Outlaw, G.S., and Thomas, Randy, 1995, Methods for assessing channel conditions related to scour-critical conditions at bridges in Tennessee: U.S. Geological Survey Water-Resources Investigations Report 94–4229, 54 p.

Diehl, T.H., 1994, Causes and effects of valley plugs in West Tennessee; responses to changing multiple-use demands: New Directions for Water Resources Planning and Management, American Water Resources Association, p. 97-100.

Diehl, T.H., in press, Potential drift accumulation at bridges: U.S. Federal Highway Administration Publication No. FHWA-RD-97-028.

Debris accumulation at a bridge over the Harpeth River at Sneed Road near Bellevue, Tennessee.

## Wetland Restoration Studies

In cooperation with the Tennessee Department of Transportation (TDOT), the USGS is conducting a multidisciplinary investigation at a wetland mitigation banking site in Shelby County. Monitoring of conditions at this site began in June 1993 and is ongoing.

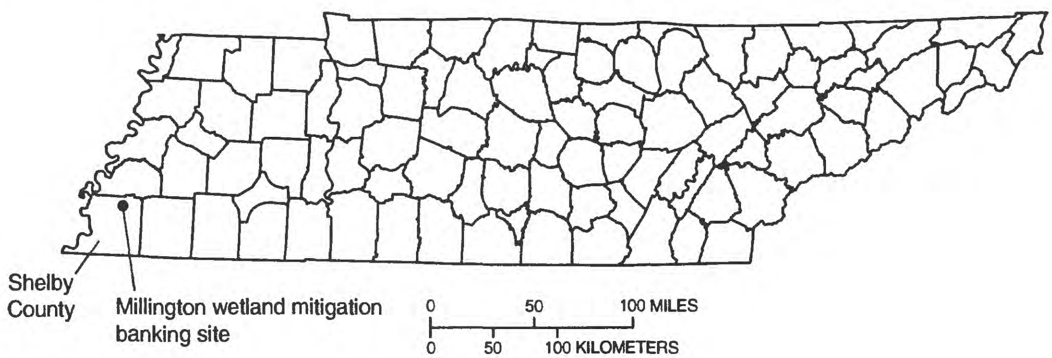
The USGS assists TDOT in identifying potential restoration sites, assessing the difficulty of restoring wetland hydrology, and developing a restoration plan that has a high likelihood of achieving the desired restoration objectives. Hydrologic conditions at the sites selected are monitored continuously to evaluate existing conditions and changes produced by application of the restoration plan. Geomorphic and biological techniques are used to enhance the cost-effectiveness of surface-water and ground-water monitoring.

The project chief is Timothy H. Diehl of the District office in Nashville.

PUBLICATIONS

Robinson, J.R., and Diehl, T.H., 1996, Hydrologic data for wetland sites at Millington, Shelby County, and Huntingdon, Carroll County, Tennessee, May 1994 through September 1995: U.S. Geological Survey Open-File Report 96-468, 31 p.

Robinson, J.R., Diehl, T.H., and Stogner, R.W., Sr., 1995, Hydrologic data at a wetland site, Millington, Shelby County, Tennessee, June 1993 through June 1994: U.S. Geological Survey Open-File Report 95-715, 26 p.



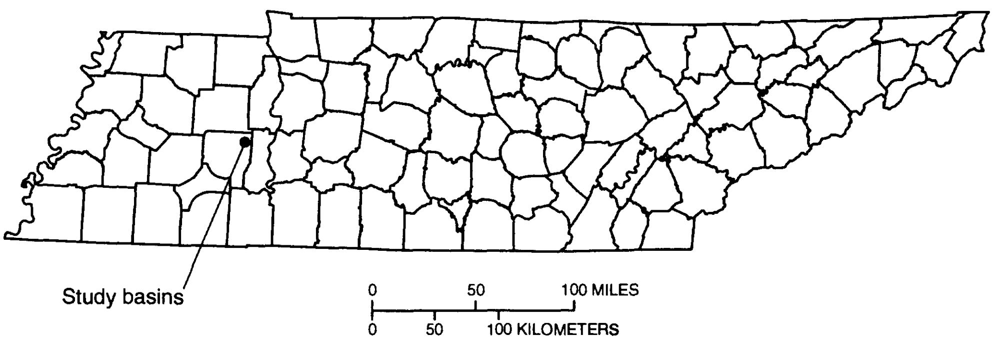

Location of Millington wetland banking site, Shelby County, Tennessee.

## Sediment Sources in Natchez Trace State Forest

Natchez Trace State Forest was created to reclaim tens of thousands of acres of severely eroded land in West Tennessee. The reclamation was successful over nearly the entire forest, and erosion rates on the land surface have been reduced to near-natural levels. Concerns remain, however, about the sediment carried off the forest by streams.

In cooperation with the Tennessee Department of Agriculture, Division of Forestry, and in partnership with the U.S. Department of Agriculture Forest Service Center for Bottomland Hardwood Research, the USGS is investigating the sources of stream-borne sediment in the Natchez Trace State Forest. The volume of sediment transport of the geomorphically active channel system and the area of surface erosion have been measured in two small basins in Henderson County, one recently disturbed and the other less recently disturbed. Preliminary results indicate that the channel network, rather than areas of surface erosion, is the major source of sediment exported from these basins. Field work was conducted in the summer of 1996 and data compilation and analysis are underway.

The project chief is Timothy H. Diehl of the District office in Nashville.




Location of study basins in Natchez Trace State Forest, Henderson County, Tennessee.

# OTHER ACTIVITIES

## Development of a Digital Data Base for Assessing Environmental Contamination

The Tennessee Department of Environment and Conservation, Division of Superfund (DSF), oversees assessment and remediation at approximately 250 contaminated sites in Tennessee. Contaminants at these sites include petroleum products, heavy metals, chlorinated solvents, and radioisotopes, among others. Evaluating public-health risks from contamination and prioritizing sites for remediation requires the collection and organization of pertinent environmental data. Currently, relevant data are stored in diverse formats by several State and Federal agencies. Collecting these data in a central location and recompiling them to a common format will enhance the DSF's ability to evaluate and manage public-health risks from environmental contamination in Tennessee.

The USGS, in cooperation with the Tennessee Department of Environment and Conservation, DSF, is creating a geographic information system (GIS) data base of factors relevant to potential transport of contaminants to water resources in Tennessee. A GIS combines the information-management functions of a relational data base with a geographic frame of reference. This combination makes the GIS a powerful tool for analyzing the interaction of spatially distributed variables. The public-health risk associated with a given contaminant release varies spatially with environmental factors affecting the fate and transport of contaminants and with socioeconomic factors that reflect the human demands on water resources.

The data base will encompass the State of Tennessee and will consist of statewide GIS coverages. Examples of these coverages include:

- Location of Superfund sites.
- Location of potential sources of chlorinated-solvent releases.
- Domestic use of untreated ground water.
- Location of public wells and springs.
- Statewide geology.
- Soil thickness and permeability.

The project is directed by William J. Wolfe with GIS management and creation assistance from David C. Greene of the District office in Nashville.

## Outreach

USGS employees of the District office and three Subdistrict offices in Tennessee have presented numerous talks and seminars on various aspects of hydrology to the students and faculty of several schools and universities in the State. The list of schools includes the University of Tennessee, Middle Tennessee State University, The University of Memphis, and Tennessee State University. Seminars, frequently with hands-on demonstrations, also have been given to teachers, high school students, and elementary school students. Talks on hydrology also have been presented to non-academic organizations such as the Tennessee Association of Utility Districts, Fort Campbell Environmental-Quality Officers, various Chambers of Commerce, watershed management committees, and Soil Conservation District field days.

The Tennessee District is one of the sponsors of the Tennessee Water Resources Symposium. This annual symposium provides a forum for the exchange of water-resources information and ideas among scientists and others within the State. Additionally, the USGS has provided financial support each year to the Tennessee Water Resources Research Center.

The Tennessee District Office assisted in the preparation of "The Geologic Story of the Ocoee River," which describes the geologic history of the Ocoee River, the site of the 1996 Summer Olympic kayaking competition. The pamphlet was published by the USGS in conjunction with the Tennessee Valley Authority and the U.S. Forest Service and was prepared for the Olympics to provide a geologic description for the many visitors to the area.

PUBLICATIONS

U.S. Geological Survey, 1995, U.S. Geological Survey, Programs in Tennessee: U.S. Geological Survey Fact Sheet FS–42–95, 4 pages.

———1996a, U.S. Geological Survey, Programs in Tennessee: U.S. Geological Survey Fact Sheet FS–042–96, 4 pages.

———1996b, U.S. Geological Survey, Tennessee: U.S. Geological Survey Open-File Report 96–176, 1 sheet.

## World Wide Web Access to Tennessee District Home Page

By accessing the Tennessee District Home Page, various types of information can be obtained. Information currently available for access includes real-time streamflow data via satellite from USGS-operated gages; historical surface-water data retrieval by station; selected recent USGS publications; the Tennessee District Water Resources Publications Bibliography, 1987-93; descriptions of USGS programs in Tennessee; the names of key personnel; as well as information about earthquakes in the Mississippi Valley.

We encourage you to visit our home page where you can browse and learn more about our agency operations in Tennessee or, through available links, visit the USGS Home Page, the USGS Water Resources Home Page, the EROS Data Center, or other sites. The Tennessee District home page is maintained by David Greene (dgreene@usgs.gov) of the District office in Nashville.

Access may be obtained to the following using the uniform resource locators listed below:

Tennessee District Home Page: http://wwwdtnnsh.er.usgs.gov/index.html

USGS Home Page: http://www.usgs.gov

USGS Water Resources Home Page: http://water.usgs.gov

EROS Data Center: http://edcwww.cr.usgs.gov

## Geophysical Logging

The Tennessee District of the USGS conducts an active program of geophysical logging in cooperation with the Memphis Light, Gas and Water Division (MLGW) and in support of other ground-water investigations across the State. Geophysical logs can provide valuable information on the geologic and hydrologic conditions at a well. These logs can be used to identify changes in lithology and to determine the occurrence and depth of fractures and solution openings intercepted by a well.

Test wells drilled by MLGW are logged by the USGS to provide information on the Memphis aquifer and the Fort Pillow aquifer in Shelby County. The Tennessee District geophysical logging unit in Memphis supports the cooperative work with MLGW. This logging unit can run caliper, natural gamma, and electric logs to depths of about 1,500 feet below land surface.

## District Drilling Capabilities

A CME 55 drill rig is stationed at the Memphis Subdistrict to support USGS drilling activities in Tennessee and other Water Resources Division districts. The rig can be used to drill in unconsolidated soils to a depth of about 150 feet. Capabilities of the drilling operations include hollow- and solid-stem augering, mud-rotary drilling, and split-spoon sampling. The drill rig significantly improves the Tennessee District capabilities to install monitoring wells in a cost-efficient and timely manner. For example, the CME 55 drill rig was used to install 36 monitoring wells at a U.S. Environmental Protection Agency Superfund site in Jackson, Tennessee, where the soils were highly contaminated with organic chemicals.

Drilling operations are directed by Larry B. Thomas with assistance from W. Kevin Kelly, Amy M. Fielder, and Randy Thomas, all of the Memphis Subdistrict office.

## Recent Publications

The Tennessee Publications Section prepared for publication 14 Water-Resources Investigations Reports; 25 Open-File Reports; 14 journal articles, abstracts, and symposia articles; 3 Fact Sheets; 2 annual data reports; 1 Hydrologic Investigations Atlas; 6 Administrative Reports; and 1 Water-Supply Paper. The Publications Section also coordinated the printing of 6 reports from other Districts and Headquarters. Currently, approximately 20 reports are in various stages of preparation. Reports recently printed include:


Balthrop, B.H., and Mattraw, H.C., Jr., 1995, Water-resources investigations in Tennessee: Programs and activities of the U.S. Geological Survey, 1992–94: U.S. Geological Survey Open-File Report 94–498, 65 p.

Brede, L.M., and Benham, B.L., 1996, Water-quality characteristics and suspended sediment of the Clinch and Powell Rivers in northeastern Tennessee, 1989–94: U.S. Geological Survey Open-File Report 96–247, 30 p.

Bryan, B.A., Simon, Andrew, Outlaw, G.S., and Thomas, Randy, 1995, Methods for assessing channel conditions related to scour-critical conditions at bridges in Tennessee: U.S. Geological Survey Water-Resources Investigations Report 94–4229, 54 p.

Byl, T.D., and Carney, K.A., compilers, 1996, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 96–4186, 34 p.

Byl, T.D., Jiao, Yun, and Hutson, S.S., 1996, Influence of riparian vegetation on the biological structure and processing function of a channelized stream in West Tennessee, *in* Byl, T.D., and Carney, K.A., compilers, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 96–4186, p. 21–26.

Byl, T.D., and Mattraw, H.C., Jr., 1995, Characterizing water quality in the North Fork-Fall Creek hydrologic unit area, Tennessee: U.S. Geological Survey Open-File Report 95–372, 1 sheet.

Cochrane, H.H., and Williams, S.D., 1996, Nutrient and sediment loads in a channelized stream and a nonchannelized wetland stream in the Beaver Creek watershed, West Tennessee, *in* Byl, T.D., and Carney, K.A., compilers, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 96–4186, p. 3-8.

Diehl, T.H., in press, Potential drift accumulation at bridges: U.S. Federal Highway Administration Publication No. FHWA–RD–97–028, 104 p.

Doyle, W.H., Jr., and Baker, E.G., 1995, Collection of short papers on the Beaver Creek watershed study in West Tennessee, 1989–94: U.S. Geological Survey Open-File Report 95–156, 54 p.

Doyle, W.H., Jr., Whitworth, B.G., Smith, G.F., and Byl, T.D., 1996, The Beaver Creek Story: U.S. Geological Survey Open-File Report 96–398, 1 sheet.

Flohr, D.F., Hamilton, J.T., Lewis, J.G., and Thomas, L.B., 1995, Water resources data, Tennessee, Water year 1994: U.S. Geological Survey Water-Data Report TN–94–1, 399 p.

———1996, Water resources data, Tennessee, Water year 1995: U.S. Geological Survey Water-Data Report TN–95–1, 445 p.

Hampson, P.S., 1995, National Water-Quality Assessment Program—the upper Tennessee River basin study unit: U.S. Geological Survey Fact Sheet FS–150–95, 1 sheet.

Hanchar, D.W., 1995, Ground-water data for the Suck Creek area of Walden Ridge, southern Cumberland Plateau, Marion County, Tennessee: U.S. Geological Survey Open-File Report 94–704, 15 p.

Haugh, C.J., 1996a, Hydrogeology of the area near the J4 test cell, Arnold Air Force Base, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4182, 43 p.

———1996b, Well-construction, water-level, and water-quality data for ground-water monitoring wells for the J4 hydrogeologic study, Arnold Air Force Base, Tennessee: U.S. Geological Survey Open-File Report 95–763, 81 p.

Hollyday, E.F., and Byl, T.D., 1995, Water-quality, discharge, and biologic data for streams and springs in the Highland Rim escarpment of southeastern Bedford County, Tennessee: U.S. Geological Survey Open-File Report 95–732, 36 p.

Hollyday, E.F., Hileman, G.E., Smith, M.A., and Pavlicek, D.J., 1996, Hydrogeologic terranes and potential yield of water to wells in the Valley and Ridge physiographic province in Maryland, New Jersey, and Pennsylvania: U.S. Geological Survey Hydrologic Investigations Atlas HA–732–A, 2 sheets.

Hoos, A.B., and Patel, A.R., 1996, Adjustment of regional regression models of urban-runoff quality using data for Chattanooga, Knoxville, and Nashville, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 95–4140, 12 p.

Hutson, S.S., 1995a, Estimated use of water in Tennessee, 1990: U.S. Geological Survey Water-Resources Investigations Report 94–4055, 1 sheet.

———1995b, Ground-water use by public-supply systems in Tennessee, 1990: U.S. Geological Survey Open-File Report 94–483, 1 sheet.

———1996, Estimates of future water demand for selected water-service areas in the upper Duck River Basin, central Tennessee, *with a section on* Methodology used to develop population forecasts for Bedford, Marshall, and Maury Counties, Tennessee, from 1993 through 2050 by G.E. Schwarz: U.S. Geological Survey Water-Resources Investigations Report 96–4140, 58 p.

Johnson, G.C., 1996, A seepage investigation of an area at and near Oak Ridge National Laboratory, Oak Ridge, Tennessee, March through August 1993: U.S. Geological Survey Open-File Report 95–442, 51 p.

Johnson, G.C., and Brede, L.M., 1995, Hydrologic data of two wetlands at Spring City, Tennessee, December 1991 through November 1992: U.S. Geological Survey Open-File Report 95–278, 16 p.

Johnson, S.E., 1995, Hydrogeology of the Cascade Springs area near Tullahoma, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 95–4002, 17 p.

Kingsbury, J.A., 1996, Altitude of the potentiometric surfaces, September 1995, and historical water-level changes in the Memphis and Fort Pillow aquifers in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4278, 1 sheet.

Kingsbury, J.A., and Carmichael, J.K., 1995, Hydrogeology of post-Wilcox group stratigraphic units in the area of the Naval Air Station Memphis, near Millington, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 95–4011, 1 sheet.

Ladd, D.E., 1996a, Base-flow data for the Little West Fork Basin, Fort Campbell, Tennessee and Kentucky, 1993 and 1994: U.S. Geological Survey Open-File Report 96–343, 28 p.

———1996b, Construction, lithologic, and water–level data for wells near the Dickson County landfill, Dickson County, Tennessee, 1995: U.S. Geological Survey Open-File Report 96–229, 16 p.

Olsen, L.D., 1995, Pesticide movement in soils: a comparison of no-tillage and conventional tillage in the Beaver Creek watershed in West Tennessee: U.S. Geological Survey Open-File Report 95-329, 1 sheet.

Outlaw, G.S., 1996, Flood-frequency and detention-storage characteristics of Bear Branch watershed, Murfreesboro, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4005, 24 p.

Outlaw, G.S., and Weaver, J.D., 1996, Flow duration and low flows of Tennessee streams through 1992: U.S. Geological Survey Water-Resources Investigations Report 95–4293, 245 p.

Parks, W.S., Mirecki, J.E., and Kingsbury, J.A., 1995, Hydrogeology, ground-water quality, and source of ground water causing water-quality changes in the Davis well field at Memphis, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 94–4212, 58 p.

Pavlicek, D.J., 1996, Hydrogeology and hydrochemistry of the Cave Springs basin near Chattanooga, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4248, 35 p.

Robinson, J.A., and Diehl, T.H., 1996, Hydrologic data for wetland sites at Millington, Shelby County, and Huntingdon, Carroll County, Tennessee, May 1994 through September 1995: U.S. Geological Survey Open-File Report 96–468, 31 p.

Robinson, J.A., Diehl, T.H., and Stogner, R.W., Sr., 1996, Hydrologic data at a wetland site, Millington, Shelby County, Tennessee, June 1993 through June 1994: U.S. Geological Survey Open-File Report 95–715, 26 p.

Robinson, J.A., and Johnson, G.C., 1996, Results of a seepage investigation at Bear Creek Valley, Oak Ridge, Tennessee, January through September 1994: U.S. Geological Survey Open-File Report 95–459, 45 p.

Robinson, J.A., and Mitchell, R.L., III, 1996, Gaining, losing, and dry stream reaches at Bear Creek Valley, Oak Ridge, Tennessee, March and September 1994: U.S. Geological Survey Open-File Report 96–557, 17 p.

Smink, J.A., and Byl, T.D., 1996, Evaluation of a constructed wetland to control agricultural row-crop nonpoint-source pollution, *in* Byl, T.D., and Carney, K.A., compilers, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 96–4186, p. 11–17.

U.S. Geological Survey, 1995a, An overview of the Beaver Creek study in West Tennessee: U.S. Geological Survey Open-File Report 95–312, 1 sheet.

———1995b, United States Geological Survey, Programs in Tennessee: U.S. Geological Survey Fact Sheet FS–42–95, 4 pages.

———1996a, U.S. Geological Survey, Programs in Tennessee: U.S. Geological Survey Fact Sheet FS–042–96, 4 pages.

———1996b, U.S. Geological Survey, Tennessee: U.S. Geological Survey Open-File Report 96–176, 1 sheet.

Webbers, Ank, 1995, Ground-water quality protection—Why it's important to you: U.S. Geological Survey Open-File Report 95–376, 1 sheet.

Webster, D.A., 1996, Results of ground-water tracer tests using tritiated water at Oak Ridge National Laboratory, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 95–4182, 50 p.

Williams, S.D., 1996a, Ground-water-quality data for selected wells in the Beaver Creek watershed, West Tennessee: U.S. Geological Survey Open-File Report 95–769, 30 p.

———1996b, Transport of aldicarb and aldicarb metabolites in runoff from agricultural fields in the Beaver Creek watershed, West Tennessee, *in* Byl, T.D., and Carney, K.A., compilers, Instream investigations in the Beaver Creek watershed in West Tennessee, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 96–4186, p. 29–34.

Williams, S.D., and Harris, R.M., 1996, Nutrient, sediment, and pesticide data collected at four small agricultural basins in the Beaver Creek watershed, West Tennessee, 1990–1995: U.S. Geological Survey Open-File Report 96–366, 115 p.

Wolfe, W.J., 1996, Hydrology and tree-distribution patterns of karst wetlands at Arnold Engineering Development Center, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96–4277, 46 p.

Wolfe, W.J., and League, D.E., 1995, Water-surface elevations of wetlands and nearby wells at Arnold Air Force Base, near Manchester, Tennessee: U.S. Geological Survey Open-File Report 95–753, 19 p.

# Appendix 1
# Active Recording Surface-Water Stations in Tennessee as of 9/30/95

[*, current conditions available on the World Wide Web at *http://wwwdtnnsh.er.usgs.gov/rts/index.html*]

| Station number | Name | Drainage area (mi²) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | CUMBERLAND RIVER BASIN | | | | |
| * 03312255 | Salt Lick Cr at Red Boiling Springs | 12.6 | 363227 | 855101 | 1991 |
| 03409500 | Clear Fork near Robbins | 272 | 362318 | 843749 | 1930 |
| 03409700 | East Branch Bear Creek near Oneida | 2.32 | 363242 | 842919 | 1994 |
| * 03414500 | E Fork Obey River nr Jamestown | 202 | 362458 | 850135 | 1942 |
| * 03416000 | Wolf River near Byrdstown | 106 | 363337 | 850423 | 1942 |
| * 03418070 | Roaring River above Gainsboro | 210 | 362104 | 853245 | 1974 |
| 03418420 | Cumberland River below Cordell Hull Dam | 8,095 | 361712 | 855627 | 1980 |
| 03420185 | Collins River at Beersheba Springs | 157 | 352847 | 853857 | 1994 |
| 03420200 | Collins River near Tarlton | 174 | 353104 | 854027 | 1994 |
| * 03421000 | Collins River near McMinnville | 640 | 354232 | 854346 | 1925 |
| * 03422500 | Caney Fork near Rock Island | 1,678 | 354826 | 853744 | 1911 |
| * 03424730 | Smith Fork at Temperance Hall | 214 | 360514 | 855429 | 1991 |
| * 03425000 | Cumberland River at Carthage | 10,690 | 361453 | 855719 | 1922 |
| * 03425400 | Cumberland River at Hunters Point | 11,107 | 361757 | 861549 | 1986 |
| 03426310 | Cumberland River at Old Hickory Dam | 11,673 | 361747 | 863928 | 1931-42, 1947 |
| * 03426385 | Mansker Crk above Goodlettsville | 27.7 | 362020 | 864304 | 1993 |
| * 03427500 | East Fork Stones River nr Lascassas | 262 | 355506 | 862002 | 1951 |
| * 03428200 | W Fork Stones River at Murfreesboro | 177 | 355410 | 862548 | 1972-82, 1986 |
| * 03428500 | West Fork Stones River near Smyrna | 237 | 355625 | 862754 | 1965 |
| 03430118 | McCrory Cr at Ironwood Dr, at Donelson | 7.31 | 360907 | 863902 | 1977 |
| 03430147 | Stoners Creek nr Hermitage | 20.6 | 361140 | 863628 | 1992 |
| 03430550 | Mill Creek near Nolensville | 40.5 | 360033 | 864206 | 1992 |
| * 03431000 | Mill Creek near Antioch | 64.0 | 360454 | 864050 | 1953-75, 1992 |
| * 03431300 | Browns Creek at State Fairgrounds at Nashville | 11.8 | 360747 | 864540 | 1964-75, 1993 |
| 03431490 | Pages Branch at Avondale | 2.01 | 361222 | 864624 | 1977 |
| * 034315005 | Cumberland River at Woodland St. at Nashville | 12,860 | 361002 | 864635 | 1992 |
| * 03431599 | Whites Creek near Bordeaux | 51.3 | 361303 | 864913 | 1993 |
| * 03431700 | Richland Creek at Charlotte Ave. at Nashville | 24.3 | 360904 | 865116 | 1964-1990, 1993 |
| * 03431800 | Sycamore Creek near Ashland City | 97.2 | 361912 | 870304 | 1961 |
| * 03432350 | Harpeth River at Franklin | 191 | 355514 | 865156 | 1974 |
| 03432400 | Harpeth River below Franklin | 210 | 355653 | 865254 | 1988 |
| * 03433500 | Harpeth River at Bellevue | 408 | 360316 | 865542 | 1920 |
| * 03434500 | Harpeth River near Kingston Springs | 681 | 360719 | 870556 | 1925 |
| 03435305 | Red River below Highway 161 near Barren Plains | 549 | 363832 | 865918 | 1994 |
| 03436420 | Piney Fork at Fort Campbell, KY-TN | 50.2 | 363659 | 873051 | 1993 |
| 03436426 | Little West Fork nr Fort Campbell, KY-TN | 128 | 363637 | 872811 | 1993 |

## Active Recording Surface-Water Stations in Tennessee as of 9/30/95—Continued

| Station number | Name | Drainage area ($mi^2$) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | CUMBERLAND RIVER BASIN—Continued | | | | |
| * 03436100 | Red River at Port Royal | 935 | 363317 | 870831 | 1961 |
| * 03436500 | Cumberland River at Clarksville | 16,000 | 363228 | 872204 | 1924-44, 1986 |
| * 03436690 | Yellow Creek at Ellis Mills | 103 | 361839 | 873315 | 1980 |
| * 03437000 | Cumberland River at Dover | 16,530 | 362926 | 875020 | 1986 |
| | TENNESSEE RIVER BASIN | | | | |
| * 03465500 | Nolichucky River at Embreeville | 805 | 361035 | 822727 | 1920 |
| 03465830 | Muddy Fork near Leesburg | 13.5 | 361759 | 823336 | 1994 |
| 03466098 | Jockey Creek near Mt. Bethel Church near Limestone | 18.5 | 361406 | 823848 | 1994 |
| * 03466228 | Sinking Creek at Afton | 13.7 | 361155 | 824431 | 1977 |
| 03466825 | Lick Creek Near Holland Mill | 53.0 | 361919 | 824716 | 1994 |
| * 03469175 | Little Pigeon River above Sevierville | 184 | 355155 | 833201 | 1988 |
| 03491000 | Big Creek near Rogersville | 47.3 | 362534 | 825707 | 1957 |
| 03491544 | Crockett Creek below Rogersville | 4.67 | 362247 | 830248 | 1989 |
| 03497300 | Little River above Townsend | 106 | 353952 | 834241 | 1963 |
| * 03498500 | Little River near Maryville | 269 | 354710 | 835304 | 1951 |
| 03498850 | Little River near Alcoa | 300 | 354832 | 835536 | 1987 |
| * 03528000 | Clinch River above Tazewell | 1,474 | 362530 | 832354 | 1918 |
| 03536320 | White Oak Creek near Melton Hill | 1.31 | 355556 | 841820 | 1987 |
| 03536380 | Whiteoak Creek near Wheat | 2.10 | 355530 | 841852 | 1987 |
| 03536440 | Northwest Tributary near Oak Ridge | .67 | 355518 | 841913 | 1987 |
| 03536450 | First Creek near Oak Ridge | .33 | 355521 | 841910 | 1987 |
| 03536550 | Whiteoak Creek bl Melton Valley Drive near Oak Ridge | 3.28 | 355510 | 841902 | 1985 |
| 03537100 | Melton Branch nr Melton Hill nr Oak Ridge | 0.52 | 355459 | 841753 | 1985 |
| 03538231 | E. Fk. Poplar Cr at Y-12 at Oak Ridge | .81 | 355911 | 841502 | 1993 |
| 03538235 | E. Fk. Poplar Cr at Bear Creek Road at Oak Ridge | 1.69 | 355948 | 841425 | 1993 |
| 03538256 | Bear Creek at Bear Creek Road near Oak Ridge | .42 | 355817 | 841649 | 1993 |
| 03538260 | Bear Creek at County Line nr Oak Ridge | 1.57 | 355726 | 841803 | 1993 |
| 03538270 | Bear Creek at St. Hwy. 95 nr Oak Ridge | 4.34 | 355614 | 842022 | 1959-64, 1985 |
| 03538600 | Obed River at Crossville | 12.0 | 355727 | 850300 | 1992 |
| * 03540500 | Emory River at Oakdale | 764 | 355859 | 843329 | 1927 |
| 03563000 | Ocoee River at Emf | 524 | 350548 | 843207 | 1913 |
| 03566000 | Hiwassee River at Charleston | 2,298 | 351716 | 844507 | 1898-1903, 1919-40, 1963 |
| 035661285 | North Mouse Creek near Rocky Mount Hollow near Athens | 42.1 | 352655 | 843923 | 1993 |
| 03568000 | Tennessee River at Chattanooga | 21,380 | 350512 | 851643 | 1874 |
| 03578455 | Bradley Cr Trib. at AEDC nr Manchester | -- | 352327 | 860216 | 1993 |
| 03578600 | Brumalow Cr at AEDC nr Manchester | -- | 352220 | 860233 | 1993 |

## Active Recording Surface-Water Stations in Tennessee as of 9/30/95—Continued

| Station number | Name | Drainage area (mi²) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | TENNESSEE RIVER BASIN—Continued | | | | |
| 03578970 | Rowland Cr at AEDC nr Manchester | -- | 352211 | 860332 | 1993 |
| 03579620 | Rock Creek at Tullahoma | 12.3 | 352134 | 861247 | 1992 |
| 03593500 | Tennessee River at Savannah | 33,140 | 351329 | 881526 | 1930 |
| *03597210 | Garrison Fork above L&N Railroad at Wartrace | 85.5 | 353042 | 861926 | 1990 |
| *03597590 | Wartrace Creek below County Road at Wartrace | 35.7 | 353138 | 862025 | 1990 |
| 03597860 | Duck River at Shelbyville | 425 | 352851 | 862745 | 1992 |
| *03598000 | Duck River near Shelbyville | 481 | 352849 | 862957 | 1934 |
| 03598173 | Fall Creek near Deason | 16.4 | 353501 | 862917 | 1994 |
| 03598179 | Fall Creek near Halls Mill | 39.0 | 353309 | 863214 | 1994 |
| 03598250 | N Fork Creek near Poplins Crossroads | 71.9 | 353506 | 863545 | 1994 |
| *03599500 | Duck River at Columbia | 1,208 | 353705 | 870156 | 1905-08, 1920 |
| 03600088 | Carters Creek at Butler Rd at Carters Creek | 20.1 | 354302 | 865945 | 1986 |
| 03602219 | Piney River at Cedar Hill | 46.6 | 355943 | 872622 | 1988 |
| *03604000 | Buffalo River near Flat Woods | 447 | 352945 | 874958 | 1920 |
| 03605078 | Cypress Creek at Camden | 27.3 | 360249 | 880433 | 1992 |
| 03607198 | Clifty Creek at Clifty Creek Road nr Paris | 8.06 | 361553 | 881514 | 1994 |
| 03607225 | Holly Fork Creek at Nobles | 26.8 | 362101 | 881346 | 1994 |
| 03607232 | Beaverdam Creek at Sulfur Well Road at Noble | 6.69 | 362011 | 881110 | 1994 |
| | OBION RIVER BASIN | | | | |
| 07024200 | Crooked Creek at Highway 22 nr Huntingdon | 89.8 | 360316 | 882719 | 1994 |
| 07024305 | Beaver Creek at Highway 22 bypass near Huntingdon | 58.6 | 360047 | 882642 | 1994 |
| 07026040 | Obion River at U.S. Highway 51 near Obion | 1,875 | 361427 | 891303 | 1929-58, 1966 |
| 07027000 | Reelfoot Lake near Tiptonville (gage height) | 240 | 362109 | 892507 | 1940 |
| | HATCHIE RIVER BASIN | | | | |
| *07029500 | Hatchie River at Bolivar | 1,480 | 351631 | 885836 | 1929 |
| | LOOSAHATCHIE RIVER BASIN | | | | |
| 07030240 | Loosahatchie River near Arlington | 262 | 351837 | 893823 | 1969 |
| 07030250 | Beaver Creek near Arlington | 148 | 351912 | 893928 | 1994 |
| | WOLF RIVER BASIN | | | | |
| 07031650 | Wolf River at Germantown | 699 | 350659 | 894805 | 1970-86, 1991 |
| | NONCONNAH CREEK BASIN | | | | |
| 07032200 | Nonconnah Creek near Germantown | 68.2 | 350259 | 894908 | 1969 |

## Appendix 1—Continued
## Active Crest-Stage Stations in Tennessee as of 9/30/95

[#, Operated as a continuous-record gaging station]

| Station number | Name | Drainage area ($mi^2$) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | | CUMBERLAND RIVER BASIN | | | |
| 03409000 | White Oak Creek at Sunbright | 13.5 | 361438 | 844014 | 1934, 1955-82, 1985 |
| 03414500 | East Fork Obey River | 202 | 362458 | 850135 | 1942-91#, 1992 |
| 03416000 | Wolf River near Byrdstown | 106 | 363337 | 850423 | 1942-91#, 1992 |
| 03418070 | Roaring River above Gainsboro | 210 | 362104 | 853245 | 1974-91#, 1992 |
| 03418201 | Doe Creek at Gainesboro | 5.72 | 362123 | 853920 | 1978 |
| 03421200 | Charles Creek near McMinnville | 31.1 | 354300 | 854605 | 1955 |
| 03424900 | Mulherrin Creek near Gordonsville | 26.9 | 361128 | 855711 | 1982, 1986 |
| 03425045 | Peyton Creek at Monoville | 44.7 | 361837 | 855921 | 1986 |
| 03425365 | Second Creek near Walnut Grove | 3.47 | 362401 | 861248 | 1986 |
| 03425637 | Station Camp Creek at Cottontown | 7.21 | 362706 | 863216 | 1995 |
| 03426800 | East Fork Stones River at Woodbury | 39.1 | 354941 | 860436 | 1962-89#, 1990 |
| 03426874 | Brawleys Fork below Bradyville | 15.4 | 354444 | 861014 | 1983 |
| 034269424 | Reed Creek near Bradyville | 3.52 | 354444 | 861231 | 1983 |
| 03427500 | East Fork Stones River nr Lascassas | 262 | 355506 | 862002 | 1950-58#, 1963-91#, 1992 |
| 03427690 | Bushman Creek at Pitts Lane Ford near Compton | 9.67 | 355308 | 862047 | 1989-92#, 1993 |
| 03428043 | Lytle Creek at Sanbyrne Drive at Murfreesboro | 17.6 | 354938 | 862328 | 1978 |
| 03428270 | Unnamed Sink near Almaville | -- | 355121 | 863221 | 1994-95 |
| 03428500 | West Fork Stones River near Smyrna | 237 | 355625 | 862754 | 1965-91#, 1992 |
| 03428513 | Unnamed Sink on I-840 at Leanne | -- | 355613 | 862614 | 1994 |
| 03428515 | Unnamed Sink at Leanne | -- | 355619 | 862649 | 1994 |
| 03430118 | McCrory Creek at Ironwood Drive near Donelson | 7.31 | 360907 | 863902 | 1977 |
| 03430400 | Mill Creek at Nolensville | 12.0 | 355732 | 864031 | 1965 |
| 03431040 | Sevenmile Creek at Blackman Road at Nolensville | 12.2 | 360421 | 864400 | 1965 |
| 03431060 | Mill Creek at Thompson Lane, near Woodbine | 93.4 | 360704 | 864308 | 1965 |
| 03431062 | Mill Creek tributary at Glenrose Ave at Woodbine | 1.17 | 360702 | 864337 | 1977 |
| 03431120 | West Fork Browns Creek at General Bates Drive, at Nashville | 3.30 | 360629 | 864707 | 1965 |
| 03431240 | East Fork Browns Creek at Baird-Ward Printing Company, at Nashville | 1.58 | 360633 | 864600 | 1965 |
| 03431340 | Browns Creek at Factory Street, at Nashville | 13.2 | 360826 | 864531 | 1965 |

## Active Crest-Stage Stations in Tennessee as of 9/30/95—Continued

| Station number | Name | Drainage area ($mi^2$) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | CUMBERLAND RIVER BASIN—Continued | | | | |
| 03431490 | Pages Branch at Avondale | 2.01 | 361222 | 864624 | 1977 |
| 03431550 | Earthman Fork at Whites Creek | 6.29 | 361555 | 864951 | 1965 |
| 03431573 | Ewing Creek at Richmond Hill Drive at Parkwood | 2.17 | 361350 | 864628 | 1976 |
| 03431575 | Ewing Creek at Brick Church Pike at Parkwood | 3.02 | 361358 | 864654 | 1976 |
| 03431578 | Ewing Creek at Gwynwood Drive near Jordonia | 9.98 | 361358 | 864732 | 1976 |
| 03431581 | Ewing Creek below Knight Road, near Bordeaux | 13.3 | 361355 | 864814 | 1976 |
| 03431677 | Sugartree Creek at YMCA Access Road, at Green Hills | 1.51 | 360613 | 864912 | 1976 |
| 03431679 | Sugartree Creek at Abbott Martin Road, at Green Hills | 2.19 | 360623 | 864917 | 1976 |
| 03431800 | Sycamore Creek near Ashland City | 97.2 | 361912 | 870304 | 1961-87#, 1988-91#, 1992 |
| 03432470 | Murfrees Fork above Burwood | 7.43 | 354858 | 865720 | 1986 |
| 03432925 | Little Harpeth River at Granny White Pike, at Brentwood | 22.0 | 360130 | 864909 | 1978 |
| 03434590 | Jones Creek near Burns | 13.3 | 360615 | 871905 | 1984 |
| 034350021 | Bartons Creek near Cumberland Furnace | 22.3 | 361502 | 872000 | 1984 |
| 034350035 | Louise Creek nr Grays Chapel | 12.7 | 362152 | 872030 | 1995 |
| 034351105 | Honey Run Creek nr Cross Plains | 17.0 | 363152 | 874010 | 1995 |
| 034351113 | Honey Run Creek below Cross Plains | 20.0 | 363231 | 864214 | 1986 |
| 03435739 | Beaver Dam Creek above Springfield | 12.9 | 363140 | 864929 | 1995 |
| 03435770 | Sulphur Fork Red River above Springfield | 65.6 | 363047 | 865144 | 1975 |
| 03435930 | Spring Creek tributary near Cedar Hill | 1.40 | 363208 | 865926 | 1986 |
| 03436082 | Sulphur Fork Red River above Port Royal | 214 | 363223 | 870651 | 1995 |
| 03436100 | Red River at Port Royal | 935 | 363317 | 870831 | 1961-91#, 1992 |
| 03436130 | Passenger Creek near Sango | 20.5 | 363207 | 871150 | 1995 |
| 03436505 | Cummings Creek nr Dotsonville | 2.65 | 362918 | 872806 | 1984 |
| 03436690 | Yellow Creek at Ellis Mills | 103 | 361839 | 873315 | 1980-91#, 1992 |
| 03436700 | Yellow Creek near Shiloh | 124 | 362055 | 873220 | 1957-80#, 1982 |
| | TENNESSEE RIVER BASIN | | | | |
| 03461230 | Caney Creek near Cosby | 1.62 | 354703 | 831211 | 1967 |
| 03465607 | Cherokee Creek near Embreeville | 22.9 | 361224 | 822923 | 1984 |
| 03465780 | Clear Fork near Fairview | 10.5 | 361933 | 823347 | 1983 |
| 03466890 | Lick Creek near Albany | 172 | 361454 | 825534 | 1984 |
| 03467480 | Bent Creek at Taylor Gap | 2.18 | 361408 | 830641 | 1986 |
| 03467992 | Carter Branch near White Pine | 4.25 | 360705 | 831855 | 1986 |
| 03467993 | Cedar Creek near Valley Home | 2.01 | 360803 | 831847 | 1986 |
| 03467998 | Sinking Fork at White Pine | 6.38 | 360721 | 831744 | 1986 |

## Appendix 1—Continued
## Active Crest-Stage Stations in Tennessee as of 9/30/95—Continued

| Station number | Name | Drainage area (mi²) | Latitude | Longitude | Beginning year |
|---|---|---|---|---|---|
| | TENNESSEE RIVER BASIN—Continued | | | | |
| 03470215 | Dumplin Creek at Mt. Hareb | 3.65 | 360459 | 832551 | 1986 |
| 03476960 | Indian Creek at Childress | 6.79 | 362538 | 821554 | 1983 |
| 03478615 | Evans Creek near Blountville | 2.50 | 363119 | 821812 | 1983 |
| 03487550 | Reedy Creek at Orebank | 36.3 | 363342 | 822736 | 1963-89#, 1990 |
| 03490522 | Forgey Creek at Zion Hill | 0.86 | 362912 | 825308 | 1986 |
| 03491540 | Robertson Creek near Persia | 14.6 | 362024 | 830227 | 1986 |
| 03494714 | Dry Land Creek tributary nr New Market | 0.20 | 360333 | 833413 | 1986 |
| 03494990 | Flat Creek at Luttrell | 22.4 | 361145 | 834444 | 1986 |
| 03519610 | Baker Creek tributary near Binfield | 2.10 | 354156 | 840246 | 1966-77, 1979 |
| 03519640 | Baker Creek near Greenback | 16.0 | 354021 | 860628 | 1965-75#, 1976 |
| 03527800 | Big War Creek at Luther | 22.3 | 362718 | 831429 | 1986 |
| 03528390 | Crooked Creek near Maynardville | 2.23 | 361556 | 835025 | 1986 |
| 03534000 | Coal Creek at Lake City | 24.5 | 361314 | 840927 | 1932-34#, 1955 |
| 03535180 | Willow Fork near Halls Crossroads | 3.23 | 360559 | 835427 | 1967 |
| 03555900 | Coker Creek near Ironsburg | 22.4 | 351305 | 842028 | 1983 |
| 03566420 | Wolftever Cr nr Ooltewah | 18.8 | 350343 | 850359 | 1964-1989#, 1992 |
| 03566599 | North Chickamauga Creek at Greens Mill, near Hixson | 99.5 | 351030 | 851340 | 1925, 1944, 1953-56, 1980 |
| 03569168 | Stringers Branch at Leawood Drive, at Red Bank | 1.54 | 350700 | 851728 | 1980 |
| 03571500 | Little Sequatchie River at Sequatchie | 116 | 350747 | 853510 | 1925, 1929-30, 1932-34#, 1944, 1951-54, 1965, 1979 |
| 03571730 | Standifer Branch at Jasper | 15.3 | 350422 | 853656 | 1982 |
| 03571800 | Battle Creek near Monteagle | 50.4 | 350803 | 854615 | 1955 |
| 03583300 | Richland Creek near Cornersville | 47.5 | 351910 | 865220 | 1962-68#, 1969 |
| 035944242 | Owl Creek at Lexington | 2.50 | 353826 | 882213 | 1984 |
| 03597300 | Wartrace Creek above Bell Buckle | 4.99 | 353745 | 862122 | 1966 |
| 03602170 | West Piney River at Hwy 70 nr Dickson | 2.16 | 360521 | 872812 | 1984 |
| 03602500 | Piney River at Vernon | 193 | 355216 | 873005 | 1925-93#, 1995 |
| 03604090 | Coon Creek above Chop Hollow, near Hohenwald | 6.02 | 353519 | 874109 | 1967 |
| 03604580 | Blue Creek near New Hope | 13.2 | 360352 | 873858 | 1984 |
| 03605555 | Trace Creek above Denver | 31.9 | 360308 | 875427 | 1963-88#, 1989 |
| 03605880 | Cane Creek at Stewart | 4.12 | 361909 | 875021 | 1984 |
| | OBION RIVER BASIN | | | | |
| 07024225 | Neil Ditch near Henry | 4.07 | 361019 | 882333 | 1984 |
| 07024370 | Little Reedy Creek near Huntingdon | 0.91 | 355544 | 882950 | 1984 |
| 07025500 | North Fork Obion River at Union City | 480 | 362359 | 885943 | 1929-66, 1967-71, 1989-93#, 1994 |
| 07028505 | North Fork Forked Deer River at U.S. Highway 45W Bypass at Trenton | 73.9 | 355858 | 885549 | 1987 |
| 07029090 | Lewis Creek near Dyersburg | 25.5 | 360314 | 892142 | 1955-78, 1980-83, 1985 |
| 07030100 | Cane Creek at Ripley | 33.9 | 354525 | 893305 | 1957-62#, 1963-70, 1986-88#, 1989 |

# Appendix 2
# Water-quality and suspended-sediment stations

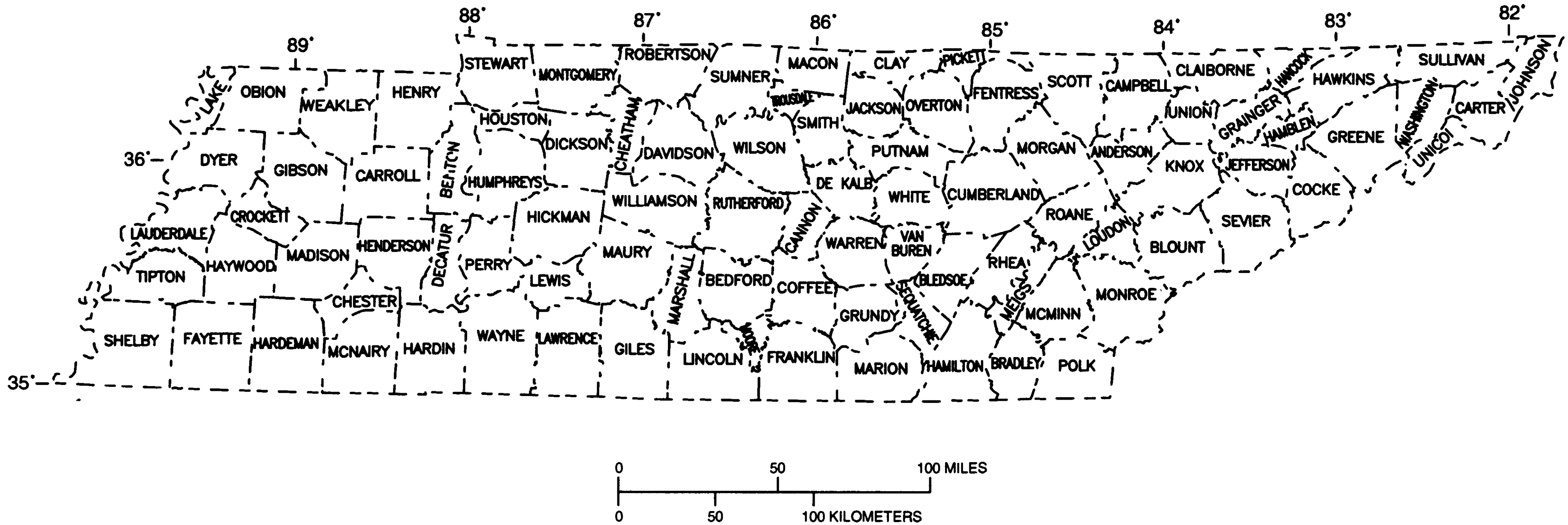
[Q, chemical; B, bacteriological; S, sediment]

| Station number | Name | Drainage area ($mi^2$) | Lat | Long | Date began | Data type |
|---|---|---|---|---|---|---|
| | CUMBERLAND RIVER BASIN | | | | | |
| 03417500 | Cumberland River at Celina | 7,307 | 363315 | 853052 | 1992 | Q |
| 03418420 | Cumberland River below Cordell Hull Dam | 8,095 | 361712 | 855627 | 1980 | Q |
| 03426310 | Cumberland River at Old Hickory Dam (Tailwater) | 11,673 | 361747 | 863928 | 1979 | Q |
| 03428200 | W Fork Stones River at Murfreesboro | 177 | 355410 | 862548 | 1986 | Q |
| 03435000 | Cumberland River below Cheatham Dam | 14,163 | 361922 | 871342 | 1993 | Q |
| | TENNESSEE RIVER BASIN | | | | | |
| 03497300 | Little River above Townsend | 106 | 353952 | 834241 | 1964-82, 1986 | Q,B,S |
| 03597860 | Duck River at Shelbyville | 425 | 352851 | 862745 | 1991 | Q |
| 03600085 | Carters Creek at Petty Lane near Carters Creek | 16.6 | 354339 | 865919 | 1986 | Q,B,S |
| 03600086 | Carters Creek Trib near Carters Creek | 2.94 | 354334 | 865919 | 1986 | Q,B,S |
| 03600088 | Carters Creek at Butler Road at Carters Creek | 20.1 | 354302 | 865945 | 1986 | Q,B,S |
| 03604000 | Buffalo River near Flat Woods | 447 | 352945 | 874958 | 1964 | Q,B,S |

## Appendix 3
## Active ground-water network in Tennessee as of 9/30/95

| Station number | Local well number | Latitude | Longitude | Beginning year |
|---|---|---|---|---|
| | RECORDER—60-MINUTE PUNCH INTERVAL | | | |
| 360835086441100 | Dv:L-10 | 360835 | 864411 | 1985 |
| 350234085181200 | Hm:G-36 | 350234 | 851812 | 1981 |
| 351428085003600 | Hm:O-15 | 351428 | 850036 | 1975 |
| 360020087573300 | Hs:H-1 | 360020 | 875733 | 1962 |
| 353839089493500 | Ld:F-4 | 353839 | 894935 | 1966 |
| 350035086423100 | Li:G-2 | 350035 | 864231 | 1988 |
| 354223088380200 | Md:N-1 | 354223 | 883802 | 1949 |
| 360543084343101 | Mg:F-5 | 360543 | 843431 | 1984 |
| 360521085432601 | Pm:C-1 | 360521 | 854326 | 1968 |
| 350506089483101 | Sh:L-89 | 350506 | 894831 | 1990 |
| 350406089444401 | Sh:M-40 | 350406 | 894444 | 1990 |
| 350857089591401 | Sh:P-99 | 350857 | 895914 | 1968 |
| 350735089593300 | Sh:P-76 | 350735 | 895933 | 1928 |
| 350900089482300 | Sh:Q-1 | 350900 | 894823 | 1940 |
| 350811089430901 | Sh:R-30 | 350811 | 894309 | 1940 |
| 350810089430801 | Sh:R-31 | 350810 | 894308 | 1989 |
| 353922083345600 | Sv:E-2 | 353922 | 833456 | 1979 |
| | TAPE DOWN—MEASUREMENT MADE MANUALLY | | | |
| 350344090130000 | Ar:H-2 | 350344 | 901300 | 1983 |
| 352226089330101 | Fa:R-1 | 352226 | 893301 | 1949 |
| 352226089330102 | Fa:R-2 | 352226 | 893301 | 1949 |
| 350002090054400 | Sh:J-1 | 350002 | 900544 | 1960 |
| 350432090015100 | Sh:J-126 | 350432 | 900151 | 1949 |
| 350124090072200 | Sh:J-140 | 350124 | 900722 | 1968 |
| 350508090015001 | Sh:J-171 | 350508 | 900150 | 1987 |
| 350125090072201 | Sh:J-185 | 350125 | 900722 | 1994 |
| 350658089560100 | Sh:K-45 | 350658 | 895601 | 1945 |
| 350724089555600 | Sh:K-66 | 350724 | 895556 | 1946 |
| 350514089553700 | Sh:K-75 | 350514 | 895537 | 1948 |
| 350207089511002 | Sh:L-39 | 350207 | 895110 | 1959 |
| 350234089515602 | Sh:L-103 | 350234 | 895156 | 1990 |
| 351435090005200 | Sh:O-1 | 351435 | 900052 | 1940 |
| 350910090015101 | Sh:O-170 | 350910 | 900151 | 1945 |
| 350921090015300 | Sh:O-179 | 350921 | 900153 | 1944 |
| 350914090010503 | Sh:O-181 | 350914 | 900105 | 1971 |
| 350914090010600 | Sh:O-212 | 350914 | 900106 | 1971 |
| 350913090010302 | Sh:O-229 | 350913 | 900103 | 1984 |
| 351320089535800 | Sh:P-1 | 351320 | 895358 | 1940 |
| 351100089523600 | Sh:P-85 | 351100 | 895236 | 1953 |
| 350925089595200 | Sh:P-97 | 350925 | 895952 | 1971 |
| 351439089572301 | Sh:P-113 | 351439 | 895723 | 1976 |
| 351432089573101 | Sh:P-202 | 351432 | 895731 | 1994 |
| 351126089513000 | Sh:Q-59 | 351126 | 895130 | 1973 |
| 351111089512501 | Sh:Q-94 | 351111 | 895125 | 1987 |
| 351112089512501 | Sh:Q-154 | 351112 | 895125 | 1990 |
| 350810089430802 | Sh:R-32 | 350810 | 894308 | 1989 |
| 352112089571200 | Sh:U-1 | 352112 | 895712 | 1946 |
| 352112089571300 | Sh:U-2 | 352112 | 895713 | 1953 |
| 355505086541100 | Wm:M-1 | 355505 | 865411 | 1950 |

INDEX




Location of Tennessee counties.

Cover photo: Fall Creek Falls
State Park, Tennessee.