WATER-RESOURCES INVESTIGATIONS IN TENNESSEE: PROGRAMS AND ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, 1990-91

by Ferdinand Quinones and Barbara H. Balthrop

U.S. GEOLOGICAL SURVEY

Open-File Report 91-051

Nashville, Tennessee
1991

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
A-413 Federal Building
U.S. Courthouse
Nashville, Tennessee 37203

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center, Building 810
Box 25425
Denver, Colorado 80225

CONTENTS

A MESSAGE FROM THE TENNESSEE DISTRICT CHIEF

This report summarizes the 1990-91 programs and activities by the Tennessee District of the U.S. Geological Survey (USGS), Water Resources Division. The report describes the main objectives and current progress in the principal projects within the cooperative and Federal programs of the USGS in Tennessee. It is the most current in a series published every 2 years.

The programs and activities of the USGS respond to water-resources interests on local, state, and Federal levels. During the last few years, the focus of the investigations conducted by the USGS shifted in response to varied water-related issues. Water supply continues to be the main subject of local interest to cities and counties. USGS water-supply projects are designed to provide information about the availability, occurrence, and quality of surface and ground waters for public and industrial uses. Investigations of this type were conducted or begun in Hamilton, Blount, Sevier, Wilson, Crockett, Washington, and several other counties. Similar studies in Fayette, Scott, Hamblen, and Lawrence Counties are scheduled for 1991.

Storm runoff and its quality became an important issue in 1990. Regulations promulgated by the U.S. Environmental Protection Agency (USEPA) require that Chattanooga, Knoxville, Memphis, and Nashville define the quality of urban storm runoff. Projects to assist these cities in collecting the required data began in Nashville and Knoxville; similar studies are scheduled for 1991 at Chattanooga and Memphis.

State interests in the investigations of the USGS are directed primarily toward collecting data for use in the planning and management of Tennessee's water resources. The Tennessee Department of Health and Environment and the Tennessee Department of Transportation are the principal cooperators of the USGS in these programs. Monitoring of ground-water quality, water use, and potential for scour at bridges are among the main activities developed in support of State agencies.

On the Federal level, programs and activities respond to the data needs of other Federal agencies and the national programs of the USGS. The operation and maintenance of long-term streamflow-gaging networks in support of the U.S. Army Corps of Engineers, Nashville District, the U.S. Department of Energy, and the Tennessee Valley Authority are fundamental activities. New USGS projects in support of other Federal agencies to meet regulatory requirements began in 1990 at Tullahoma (U.S. Air Force), Millington (U.S. Navy), and Jackson (U.S. Environmental Protection Agency). Finally, national programs of the USGS include the operation of long-term stations to monitor streamflow and rainfall quantity and quality at selected sites in Tennessee.

I am pleased with the success of these and other programs of the USGS in Tennessee. The support of the local, state, and other Federal officials in the cooperating agencies is fundamental to the achievements of 1990 and the goals of 1991. The staff of the USGS in the Tennessee District is proud to participate in these projects because of their importance to the needs of the people of Tennessee.

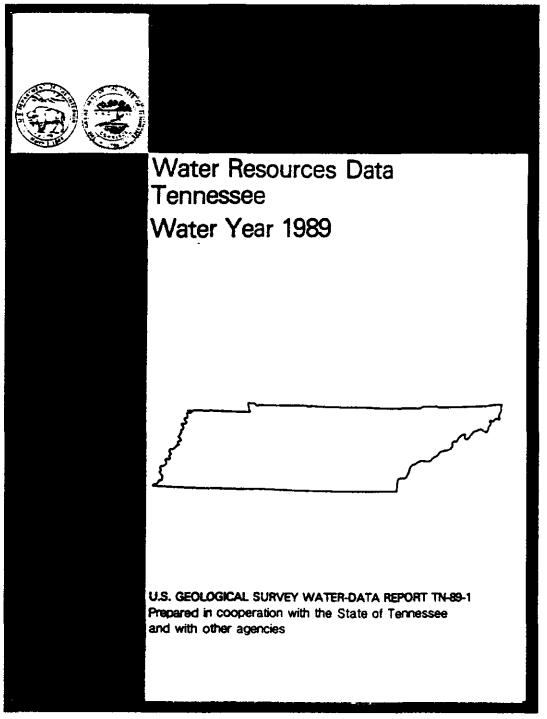
Ferdinand Quinones
District Chief
Tennessee District, USGS-WRD

WATER-RESOURCES INVESTIGATIONS IN TENNESSEE: PROGRAMS AND ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, 1990-91

by Ferdinand Quinones and Barbara H. Balthrop

HYDROLOGIC DATA COLLECTION

Hydrologic data, or basic data as it is commonly called, is the backbone of the investigations conducted by the U.S. Geological Survey (USGS). The basic data programs conducted 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 Hydrologic Data Section. Field operations are about equally divided among field offices in Memphis, Nashville, and Knoxville. A staff of about 40 engineers, hydrologists, and hydrologic technicians labor in the operation of the long-term networks as well as short-term efforts in support of areal investigations. The data collected as part of the networks are published in the series of annual data reports entitled "Water Resources Data for Tennessee."



FLOOD INVESTIGATIONS

In cooperation with the Tennessee Department of Transportation and the Metropolitan Government of Nashville and Davidson County, the USGS conducts flood investigations in Tennessee. The objective of this program is to appraise and define the flood characteristics of Tennessee streams by:

- Investigating and documenting outstanding floods
- Operating a network of about 90 crest-stage partial-record gages to provide flood data on small streams and 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 outstanding floods, have been prepared to aid in the proper design of hydraulic structures within the State's highway system. These include:

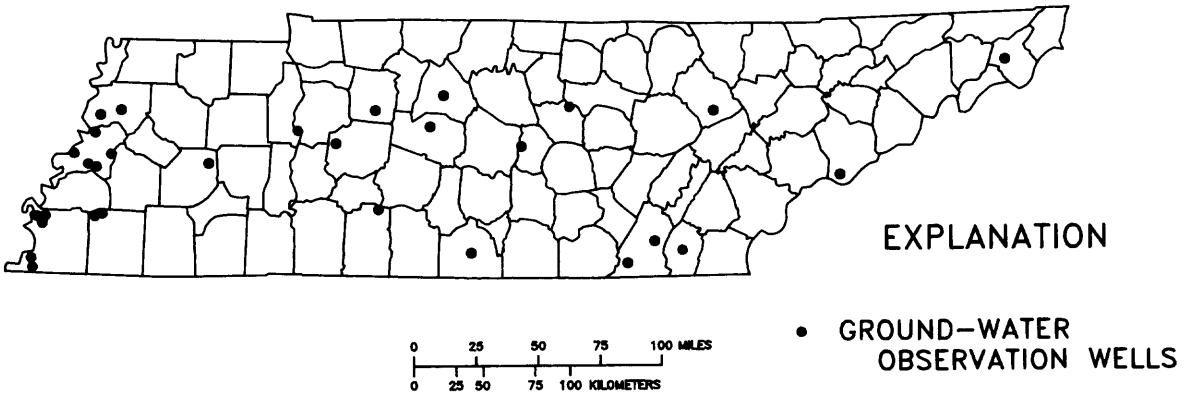
- Methods to compute depth of floods of various recurrence intervals at ungaged sites
- Methods to estimate an average flood hydrograph and runoff volume, in inches, for most ungaged sites within the State
- Regional flood-frequency analyses to provide peak discharges for ungaged sites for various recurrence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

The areal extent of the project is statewide. The project chief is hydrologist Charles R. Gamble.

GROUND-WATER-LEVEL NETWORK

The USGS operates about 30 observation wells in cooperation with the Tennessee Department of Health and Environment, Office of Water Management, and about 18 observation wells in cooperation with Memphis Light, Gas and Water. The 30 observation wells are part of the statewide ground-water-level network. These wells are used to monitor water-level fluctuations in reponse to natural and man-induced stress on the ground-water system.

The observation wells in the Memphis area monitor the water-level response to pumping from the major well fields. The Memphis Sand aquifer currently supplies about 196 million gallons of water per day for municipal and industrial supplies in the Memphis area. Memphis Light, Gas and Water is the single largest user of ground water in the State.



Location of observation wells in Tennessee.

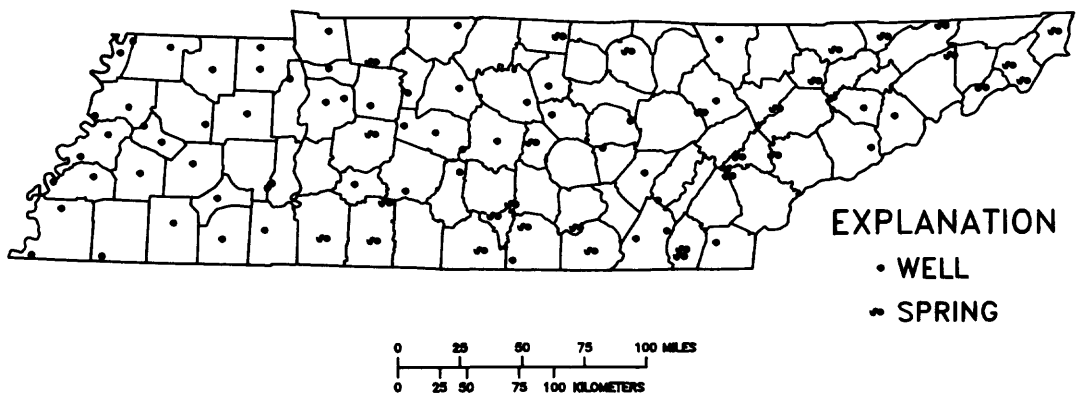
GROUND-WATER-QUALITY NETWORK IN TENNESSEE

In March 1989, a project was initiated to describe the quality of ground water in the principal aquifers in Tennessee. The project is being conducted by the USGS in cooperation with:

- Tennessee Department of Health and Environment (TDHE), Divisions of Water Pollution Control,
- Ground Water Protection, and
- Superfund; and the
- Tennessee State Planning Office

This network is designed to provide baseline water-quality data essential to the State for proposed ground-water-protection strategies and other ambient-quality regulatory programs. The program also will provide other information of interest to federal ground-water-quality definition programs.

During the first year of the program (1989-90), a network of 90 wells and springs was established and water-quality samples were collected from each site. The sites were selected to represent the principal aquifers across the State. Most of these sites are used for public water supply. Ten percent of these sites also are scheduled for short-term (quarterly) monitoring of water quality in selected areas to determine temporal variations. Selection and sampling of these sites will begin immediately upon receipt of the last complete analysis from the 90 primary network sites. In addition, six selected sites also were scheduled to be sampled for geochemical analyses during the summer of 1990. In the second and following years of the project, the network will be reduced from 90 to 75 primary sampling sites, but will retain the 10 percent short-term sampling design.



Location of wells and springs sampled for Ground-Water-Quality Network in Tennessee.

Each year, samples will be collected from each site and shipped to the USGS National Water-Quality Laboratory in Denver, Colorado, for determination of concentrations of major and trace dissolved inorganic constituents and contamination-indicator constituents. Specific conductance, pH, and alkalinity will be measured in the field at each site. Additionally, the sampling program is designed to include a 5-year rotation beginning in 1989-90 with analyses for volatile organic compounds, followed by analyses of acid and base/neutral extractable compounds (1990), pesticides (1991), and radiochemical constituents (1992). The rotation will begin again in the fifth year. The six sites for geochemical analyses also will be rotated each year. The sampling results will be presented yearly in a series of USGS data and map reports produced through the use of geographic information system software.

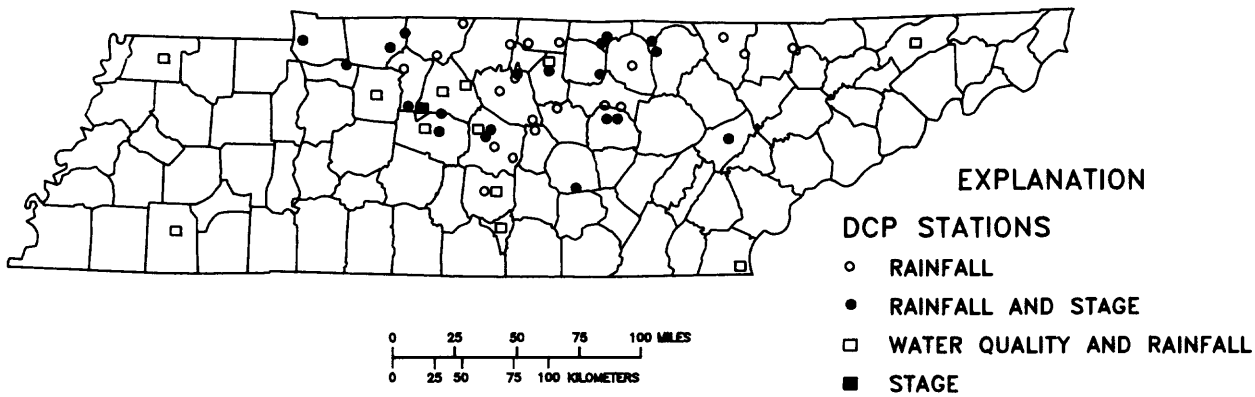
The project is under the direction of hydrologist Angel J. Roman and hydrologic technician Michael W. Bennett.

REALTIME DATA COLLECTION NETWORK

The Tennessee District of the USGS operates a network of realtime stations that monitors streamflow, rainfall, and in some cases, water quality in the Cumberland River basin and other sites in the State. The network, mostly in cooperation with the U.S. Army Corps of Engineers, Nashville District (COE), includes 38 sites in the Cumberland River basin and 12 sites in other areas of the State.

At each site, automatic recording instruments collect either streamflow, rainfall, or water-quality parameters or a combination of these. The information is transmitted by a data-collection platform (DCP) to the GOES geostationary orbiting satellite at 2-hour intervals. Emergency transmission channels allow transmissions every 5 minutes. The data are received by ground stations at the USGS facilities in South Carolina and by the COE facilities in Vicksburg, Mississippi. The ground stations transmit the data to computers at the USGS and COE offices in Nashville. Software for reading and outputting the data in graphic and tabular formats permit continuous monitoring of conditions in the field.

The COE utilizes the data for the management and operation of the Cumberland River reservoir system. The USGS computes discharges and water-quality parameters from the DCP outputs, which are archived in computer files and published in the annual data reports. The system provides realtime response during floods in the basin. Several towns and cities in Tennessee also use DCP-transmitted data to monitor waste disposal into streams.



Network of DCP stations.

STATEWIDE WATER-USE PROGRAM

The Tennessee Water-Use Information Program is one of the most important basic data programs conducted by the USGS. The program is conducted in cooperation with the Tennessee Department of Health and Environment (TDHE) and has the following objectives:

- Determine how much fresh surface and ground water is withdrawn and for what purposes, how much water is consumed during use, and how much water is returned to streams after use;
- Develop and refine a computerized system to store and retrieve the water-use information;
- Devise and apply techniques and methods to improve the analysis of water-use data; and
- Prepare and publish reports about water use in Tennessee and about the relation of water use to the hydrologic cycle.

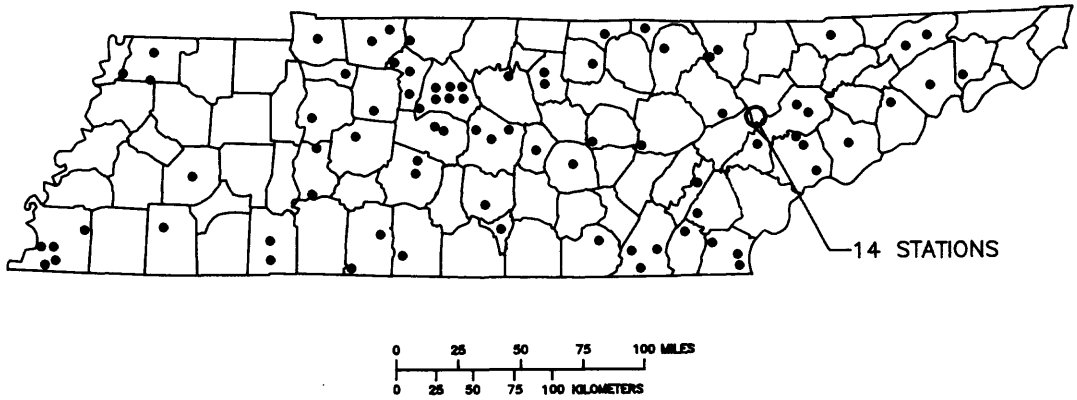
During 1989, water-use data were collected for agriculture, industry, and public supply. A report was published describing ground-water use by public supplies. An updated version of the Tennessee Water-Use Data System (TNWUDS) was installed on the USGS computer system. Data elements are stored in TNWUDS in either the water-user, conveyance, measurement-point, annual-measurement, or extended data file. Data from the Tennessee District's water-use data base can be compiled and output directly as tables, or output to the geographic information system, for graphical analysis. The project chief is hydrologist Susan S. Hutson, from the Memphis Subdistrict, with assistance from Janine A. Morris, from the Office of Water Assessment of TDHE.

SURFACE-WATER-MONITORING NETWORK

The Tennessee District operates a network of continuous streamflow-gaging stations throughout Tennessee. In 1990, the network includes 94 continuous streamflow gages and 6 continuous stream or lake water-level gages. Additionally, 23 continuous rainfall stations were operated in conjuction with other research or project activities. These data, accumulated during many years, constitute a valuable data base for developing an improved understanding of the water resources of the State. Continuous streamflow data are recorded and disseminated for many purposes, including the following:

- Assessment of quantity and quality of water available for all uses.
- Operation of impoundment and pumping structures.
- Flood or drought monitoring and forecasting.
- Waste disposal and control.
- Legal requirements and enforcement.
- Research and hydrologic trends or other special studies.

Program cooperators supporting this network are:
Tennessee Valley Authority
U.S. Army Corps of Engineers, Nashville District
Tennessee Department of Health and Environment
Tennessee Wildlife Resources Agency
U.S. Department of Energy
Memphis Light, Gas and Water
Shelby County
Cities of: Alcoa, Bartlett, Lawrenceburg, Memphis, Metropolitan Government of Nashville and Davidson County, Rogersville, Dickson, Franklin, Murfreesboro, Sevierville, and Union City

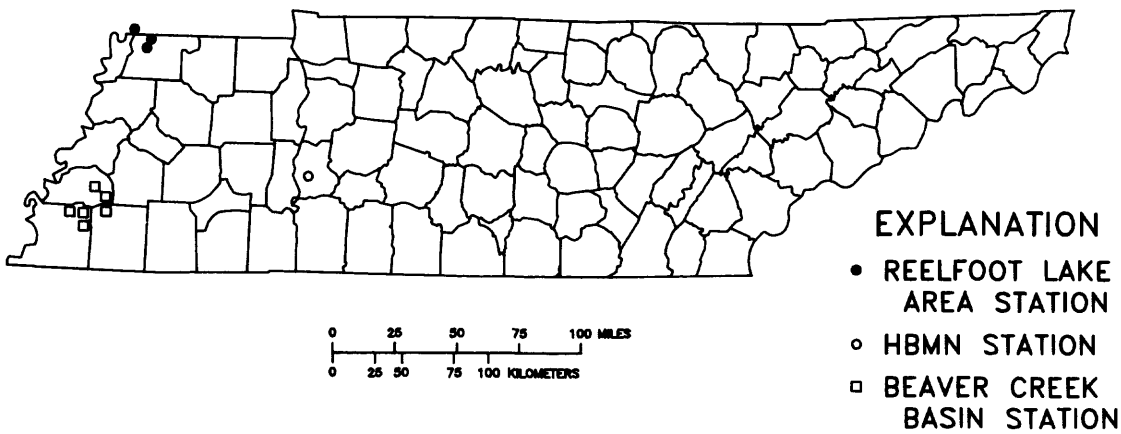


Location of streamflow stations in Tennessee.

SUSPENDED-SEDIMENT INVESTIGATIONS

The USGS began operation of daily suspended-sediment stations at six sites within the Beaver Creek basin in West Tennessee in May 1990. These stations are part of a 5-year study in the basin described on page 37. About monthly, miscellaneous and storm-runoff samples are collected from a hydrologic benchmark station (HBM) at the Buffalo River near Flat Woods. Storm-runoff samples were collected in the Reelfoot Lake area in support of a project to determine suspended-sediment and nutrients loads to the lake.

Sediment is considered perhaps the most important pollutant in stream water. Nutrients, pesticides, metals, and other contaminants are transported in sediment. Quantification of nonpoint loads of pollutants cannot be determined without definition of suspended- and bed-sediment loads. The need to establish a network of suspended-sediment stations to collect baseline data throughout the State, particularly in West Tennessee, should be a high priority of State and federal agencies.

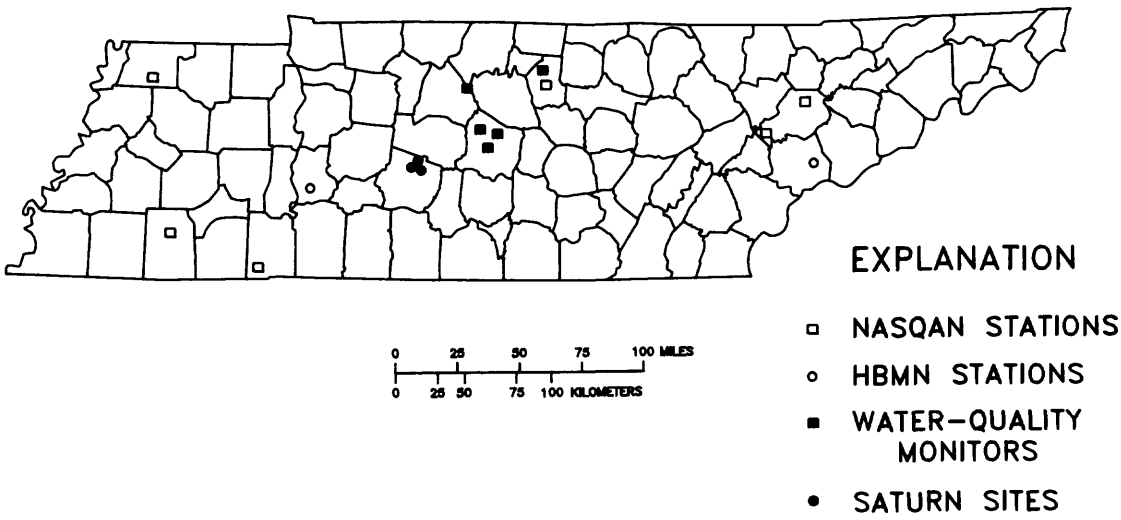


Location of suspended-sediment stations in Tennessee.

WATER-QUALITY NETWORK

The USGS monitors water quality at numerous surface-water stations in Tennessee. Six of these stations compose part of the National Stream Quality Accounting Network (NASQAN). NASQAN data-collection sites are located at or near the downstream end of hydrologic accounting units. A comprehensive list of physical and chemical characteristics are measured quarterly or bimonthly to fulfill information needs of water-resources planners and managers. Two sites within the State are part of the national Hydrologic Bench-Mark Network (HBMN). At HBMN sites, the USGS assesses natural streamflow and water quality of river basins that are known to be minimally affected by man's activities. In cooperation with the U.S. Army Corps of Engineers, water-quality monitors are operated at four sites along the Cumberland River and its tributaries in Middle Tennessee. A fifth monitor is located above the wastewater-treatment plant for the City of Murfreesboro. 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 sites in Maury County near the new Saturn industrial facility. At these sites, concentrations of suspended sediments, bacteria, organic compounds, and priority-pollutant metals are determined from water samples.



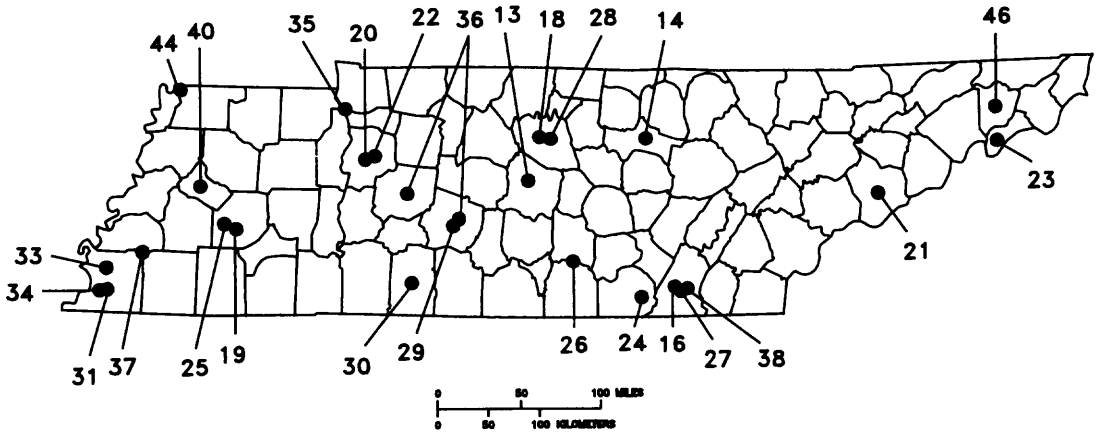
Water-quality data-collection sites in Tennessee.

HYDROLOGIC INVESTIGATIONS

The Hydrologic Investigations Section of the Tennessee District, WRD, is responsible for the design and execution of interpretive areal water-resources investigations. Surface-, ground-, and quality-of-water studies throughout the State are conducted in support of federal and cooperative programs. Projects, ranging in duration from 1 to 5 years, include areas as large as 45,000 square miles, and can cost as much as several million dollars.

The staff of the Hydrologic Investigations Section includes about 20 highly qualified and experienced geologists, engineers, biologists, and technicians. The high caliber of the staff is reflected in the number of scientists with doctoral degrees (4), master degrees (15), and other advanced college work. Experienced hydrologists and technicians are supported by a strong staff of recently hired engineers and scientists. State-of-the-art equipment is used in completing hydrological investigations.

In 1990, the Hydrologic Investigations Section was involved in 38 areal studies. Four projects were completed and four were initiated. The Section staff produced more than 29 reports, journal papers, and symposia articles.



Generalized location of the principal areal investigations. Numbers refer to page in this report describing investigation.

APPALACHIAN VALLEYS-PIEDMONT REGIONAL AQUIFER-SYSTEM ANALYSIS

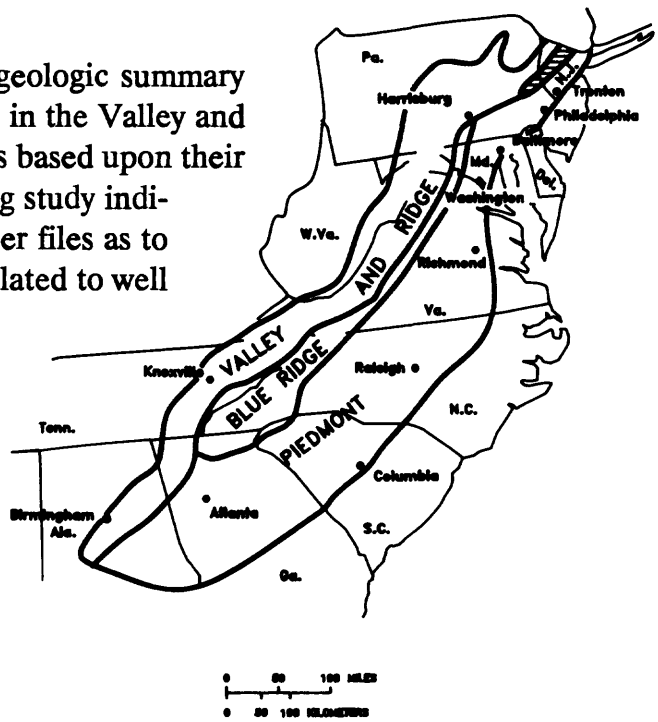
Wise development and management of water resources requires synthesis, quantification, and interpretation of information on ground water in the important aquifers of the Nation. The objective of the USGS APRASA (Appalachian Valleys-Piedmont Regional Aquifer-System Analysis) is to define the regional hydrology and geology in three physiographic provinces of the Appalachians. The study will establish a framework of background information on geology, hydrology, and water quality that can be used for regional assessment of ground-water resources and in support of more detailed local studies. Two major efforts within the approach are to:

- Assemble, analyze, and summarize information on geology, hydrology, and ambient water quality; and
- Quantify ground-water flow and quality in selected type areas that have been picked as representative of flow systems that recur throughout the study area and are significant to water supply.

As part of this federally funded project, the Tennessee District is responsible for:

- The hydrogeologic summary for the Valley and Ridge subregion of the study; and
- A type-area study (see "Quality and source of water at Cave Springs near Chattanooga, Tennessee," this report).

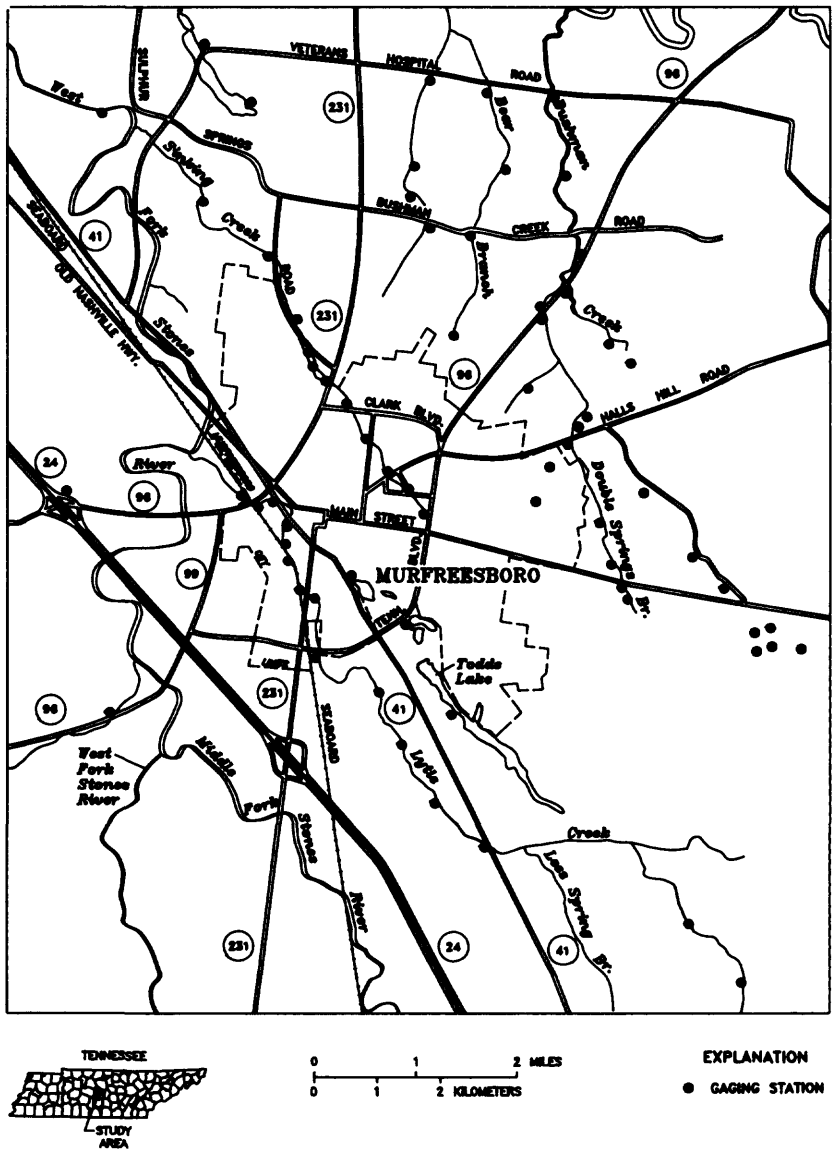
Accomplishments during 1989 on the hydrogeologic summary include classifying several hundred rock formations in the Valley and Ridge province as least, minor, or principal aquifers based upon their lithology and estimated yield to wells. A supporting study indicated that the average and range of data in computer files as to yield of wells per foot of drawdown are primarily related to well diameter, water use, lithology, and topography. Four of 15 proposed type areas were selected for study; 2 of these are in the Valley and Ridge. Work was begun on digitizing State geologic maps from film copies to geographic information system coverages. The project leader for the Valley and Ridge subregion of the APRASA is E.F. "Pat" Hollyday. The 5-year investigation is scheduled to be completed September 1993.



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

BASIN MODELING AND BASIC DATA COLLECTION NETWORK FOR MURFREESBORO

Murfreesboro, Tennessee, similiar to most cities and towns in Middle Tennessee, experiences problems related to storm runoff after intense periods of rainfall. The USGS, in cooperation with the City of Murfreesboro, is investigating these problems and the methods and tools which can be used by the city to aid in planning and managing development near these flood-prone areas. This investigation is part of a national program of urban hydrology studies. The project is being directed by hydrologist George S. Outlaw and includes the following steps:



Murfreesboro gaging network.

- Collection of streamflow data (6 sites measuring 32.5 square miles of drainage area), rainfall data (8 sites), and peak-stage elevations (60 sites);
- Development of a basin streamflow model for use in estimating runoff from future development in the Bear Branch basin;
- Definition of flood profiles and flood hydrographs based on actual flood data;
- Definition of flood profiles for various recurrence-interval floods for use in delineating flood-prone areas;
- Development of a flood-prone-area frequency relation from recorded elevations for selected sinkholes in the Bushman Creek (Double Springs) basin; and
- Collection of aerial photos during flood periods to define inundated areas.

DETERMINATION OF REAERATION CHARACTERISTICS AT SELECTED STREAM REACHES THROUGHOUT TENNESSEE

The U.S. Geological Survey (USGS), as part of its ongoing investigations of streamflow characteristics, is collecting data on reaeration rates (K coefficients) at streams throughout the State. Reaeration coefficients are essential for waste allocation permits under current State and Federal regulations. The data will eventually be used to develop statewide correlations to verify the empirical equations normally used in estimating K values.

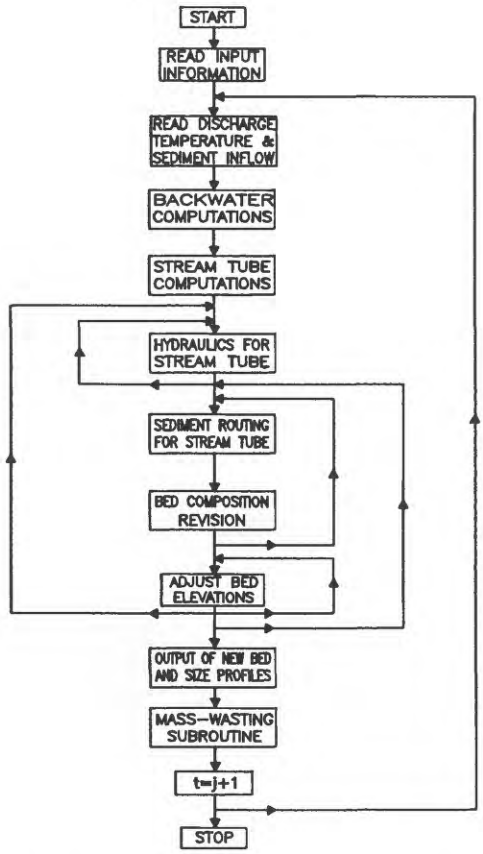
Gas- and dye-tracer techniques are used by the USGS to estimate K values within a reach of a stream. Propane gas is injected into the stream at a known rate with a 2-micron pore-opening gas diffuser. A dye (Rhodamine WT) is also injected into the stream at the same time. Samples are then collected and analyzed for concentrations of propane and the dye at points downstream from the injection zone. Streamflow measurements are made at the same time that the injection and sampling takes place. The K coefficient of the stream reach is then computed with empirical equations from the propane and dye analyses and the streamflow data.

During the last year, K coefficients were determined for reaches at West Prong Pigeon Fork near Pigeon Forge (in cooperation with the City of Pigeon Forge) and at Pigeon Roost Creek near Cookeville (in cooperation with the Tennessee Department of Health and Environment). Hydrologists Anne B. Hoos, Malcom A.Dugliss, and Connor J. Haugh directed these activities.

DEVELOPMENT OF A MASS-WASTING SUBROUTINE FOR CHANNEL EVOLUTION MODELING

Stream channels are constantly evolving systems, continually changing their form through the processes of erosion and deposition. In West Tennessee, stream channels are changing rapidly, and bridges and other structures are being undercut and destroyed by massive bank failures. The changes in the stream network are uncontrolled and largely unpredictable by current methods.

A quantitative model of channel evolution, based on well-defined physical processes is needed to predict the rates of aggradation, degradation, and channel widening in a wide range of settings. The best available existing model of channel evolution is the Bridge Streamtube Alluvial-River Simulation model (BRI-STARS) developed at Colorado State University. Like other existing models of channel evolution, it adjusts channel width guided by the principle of energy minimization. Although this approach has merit, it is not process-oriented and does not account for changes in bank geometry through landslides and other mass movements. In West Tennessee, these processes are prominent mechanisms of rapid channel evolution.



Flow chart showing location of the mass-wasting subroutine in the BRISTARS model.

The USGS, in cooperation with the Tennessee Department of Transportation, is developing a mass-wasting subroutine to compute the contributions of bank failure to channel changes. This subroutine will be incorporated into BRI-STARS, making it the first channel-evolution model to include prediction of massive bank failure. Hydrologist William J. Wolfe assisted by Dr. Andrew Simon (USGS office in Vancouver, Washington) directs the project.

DEVELOPMENT OF GROUND-WATER RESOURCES IN THE EASTSIDE UTILITY DISTRICT

The Eastside Utility District supplies 3 to 4 million gallons of water per day to 26,000 customers near Chattanooga in southeastern Hamilton County. The utility district obtains its water from wells at Carson Spring, one of the largest natural springs in Tennessee.

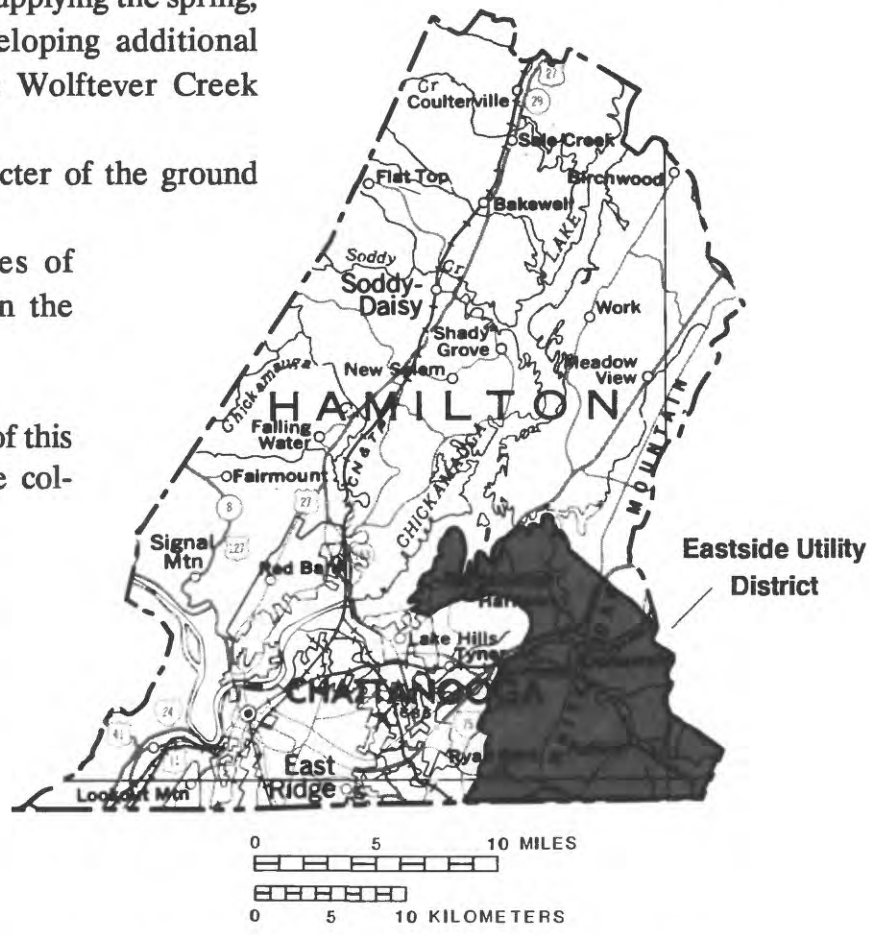
The demand for water within the Eastside Utility District service area has increased to the level where demand exceeds replenishment ability during peak hours of use. The U. S. Geological Survey, in cooperation with the utility district, has completed an investigation of the ground-water potential of the Carson Spring drainage basin and part of the adjacent Wolftever Creek drainage basin.

Objectives of the study were to:

- Determine the average daily flow and seasonal variations in the daily flow from Carson Spring,
- Define the size of the aquifer supplying the spring,
- Assess the potential for developing additional ground-water supplies in the Wolftever Creek drainage basin,
- Document the chemical character of the ground water,
- Identify nondomestic sources of ground-water contamination in the Carson Spring watershed.

During the final part of Phase 2 of this investigation; (1) water samples were collected from 16 wells in the Carson Spring watershed and were analyzed for chemical content; (2) pumpage and spring discharge over a 31-month period were computed; (3) variations in seasonal flow were determined; (4) the extent of the aquifer supplying the spring was estimated; and (5) a report of the investigation was prepared.

Hydrologist David A. Webster was the project leader.



Location of the area serviced by the Eastside Utility District in southeastern Hamilton County, Tennessee.

DIGITAL DATA ACQUISITION AND DEVELOPMENT OF COVERAGES OF WELLS AND SPRINGS USED FOR PUBLIC SUPPLY IN TENNESSEE

About 55 percent of the people in Tennessee use ground water for drinking and other domestic uses. More than 280 wells and springs are used in the State for public supply. These wells and springs are vulnerable to surface or near-surface contamination depending on the geohydrologic environment around the wells and the proximity to potential contamination sources. Potential contamination sources are widespread across the State, with more than 650 potential sites identified by the Tennessee Department of Health and Environment (TDHE), Division of Superfund.

The potential and extent of contamination of these public-supply sources is poorly known. Most important, in areas where there is no contamination at present, the potential may exist for future degradation of the quality of the water. The knowledge about the potential for contamination is essential for planning future strategies in managing ground-water supplies.

The USGS, as part of its water-resources investigations programs and in cooperation with the TDHE, Division of Superfund, is engaged in a project to acquire data and develop digital data sets for the following:

- Available data on ground-water public-supply sources in Tennessee,
- Available data on Resource Conservation and Recovery Act sites identified by the U.S. Environmental Protection Agency (USEPA) and TDHE,
- Available data on Comprehensive Environmental Response and Compensation Liability Act sites identified by USEPA and TDHE,
- Available data on Toxic Release Inventory System sites identified from USEPA data collected by TDHE,
- Available data on Leaking Underground Storage Tank sites identified by TDHE,
- Available data on the principal aquifers in Tennessee from a base map developed by USGS, and
- Available data on the population centers from the Master Area Reference File for Tennessee.

In addition, the USGS will assist TDHE personnel with manipulation of the digital data. The project is directed by hydrologist Dr. Joseph F. Connell.

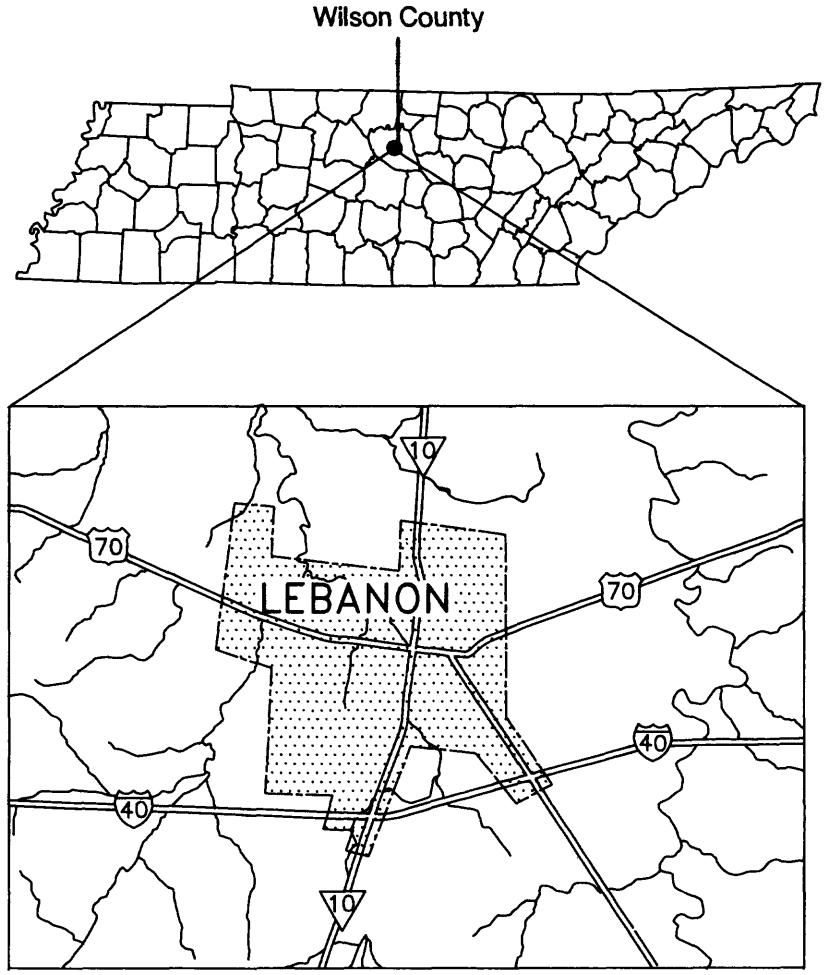
DOCUMENTATION OF 1989 FLOOD IN LEBANON

On February 14, 1989, intense rainfall and severe flooding occurred in many areas of Tennessee. One of the areas most seriously affected by flooding was the City of Lebanon in Wilson County. Flooding in the Lebanon area was caused by excess runoff from Sinking Creek, Tarver Branch, and Bartons Creek. The USGS, in cooperation with the City of Lebanon and the U.S. Army Corps of Engineers, Nashville District, initiated a study to document the flood in Lebanon and vicinity.

To accomplish the objectives of the project, the following tasks have been completed:

- Flood profiles were defined from high-water marks.
- The peak discharge, and frequency, for Sinking Creek, Bartons Creek, and Spring Creek were determined by indirect methods.
- Large-scale (1" = 200') 2-foot contour-interval topographic maps were produced from aerial photography by photogrammetric methods.
- Inundated areas caused by flooding of Sinking Creek, Tarver Branch, and Bartons Creek have been defined.
- A report documenting the flood is in preparation.

The topographic map data will be available in digital format for inclusion in geographic information system data bases. This will provide an easy means of updating the maps. The data collected during this project can provide a basis for flood-plain management decisions that could help reduce flood-damage cost in the future. The project chief, is hydrologist George Outlaw.



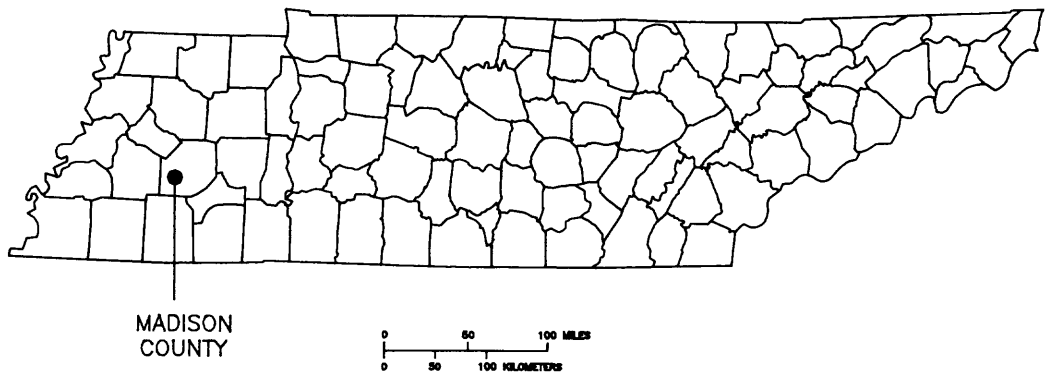
Location of Lebanon study area.

EFFECTS OF CONTAMINANTS FROM AN ABANDONED WOOD-PRESERVING FACILITY ON GROUND WATER AND SURFACE WATER, JACKSON

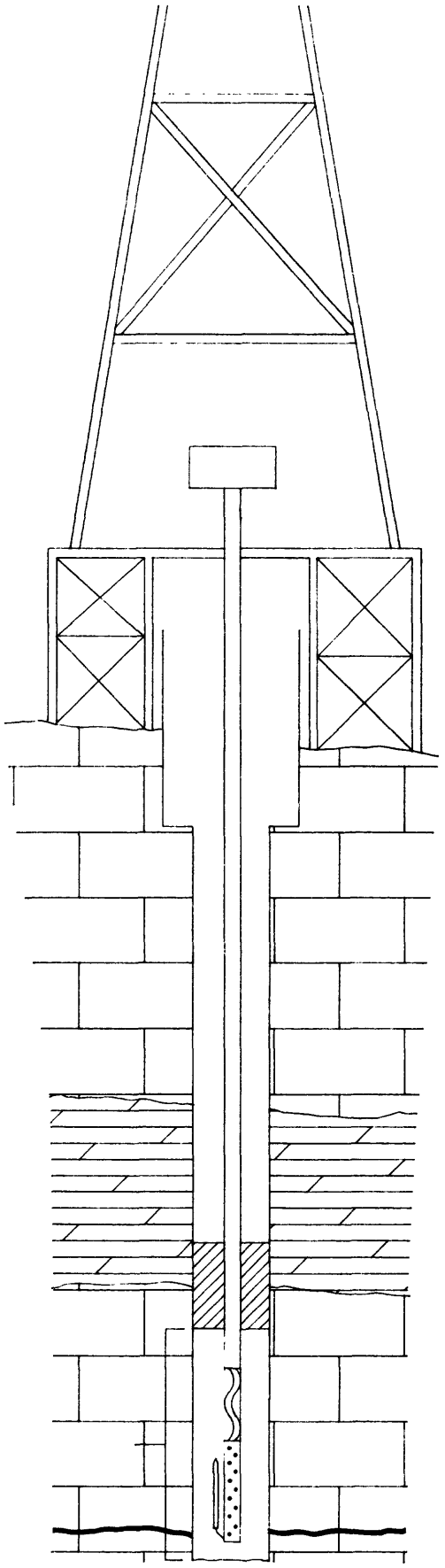
The USGS, in cooperation with the U.S. Environmental Protection Agency (USEPA), Region IV, Superfund Office, is conducting an investigation of the effects of contaminants from an abandoned wood-preserving facility on the ground water and surface water at Jackson, Tennessee. This facility, which was operated from the 1930's until December 1981, has resulted in significant soil, ground-water, and surface-water contamination. In 1984, the site was placed on the USEPA Superfund National Priority List. Both creosote and pentachlorophenol (PCP) were used at the facility. Although a remedial investigation has been conducted for EPA at the site, insufficient data exist to provide an accurate assessment of the offsite extent and characteristics of the contaminant plumes and the associated effects on nearby surface waters.

The investigation is being conducted to provide additional information to delineate and characterize the contaminant plume and to document toxicological effects on nearby surface water. The investigation also will provide information necessary for remediation of the site, as well as an assessment of potential future effects on a nearby municipal well field at Jackson.

The first 6 months of the project, which began in January 1990, was a planning phase during which literature was reviewed, a conceptual model of the ground-water flow and contaminant movement was developed, and a detailed work plan was prepared. The investigation, which is scheduled for completion in 1992, is under the direction of hydrologists William S. Parks, Memphis Subdistrict office, and John K. Carmichael, Nashville District office.



Location of American Creosote Works superfund site in Jackson, Tennessee.

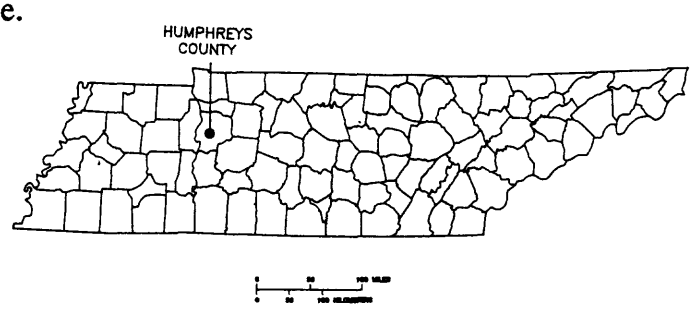


GEOHYDROLOGY OF DEEPLY BURIED ROCKS IN THE WESTERN HIGHLAND RIM OF TENNESSEE

A deep geologic and hydrologic test well in Humphreys County is being drilled by the E.I. DuPont De Nemours Co. The well is intended to be drilled to a depth of 8,500 feet below land surface. The USGS, in cooperation with Humphreys County, is conducting a study to determine the geologic and hydrologic characteristics of the deeply buried Paleozoic formations.

Continuous cores are being collected from the well. As of December 1990, coring had reached a depth of 4,320 feet below land surface. Hydrologic tests have been completed on each formation and water-quality samples were collected. The results of the hydrologic tests and the water-quality samples will be used to evaluate the hydrology of the deep formations and the potential for a regional ground-water-flow system and geochemical processes.

During the past year, tests were completed on formations in the upper Knox Group. The Mascot Dolomite is the uppermost formation of the Knox Group at this site and occurred at a depth of about 2,000 feet below land surface. Within the Mascot Dolomite were zones of intense brecciation associated with the development of a paleokarst system. The breccia zones contained open fractures and were much more permeable than anticipated. Water-bearing zones in the Mascot Dolomite were capable of flowing at land surface at a sustained rate of 80 gallons per minute. Highly fractured and brecciated zones occurred throughout the Mascot Dolomite and underlying Kingsport Formation. The investigation is being directed by hydrologist Michael W. Bradley in the Nashville District Office.



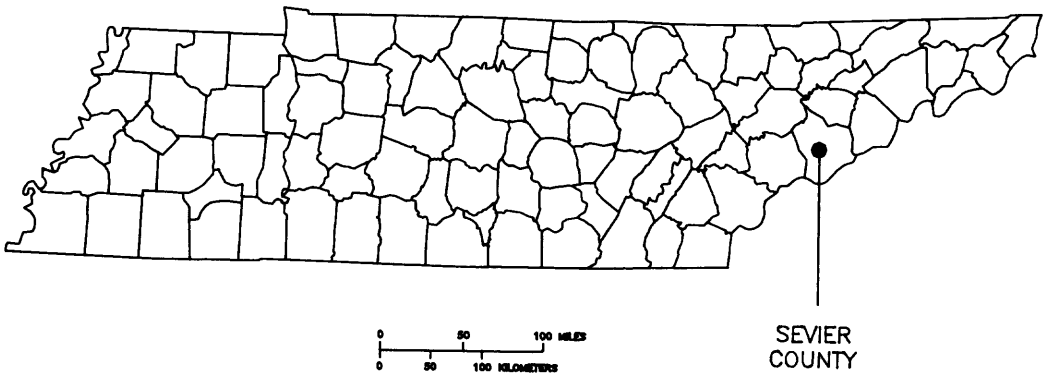
Location of study area.

GROUND-WATER CHARACTERISTICS OF THE CARDIN HOLLOW WELL FIELD AT BLOUNTVILLE

During February 1990, in cooperation with the Blountville Utility District, the USGS conducted an investigation to determine the water quality and aquifer characteristics of the Knox Group in Sevier County in upper East Tennessee. An aquifer test was conducted at the Cardin Hollow well field to collect water-quality samples and to determine the response of the aquifer to pumping.

Water samples were collected at the beginning of the aquifer test and near the end of the 72-hour test. Water-quality data indicated that the water is basically a calcium magnesium bicarbonate type which is typical of the limestone aquifers of East Tennessee. The water contained 273 milligrams per liter of dissolved solids with 260 milligrams per liter hardness.

During the 3-day test, the well was pumped at a continuous rate of about 310 gallons per minute. Water levels were monitored in the pumping well and in three observation wells. The water level in the pumped well was drawn down to about 51 feet below land surface. The specific capacity for the well was about 5.9 gallons per minute per foot of drawdown. The project, completed in September 1990, was under the direction of hydrologist Michael W. Bradley of the Nashville District Office.



Location of study area in Sevier County.

GROUND-WATER HYDROLOGY OF THE UPPER KNOX GROUP IN WESTERN MIDDLE TENNESSEE

The Knox Group in the Central Basin of Tennessee has been the subject of several hydrologic, geologic, and water-chemistry investigations. However, the upper Knox Group that underlies the western Highland Rim, the Western Valley of the Tennessee River, and the eastern part of the Coastal Plain province has not been investigated. The USGS, in cooperation with Humphreys County, is conducting an investigation of the hydrology and geology of the upper Knox Group.

Objectives of this investigation are to:

- Define the chemical characteristics and distribution of ground water in the upper Knox Group;
- Determine the occurrence and distribution of zones of high permeability; and
- Determine directions of ground-water flow and areas of recharge and discharge for the upper Knox Group.

Ten wells completed in the upper Knox Group in the western Highland Rim, the Western Valley, and parts of the Coastal Plain province and Central Basin in Tennessee were sampled and extensive borehole-geophysical logs will be run. As part of the water-quality analyses, carbon-14 and chloride-36 values will be determined to age date the ground water. The investigation, which is scheduled to be completed by January 1992, is under the direction of hydrologist Michael W. Bradley (Nashville District Office), assisted by hydrologic technician Malcolm A. Dugliss.

GROUND-WATER RESOURCES IN CARBONATE ROCKS IN THE ERWIN AREA, EAST TENNESSEE

Ground water from Cambrian-age carbonate bedrock is an important resource in the Erwin area, in East Tennessee. The City of Erwin relies on wells and springs for municipal water supply using an average of 1.6 million gallons per day. Love Spring and four other smaller springs supply water to the Tennessee Wildlife Resources Agency (TWRA) trout hatchery, located southwest of Erwin. Combined spring flow through the hatchery ranged from about 900 to 2,700 gallons of water per minute (1966-68 data).

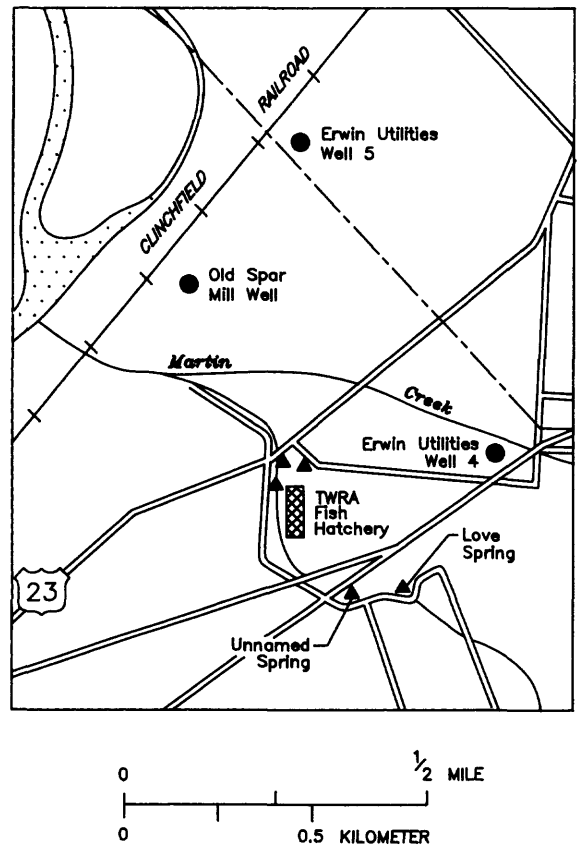
Recently, the Erwin Utilities had five test wells drilled to locate additional ground-water supplies; three of these wells are located south of town. One well is located within 2,000 feet of the TWRA fish hatchery. Drilling results and preliminary production tests indicate that this well and the springs which supply the TWRA fish hatchery are hydrologically connected.

The Erwin Utilities and the TWRA are concerned that the planned production rate for the well close to the hatchery -- 1,100 to 1,200 gallons per minute -- would substantially reduce the amount of spring flow available for use by the hatchery. Erwin Utilities would like to produce a minimum of about 500 gallons per minute from the well. TWRA requires a minimum of about 1,500 gallons per minute of springflow through the trout hatchery for their operations.

The USGS, in cooperation with Erwin Utilities and TWRA, is evaluating the ground-water resources in the area near Love Springs. This investigation will provide information on the following:

- The effect of pumping water from well 4 on springflow at the TWRA trout hatchery,
- The area contributing water to the spring system, and
- Natural variations in springflow due to recharge events and changing ground-water levels.

The investigation, which is scheduled for completion February 1991, is under the co-direction of hydrologists, Dianne Pavlicek of the Nashville District office and Gregg Johnson of the Knoxville Subdistrict office.



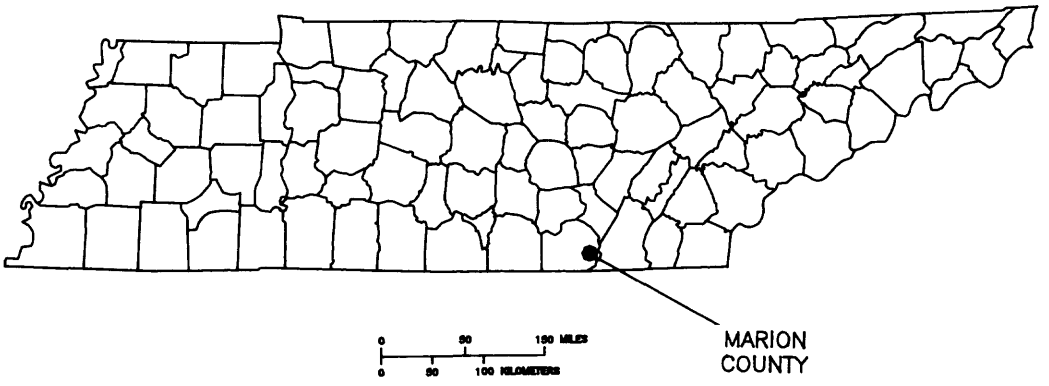
Study site, production wells and state hatchery springs in Erwin, Tennessee.

GROUND-WATER RESOURCES OF THE PENNSYLVANIAN SANDSTONES OF WALDEN RIDGE, MARION COUNTY

In cooperation with Marion County and the Suck Creek Utility District, the USGS is conducting an appraisal of the ground-water resources of the Pennsylvanian sandstones of Walden Ridge, Marion County. Objectives of this investigation are to:

- Evaluate and test geologic and hydrologic controls on ground-water flow and occurrence;
- Identify areas with potential for high ground-water yields;
- Determine the existing ground-water quality of the Pennsylvanian sandstones in the Suck Creek area; and
- Evaluate background water quality, areas possibly affected by nonpoint sources of contamination, and areas influenced by surface water.

This investigation will use geologic information, available well records, ground-water-quality data, fracture-trace analysis, and surface-water-flow conditions to refine and test concepts of ground-water occurrence and yield. Up to 14 wells will be drilled to determine ground-water yield, water quality, and the concepts of ground-water occurrence. This project, begun in January 1990, is under the direction of hydrologist Dorothea W. Hanchar, and is scheduled for completion in June 1992.



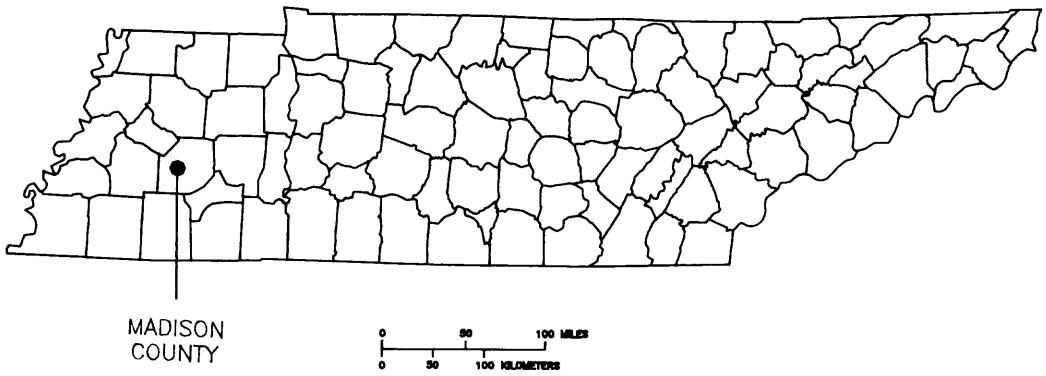
Location of Walden Ridge study area.

HYDROGEOLOGY AND DELINEATION OF AREAS CONTRIBUTING GROUND WATER TO WELL FIELDS AT JACKSON

A comprehensive hydrogeologic investigation of the Jackson area in Madison County, Tennessee, was conducted to provide preliminary information and analyses for the development of a wellhead-protection program for the North and South Well Fields. The 136-square-mile study area is between the Middle Fork Forked Deer and South Fork Forked Deer Rivers and includes the city of Jackson.

A finite-difference, ground-water-flow model was calibrated to steady-state hydrologic conditions in April 1989 and was used to simulate hypothetical pumping plans for the North and South Well Fields. The steady-state water budget of the simulated system showed that more than half of the inflow is from areal recharge and recharge from streams. About 75 percent of the discharge from the system is into the streams and lakes and a small quantity of ground-water underflow. The remaining 25 percent is lost to pumping.

A particle-tracking post-processor program, MODPATH, was used to delineate areas contributing water to the North and South Well Fields for the calibrated model and the three pumping simulations, and to estimate times-of-travel from recharge areas to the wells. Hydrologist Zelda C. Bailey was the project chief.



Location of study area.

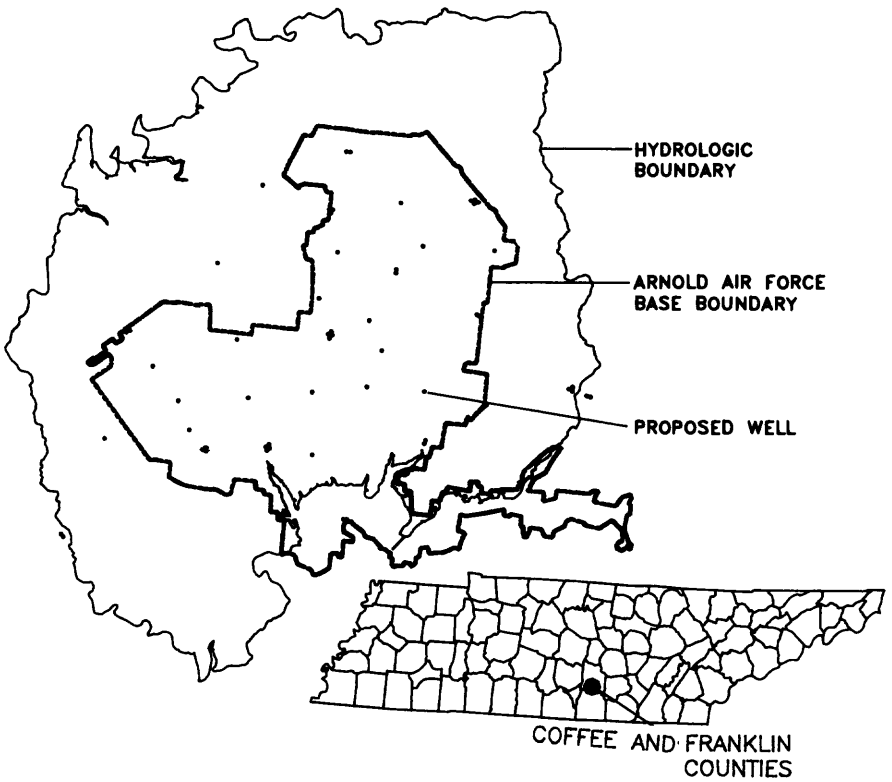
HYDROGEOLOGY OF ARNOLD AIR FORCE BASE, TULLAHOMA

The USGS has begun a base-wide hydrogeologic investigation at Arnold Air Force Base. The base is located in Coffee and Franklin Counties, near Tullahoma, in south-central Tennessee. The entire base encompasses about 39,000 acres; approximately 3,000 acres are devoted to testing and support facilities known as the Arnold Engineering Development Center.

As part of the Air Force Installation Restoration Program, numerous site-specific investigations have been initiated to determine if ground-water contamination is present. Although the present program is addressing site-specific needs, an understanding of the hydrogeology of the entire base is needed so that potential long-term offsite transport of contaminants can be assessed.

The USGS base-wide hydrogeologic investigation is being conducted in two phases. The first phase of the project was completed in February 1990 and included compilation of existing data and interpretations, preliminary determination of structural and hydraulic characteristics, design of a computer data-base-management system and entry of data, and formulation of a preliminary conceptual model of the ground-water-flow system.

Phase two consists of a field investigation and calibration of the ground-water-flow model. Major work elements of phase two include the following:



Location of study area with test well locations and hydrologic boundary.

- Intensive well drilling;
- Borehole geophysics;
- Surface geophysics;
- Stream base-flow analysis;
- Water-quality sampling; and
- Development, calibration, and testing of a multi-layer digital ground-water-flow model.

Phase two will be completed by November 30, 1991. The objective of the study is to define the regional ground-water-flow system and to provide the Air Force with tools to manage the ground-water resources. Co-project chiefs of this investigation are hydrologist Connor J. Haugh and geologist Elizabeth N. Mahoney.

HYDROGEOLOGY OF CAVE SPRINGS BASIN, NEAR CHATTANOOGA, AS PART OF THE APPALACHIAN-PIEDMONT RASA STUDY

In June 1988, the Appalachian-Piedmont Regional Aquifer-System Analysis (APRASA) was initiated. Extending from Pennsylvania to Alabama, the APRASA study area is characterized by many local, discontinuous flow systems.

Because regionally continuous aquifer systems do not occur in the study area, representative area studies which typify the identified local flow systems have been selected for study. The Cave Springs ground-water basin in Hamilton County near Chattanooga was chosen as a representative Valley and Ridge province karstic spring ground-water basin. This type-area study is being conducted in cooperation with the Hixson Utility District. The utility district supplies approximately 5 million gallons of water per day to 45,000 people. This water is obtained from Cave Springs, the second largest spring in Tennessee.

The objectives of the Cave Springs type-area study are to:

- Characterize the hydrogeologic framework of the ground-water basin to support the geochemical characterization and ground-water-flow model;
- Characterize the geochemistry spacially and temporally, attempt mass-balance reaction modeling, and determine sources of recharge to the ground-water basin; and
- Quantify the Cave Springs ground-water basin with regard to recharge, discharge, water in storage, and ground-water-flow characteristics by application of a ground-water-flow model.

A west to east (bottom to top) view of the Cave Springs karstic basin, near Chattanooga, Tennessee

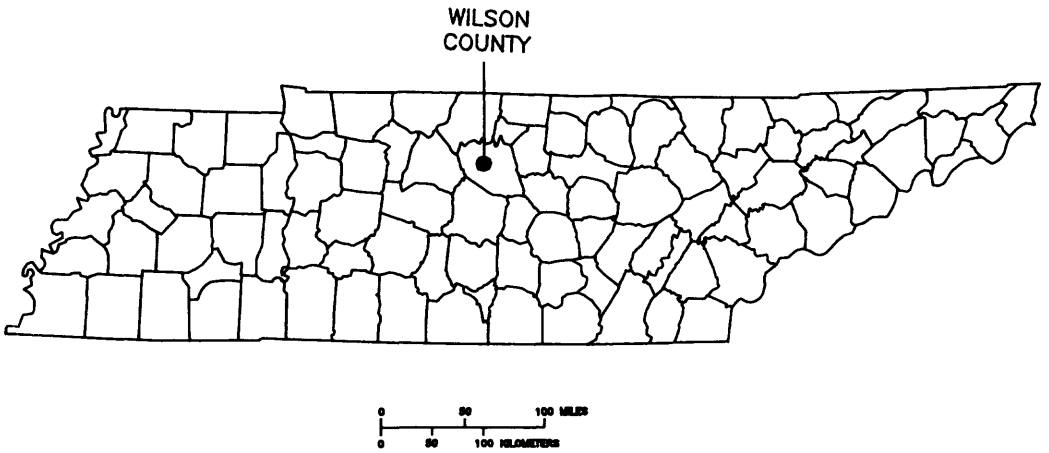
The results of this study will have transfer value to other areas in the carbonate aquifer dominated Valley and Ridge province. The project is being directed by hydrologist Dianne J. Pavlicek, with the assistance of hydrologist Arthur D. Bradfield.

HYDROLOGY OF A SINKHOLE NEAR GLADEVILLE, WILSON COUNTY

The USGS, in cooperation with the Gladeville Utility District, conducted a study from June 1989 to April 1990 of the potential storage capacity and yield of a sinkhole (Boomshaw) the utility district has proposed to use as a public water supply. The sinkhole, unlike other large sinkholes in the area, has a relatively constant pool of water. The purpose of the study was to determine the physical dimensions and storage capacity of the sinkhole, record the frequency and magnitude of fluctuations in the pool level, define the recharge area, and quantify recharge rates.

To meet these objectives, continuous-stage recorders were installed to measure (1) fluctuations in pool level, (2) stage during rising water, (3) stage in the overflow channel, and (4) the relation between the nearby stream and sinkhole overflow. A recording rain gage was installed nearby to collect precipitation data, which was used to estimate the volume of recharge to the sinkhole. A fathometer survey showed that the sinkhole is a maximum of 73 feet deep below the rim. The recharge area was delineated from maps of the area.

During the course of the study, the decision was made to drill a well to intercept flow to the sinkhole as a better option for a source of drinking water. Wells were drilled in the vicinity of the sinkhole, and an extensive solution opening was discovered between 110 and 125 feet below land surface. One well was pumped by the utility district for 72 hours at a rate of 3,000 gallons per minute. Maximum drawdown in the pumped well was less than 1 foot. Dye-tracing tests were conducted during this pumping test to see if water was being pulled from the sinkhole, or if water pumped from the well was being re-circulated through subsurface conduits. Results of dye-trace tests indicated that, for the duration and capacity of pumping during the test, no water was pumped from the sinkhole, nor was any of the discharged water being drawn back into the well. Hydrologist Dorothea W. Hanchar was project chief of the study.



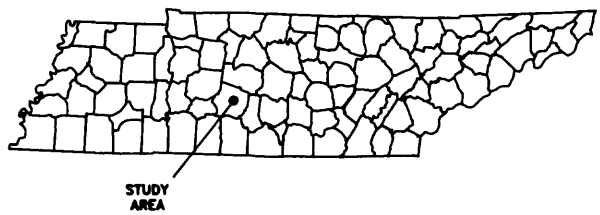
Location of sinkhole (Boomshaw) near Gladeville, Wilson County, Tennessee.

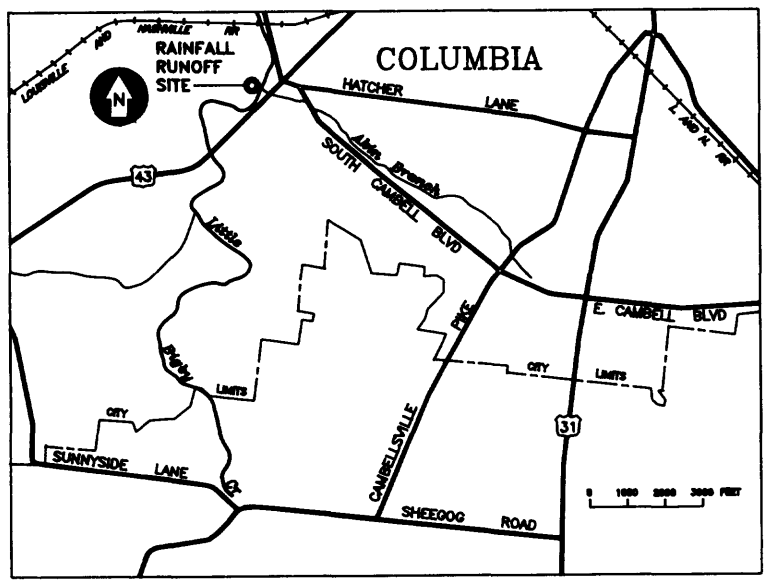
INVESTIGATION OF FLOOD PROBLEMS IN COLUMBIA

Many small towns and cities do not collect hydraulic and hydrologic data at problem areas near existing structures. The USGS, in cooperation with the City of Columbia Engineering Department, is conducting an investigation to provide this data to help city officials determine feasible corrective actions. The primary tasks of this investigation are as follows:

- Identify major drainage basins and subbasins,
- Install and operate a rainfall-runoff gaging site,
- Identify and locate existing problem areas,
- Compile existing hydraulic and hydrologic data,
- Collect existing drainage-structure details and channel characteristics,
- Compute flood profiles based on present and proposed alternative drainage structures on streams with existing problem areas, and
- Document the results in a water-resources investigation report.

The project chief is hydrologist George S. Outlaw, civil engineer.





Location of rainfall-runoff site, Columbia, Tennessee.

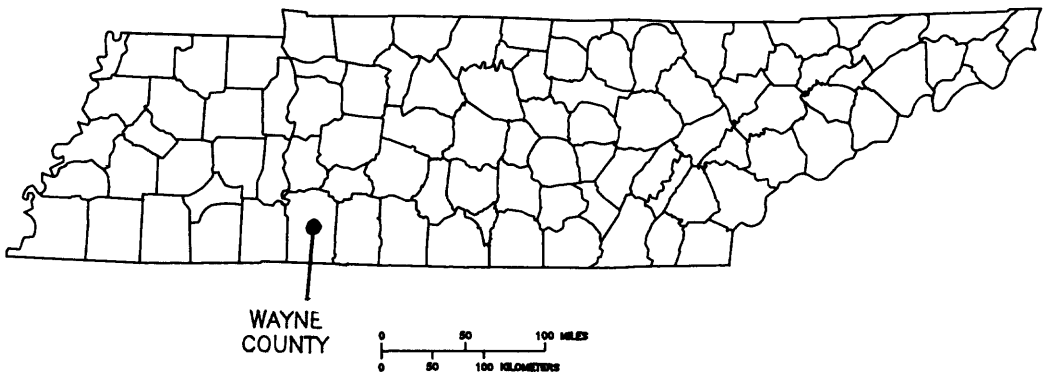
INVESTIGATION OF GROUND-WATER AVAILABILITY NEAR COLLINWOOD

In cooperation with the City of Collinwood, Wayne County, Tennessee, the USGS conducted an investigation of ground-water availability in this typical ridge area of the southwestern Highland Rim. Collinwood currently obtains its water from four springs. Increases in water use and a limited supply from the springs have created a need to locate additional sources of water. The purpose of this investigation was to develop information on the occurrence and movement of ground water in order to collect data that can be used by the city to locate additional sources of water.

Work planned for this study included:

- Gathering data from existing wells,
- Drilling new test wells,
- Running geophysical logs, and
- Conducting aquifer tests.

Drilling began in June 1990. Information provided by this work will have application in developing water supplies for other communities in the southwestern Highland Rim. The project is directed by hydrologist Gregg E. Hileman.



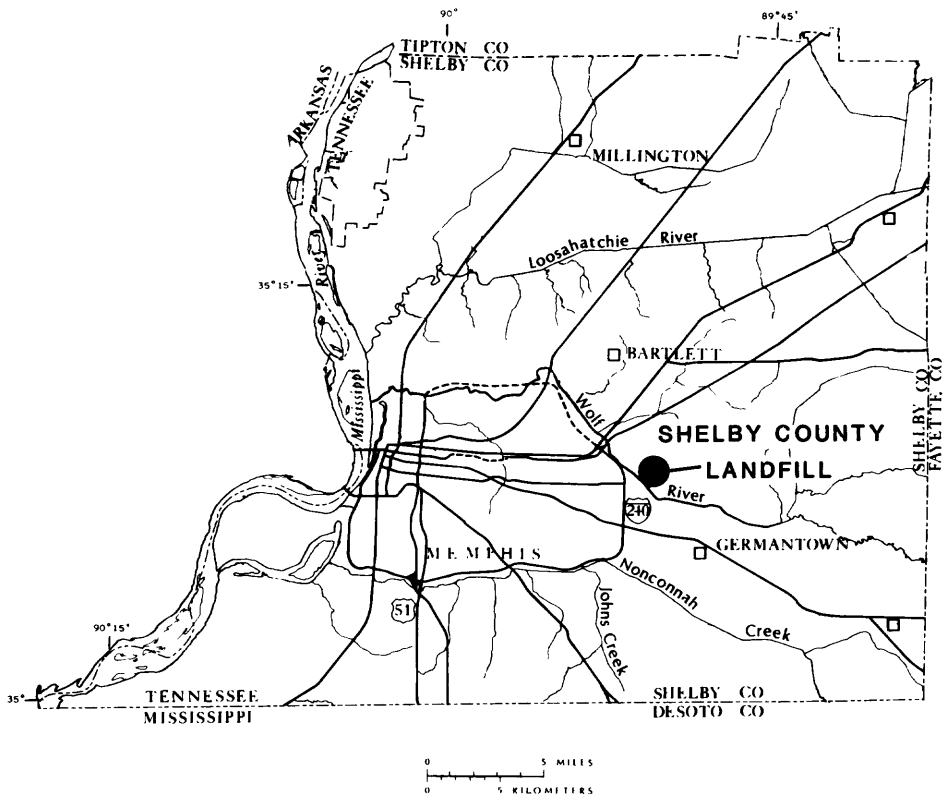
Location of Collinwood study area.

INVESTIGATION OF GROUND-WATER QUALITY AT THE SHELBY COUNTY LANDFILL

The Shelby County landfill, located in the Shelby Farms area of east Memphis, was operated for 20 years (1968-88). The landfill is in an area where the confining unit separating the water-table aquifers (alluvium and fluvial deposits) from the Memphis aquifer is thin or absent. A recently completed investigation by the USGS showed that ground water was leaking downward from the alluvial aquifer into the Memphis aquifer within a depression in the water table north of the landfill. The Memphis aquifer is the principal aquifer in the Memphis area providing water for most public and industrial uses including drinking water. The investigation also showed that leachates derived from the landfill had entered the alluvial aquifer and are moving in the ground water toward the area of downward leakage.

The objectives of the present investigation, which is being conducted in cooperation with Shelby County, are to determine the extent and degree of contamination of the alluvial and Memphis aquifers at the landfill and to establish a system of observation wells for monitoring any future water-quality changes. In August through October 1989, 18 observation wells were installed around the periphery of the landfill or in nearby areas. Twelve of these wells are screened in the alluvial aquifer and six in the Memphis aquifer. The wells ranged from about 39 to 148 feet deep. These 18 wells, along with 13 existing observation wells in the area of the landfill, were sampled for water quality in October 1989. The samples were analyzed for major inorganic constituents, physical properties, nutrients, trace inorganic constituents, and volatile and semivolatile organic compounds.

The analyses from the first round of sampling indicate that ground water from 22 of the 31 wells contained low concentrations of selected volatile organic compounds. These volatile organic compounds were reported above



Location of Shelby County landfill, Memphis, Tennessee.

a detection limit of 0.2 microgram per liter. Ground water from a few wells also contained semi-volatile organic compounds or trace inorganic constituents that exceed State maximum contaminant levels for drinking water. These 22 wells were re-sampled in early summer 1990 to confirm the results of the first analyses. The investigation, scheduled to be completed early in 1991, is under the direction of hydrologist William S. Parks of the Memphis Subdistrict office.

INVESTIGATION OF QUALITY OF DRINKING WATER AT SELECTED NONTRANSIENT NONCOMMUNITY SYSTEMS IN TENNESSEE

The U.S. Geological Survey (USGS), in cooperation with the Division of Water Supply of the Tennessee Department of Health and Environment (DWS-TDHE), is conducting a reconnaissance of the quality of drinking water at selected nontransient noncommunity systems in Tennessee. Nontransient noncommunity water systems are those that provide drinking water to at least 25 of the same people over 6 months per year. Noncommunity systems are facilities that provide drinking water to other than fixed communities. Community systems serve drinking water to at least 15 service connections used year around. Schools and factories are typical examples of nontransient noncommunity systems.

Samples will be collected at 22 sites for analyses of principal anions and cations, U.S. Environmental Protection Agency regulated organic compounds (87 compounds listed in sections 141.40, 141.61a, and 141.61c of the Federal Register), trace metals, nutrients, and other indicators of pollution. Field analyses will be performed at each site for concentrations of fecal coliform and fecal streptococci bacteria, pH, specific conductance, temperature, and alkalinity.

The USGS is providing training and logistical support to staff of the DWS-TDHE for the collection of the samples and the field determinations. The samples will be analyzed at the USGS laboratories in Denver, Colorado. A report summarizing the results of the investigation will be prepared during the summer of 1991. The project is directed by USGS hydrologist Angel J. Roman and is coordinated by Robert Foster, from the DWS-TDHE.

INVESTIGATION OF THE HYDROLOGY AND GEOLOGY OF THE NAVAL AIR STATION AT MILLINGTON, WEST TENNESSEE

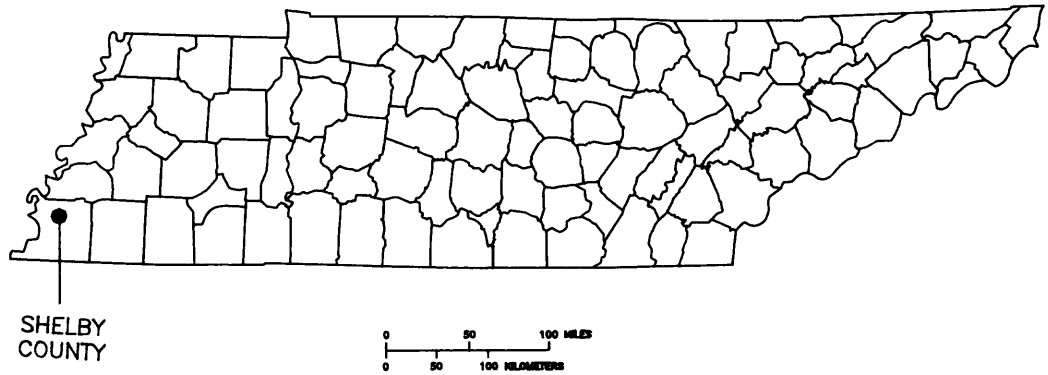
The U.S. Geological Survey (USGS), in cooperation with the U.S. Naval Southern Command (Charleston, South Carolina) has initiated a hydrologic investigation of the Naval Air Station (NAS) Memphis in Millington, Tennessee. The investigation consists of three phases:

- Assessment at 12 potential hazardous-waste sites to determine the occurrence and extent of any possible contamination.

- Development and maintenance of a geographic information system (GIS) data base for the NAS incorporating geologic, hydrologic, land features, structures, and environmental information.

- Definition of the general ground-water hydrology of the area and development of a ground-water-flow model to quantify ground-water flow, the effects of increased pumping, and possible directions of contaminant migration.

During the investigation, more than 50 wells will be installed and sampled to determine ground-water quality. Water and suspended-sediment samples will be collected from several drainage trenches within the NAS. Field techniques to be used in the investigation include surface and borehole geophysics, drive-point samples, soil-gas analyses, and field water-quality analyses. The investigation is directed by hydrologist Michael W. Bradley, from the USGS in Nashville, and coordinated by Mr. Robert Moser, from the U.S. Naval Southern Command.



Location of study area in Shelby County.

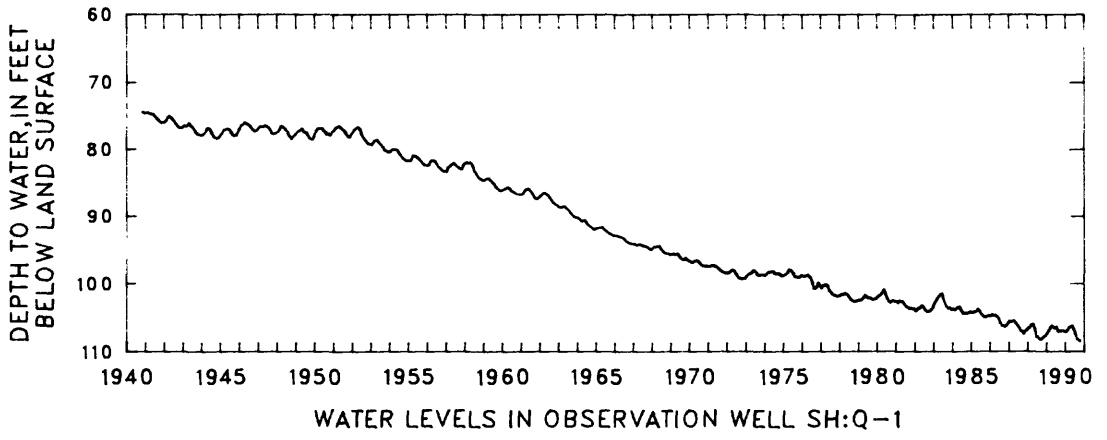
MONITORING OF AQUIFERS IN THE MEMPHIS AREA

In cooperation with the Memphis Light, Gas and Water Division (MLGW) of the City of Memphis and the City of Germantown, the USGS monitors the three principal aquifers in the Memphis area. An observation network of 43 wells provides water-level data for the three aquifers in the area--12 wells are screened in the shallow water-table aquifer, 23 in the Memphis aquifer, and 8 in the Fort Pillow aquifer. In addition, an extensometer is maintained in the MLGW Mallory well field for measuring compaction as related to pumping and water-level declines.

Ground-water withdrawal (pumping) data are collected monthly or annually from about 90 ground-water users in the Memphis area. The data are input into the USGS's water-use files in Tennessee. Annually, at low water level times in the fall, about 40 wells in the Memphis aquifer in the Shelby County area are measured within a few day period to supplement data from the observation-well network. These data are tabulated for comparison against previous measurements to detect any significant changes in water levels. Potentiometric-surface maps are prepared periodically to monitor the areal configuration of the water-level surface.

Annually, during high pumping stress times, 12 wells in the Memphis aquifer are sampled for water quality. Long-term changes are monitored in the quality of the water entering the major cone of depression in the aquifer and the major well fields. The wells sampled include eight production wells (one in each of MLGW's major well fields), two industrial wells in outlying areas, and two wells in the City of Germantown.

The USGS also logs geophysical data for MLGW's test and pilot wells. The logs are used to assist in determining screen settings and to provide a recorded profile of the rocks penetrated. These logs provide important information to further the understanding of the geologic framework of the aquifer systems in the Memphis area. Logs also are made in newly drilled or abandoned municipal, industrial, and commercial wells, as the opportunities arise.



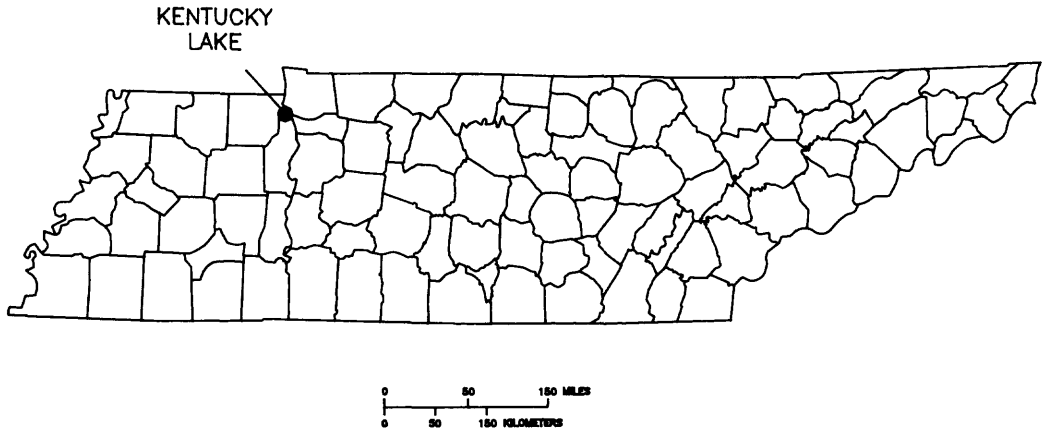
Water levels in observation well Sh:Q-1

MUSSELS AND YELLOW COLONY FORMER SYNDROME

A project to study populations of mussells in Kentucky Lake was started in 1989 in cooperation with Tennessee Department of Health and Environment (TDHE), Tennessee Wildlife Resources Agency, and Memphis State University (MSU). Because mussels live at the sediment-water interface, they serve as integrators of water-quality information at this critical boundary layer. To study mussels is to study chemical speciation, partitioning, and fluxes in aquatic environments. This project is testing the hypothesis that declines in populations of mussels indigenous to the Tennessee River basin are caused by "yellow colony former syndrome." This syndrome takes its name from bacteria that are more numerous in the tissues of sick than in healthy mussels. Actual causes of mussel population declines may include siltation, oxygen depletion, parasitism, and organic and inorganic toxicity. These factors may act synergistically, either directly or by reducing the ability of mussels to sustain bacterial infestation.

The field data-collection program includes water-quality profiling at eight sites in the Kentucky Lake. The distribution of these sites overlaps areas of diverse land use along the Tennessee River and thus provides an opportunity to relate mussel health and sediment-water chemistry to various point and nonpoint discharges. Mussel populations are being censused, and bacterial infestation is measured by standard plate counts from tissue extracts. Water (including pore water), sediment, and biotic samples are being analyzed. Mussel tissues will be analyzed for concentrations of trace metals and organic pollutants.

By addressing the interplay of physical, chemical, and biological factors, this interdisciplinary study will advance the basic understanding of the sediment-water interface. By focusing on the effect this interplay exerts on mussel health, the study will provide information vital to the effective management of a valuable indigenous resource. Finally, by relating mussel health to human influences on fluvial habitat, the study will help to provide data for use in the development of basinwide environmental policy. Project coordinators include Angel Roman (USGS), Dr. Andy Barrass (TDHE), and Dr. Steve Klaine (MSU).



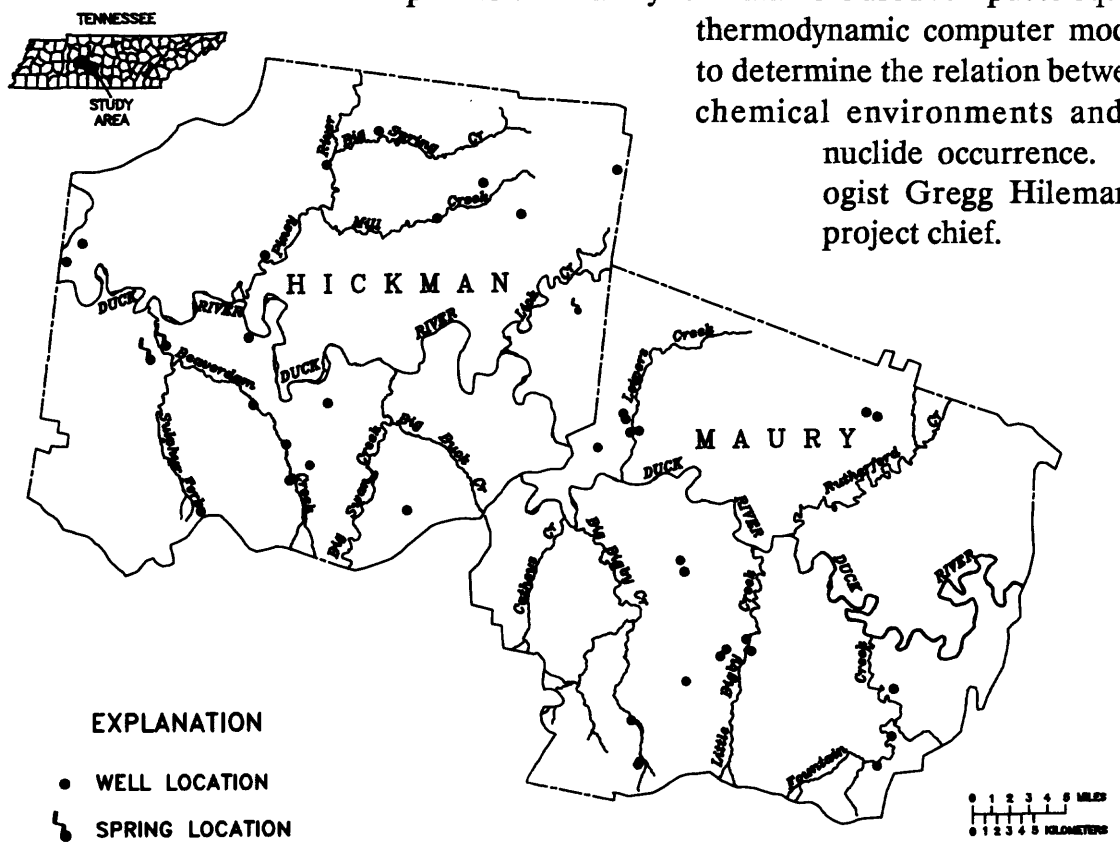
Location of study area.

OCCURRENCE OF RADIONUCLIDES IN GROUND WATER FROM HICKMAN AND MAURY COUNTIES

Black shales and phosphate-bearing limestones in Hickman and Maury Counties in Middle Tennessee contain uranium and are potential sources of radionuclides in ground water. The USGS, in cooperation with the Tennessee Department of Health and Environment, Office of Ground Water Protection, and the U.S. Environmental Protection Agency, is conducting an investigation of the occurrence of radon-222 and other radionuclides in ground water in Hickman and Maury Counties. Objectives are to:

- Describe the variation in water chemistry and concentrations of radionuclides,
- Investigate the possible association of radionuclides with other chemical constituents, and
- Investigate the relation between varied hydrogeologic and geochemical environments and the occurrence of radionuclides.

During the spring and summer, 1989, ground-water samples and site data were collected from 17 wells and 3 springs in Hickman County and from 20 wells in Maury County. Samples of waters were analyzed for major ions, trace metals, physical characteristics, and selected radionuclides including radon-222. Concentrations of radon-222 in the samples ranged from 63 to 1,490 picocuries per liter. The analytical data were used as input to equilibrium thermodynamic computer models and to determine the relation between geochemical environments and radionuclide occurrence. Hydrologist Gregg Hileman is the project chief.

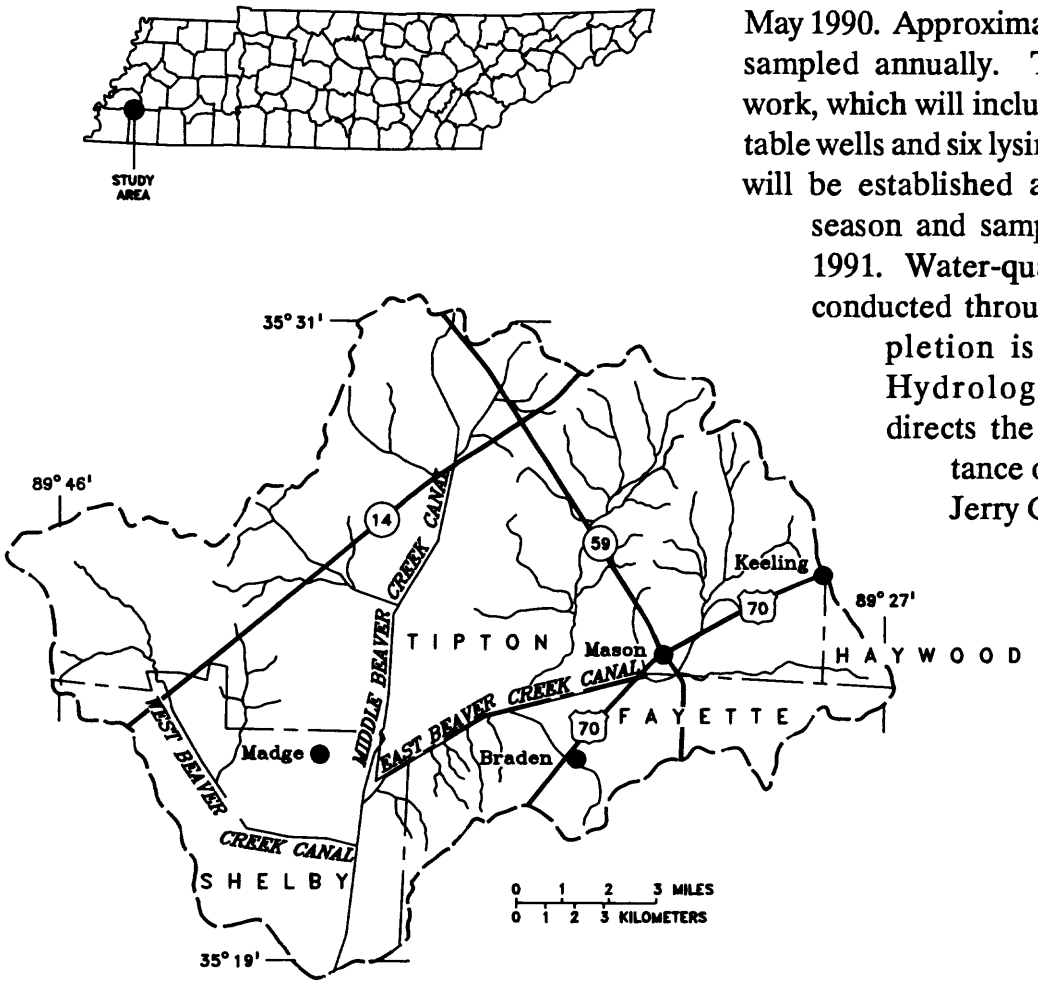


Locations of study area, wells, and springs, in Hickman and Maury Counties, Tennessee.

POTENTIAL EFFECTS OF AGRICULTURAL PRACTICES ON WATER QUALITY IN THE BEAVER CREEK DRAINAGE BASIN OF WEST TENNESSEE

In cooperation with the Tennessee Department of Agriculture, the USGS is conducting a comprehensive 5-year investigation of the effects of agriculture on water quality in the Beaver Creek watershed in West Tennessee. Six surface-water sites within the watershed are being monitored for flow and water quality. Additionally, subsurface water quality will be monitored in the unsaturated and saturated zone in each of the six subbasins. Data collected before and after the implementation of agricultural "best management" practices (BMP's) in the six subbasins will be used to document the effectiveness of the BMP's in controlling agricultural nonpoint-source pollution.

The surface-water-monitoring stations include a continuous stage-recording device, a precipitation gage, and an automatic stage-activated water-quality sampler at each site. Stage-discharge rating curves have been established for each of the six sites and storm runoff sampling began in May 1990. Approximately eight storms will be sampled annually. The ground-water network, which will include three shallow water-table wells and six lysimeters in each subbasin, will be established after the 1990 growing season and sampling will begin in late 1991. Water-quality monitoring will be conducted through 1993. Project completion is scheduled for 1994. Hydrologist Angel J. Roman directs the project with the assistance of hydrologic technician Jerry Garrett.



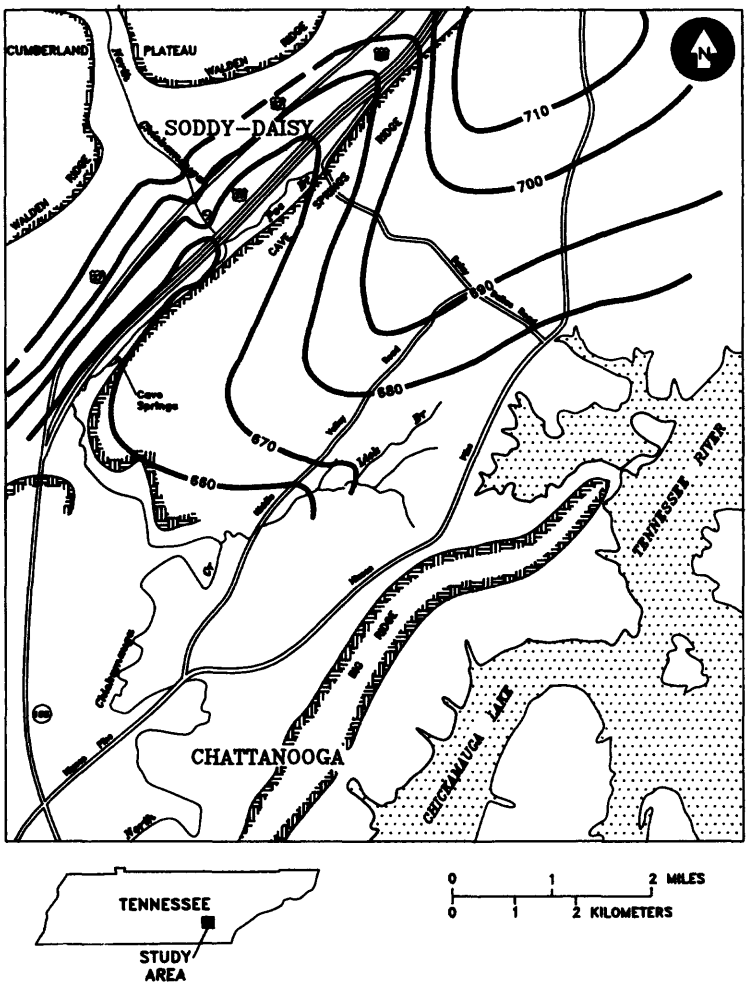
Location of Beaver Creek watershed.

QUALITY AND SOURCE OF WATER AT CAVE SPRINGS NEAR CHATTANOOGA

In cooperation with the Hixson Utility District (HUD) of Chattanooga, Tennessee, the USGS is conducting an investigation of the hydrology of Cave Springs. The spring is used by HUD to supply about 45,000 customers in Hixson. Purposes of the study are:

- Determine the sources of recharge to the Cave Springs ground-water system.
- Determine if ground water pumped from wells at Cave Springs is under the influence of surface water.
- Provide data useful in developing a watershed-control program.

Public supply systems that use ground water that is determined to be affected by surface-water conditions will be required to provide additional data to state or federal regulatory agencies. Systems that can demonstrate (1) adequate disinfection to eliminate *Giardia lambia*, (2) acceptable levels of turbidity and coliform counts in raw ground water, and (3) an adequate plan to protect areas recharging their water sources, may avoid having to install filtration.



Generalized map of the potentiometric surface in the Cave Springs ground-water basin, near Chattanooga, Tennessee.

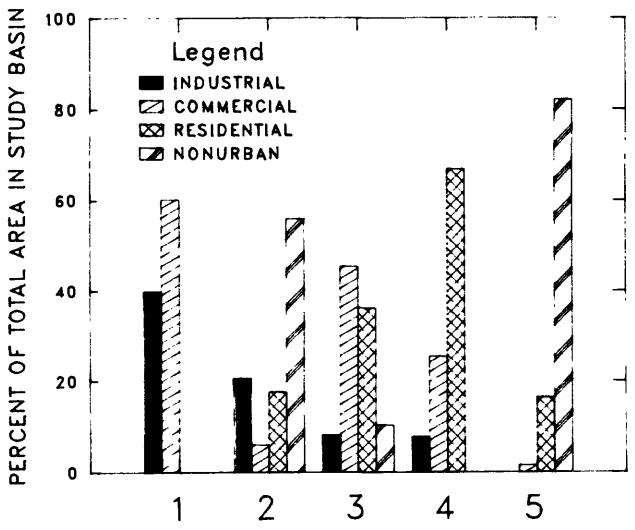
Under recently enacted U.S. Environmental Protection Agency regulations, influence of surface water is indicated by the significant occurrence of insects, rotifers, diatoms, algae, *Coccidia*, plant debris, or large diameter pathogens such as *Giardia lamblia*. Significant changes in water characteristics such as turbidity, temperature, specific conductance, and pH, closely correlated with climatological changes, or surface water conditions, also are evidence of surface-water influence. The project is under the direction of hydrologist Arthur Bradfield and is scheduled for completion in September 1991.

QUALITY OF STORM WATER IN RELATION TO LAND USE FOR URBAN AREAS IN TENNESSEE

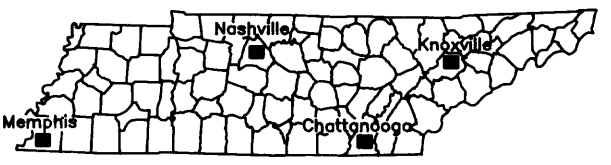
Municipalities with a population of 100,000 or greater will be required by the U.S. Environmental Protection Agency (USEPA) to obtain federal permits under the National Pollutant Discharge Elimination System to control the quality of their storm-water discharges. Each municipality will be required to perform extensive inventories and characterization of storm-sewer outfalls, to characterize storm-water quality from outfalls during dry and wet weather, and to develop and implement a comprehensive storm-water-management plan to include remedial action based on source control.

The USGS, in cooperation with the Metropolitan Government of Nashville and Davidson County, and the City of Knoxville, is collecting technical data required by the draft regulations. Similar projects will start in 1991 at Chattanooga and Memphis. For each metropolitan area this work includes the following:

- Characterization of the quantity and quality of discharge from selected watersheds during one to three major storms. The watersheds were selected to represent the primary land-use areas in Davidson County and the City of Knoxville.
- Evaluation of the accuracy of prediction equations for annual and seasonal pollutant loadings from various land-use areas. The USEPA has proposed that these equations be used by municipalities to estimate pollutant loads (a requirement for the permit applications) from all storm-sewer outfalls, providing sufficient local data has been collected to verify their accuracy.
- Characterization of the quality of water in bodies receiving storm-runoff discharges and the effect of pollutants in these discharges on the receiving body, based on existing data.
- Characterization of meteorological (rainfall) conditions based on existing data.



The investigation will continue through December 1991 under the direction of hydrologist Anne B. Hoos.



Land use in five storm-water-quality study basins in Nashville, Tennessee.

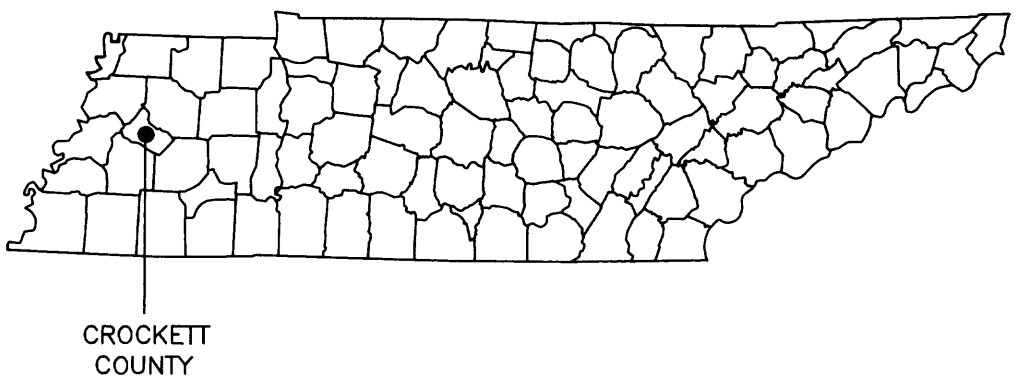
RECONNAISSANCE OF WATER QUALITY AT ALAMO

During 1989, the USGS, in cooperation with the Division of Superfund of the Tennessee Department of Health and Environment, conducted a reconnaissance investigation of ground-water quality near the city of Alamo in western Tennessee. Volatile organic compounds (VOC's) were detected in wells used for public water supply by the city. Objectives of the study were to describe the local hydrogeology, characterize present water quality, document the magnitude of VOC contamination, and identify the immediate area(s) affected by shallow ground-water contamination.

The city's water wells are screened in the Memphis Sand. The nearly ubiquitous, thick clay deposit that overlies the Memphis Sand elsewhere is absent at Alamo, exposing the aquifer locally to contamination from surface spills. Soluble contaminants entering the aquifer below the site of a former industrial spill would likely be transported west-southwesterly, following the water-table gradient, toward the city's wells. Sampling of one of those wells about 230 feet west of the spill site revealed that dichloroethylene, trichloroethane, and trichloroethylene were present in the water in concentrations 4.5 to 9 times greater than the State's maximum contaminant levels for these compounds. Water from a second well contained smaller concentrations of VOC's. No VOC's were detected in water samples from the deepest well or the well most distant from the spill site.

Soil-gas analyses were made at 42 sampling points in the area. Trichloroethylene was detected in soil gas at 13 points close to the spill site. No detectable concentrations of trichloroethylene in soil gas were found at points close to any of the wells.

The project was conducted by hydrologist Susan Hutson from the Memphis Subdistrict office.



Location of study area, Alamo, Tennessee.

REGIONAL AQUIFER-SYSTEM ANALYSIS OF WEST TENNESSEE AQUIFERS

As part of the USGS Gulf Coast Regional Aquifer-System Analysis project, a multiyear study of the regional aquifers of West Tennessee and the northern Mississippi embayment was completed in September 1990. Five reports describing the geology and hydrology of the Cockfield Formation, the Memphis Sand, and the Fort Pillow Sand within West Tennessee have been published. Hydrologist William S. Parks of the Memphis Subdistrict was responsible for this part of the subproject; he was assisted by co-author John K. Carmichael, hydrologist of the Nashville District office.

A second part of the study focuses on developing a regional understanding of the hydrology of the McNairy-Nacatoch and related aquifers in the northern Mississippi embayment. A report describing this topic is in review, as are two journal articles describing isotope research that was used to identify deeply buried boundaries of the regional flow system. Hydrologist John Van Brahana of the Nashville District is responsible for these studies.

Results from all these studies provide insight into the geologic framework, ground-water flow, and water quality in the Tertiary and Cretaceous aquifers of the northern Mississippi embayment, in general, and West Tennessee, in particular. Significant results include the following:

- The tectonic framework of the northern Mississippi embayment influences younger, nonindurated sediments. Faulting affects aquifers and confining layers and is thought to focus inter-aquifer leakage at some locations.
- With the exception of the Memphis Sand in the Memphis area, the aquifers are virtually untapped. All aquifers have significant potential for future use.
- Newly developed age-dating techniques using radioisotopes of tritium (^{3}H), carbon-14 (^{14}C), and chlorine-36 (^{36}Cl) suggest that cross-formational flow in these aquifers may represent a significant part of the hydrologic budget in some areas. Water-quality anomalies commonly define areas of cross-formational flow.

In addition to the previously mentioned publications, major accomplishments include publication of:

- Flow-modeling documentation and results;
- Documentation of hydrologic interpretations;
- Tables of data collected especially for this study; and
- Numerous abstracts for professional meetings summarizing significant conclusions.

New research techniques used in this study hold promise for widespread application to hydrologic problems in other areas of similar hydrogeology.

SEDIMENT DEPOSITION AND VEGETATION RESPONSE IN WETLANDS NEAR HIGHWAY CROSSINGS IN WEST TENNESSEE

Sediment deposition occurs naturally in wetlands, but can be accelerated by human activities. Highway crossings have been cited as a potential cause of increased deposition rates on flood plains upstream of bridges, resulting in a decline in growth rate and numbers of species of bottomland trees. The influence of highway crossings on sediment deposition in surrounding wetlands has not been adequately measured. Interactions between sediment deposition and wetland ecology are not well understood.

The USGS, in cooperation with the Tennessee Department of Transportation, conducted an investigation of sediment deposition at 11 wetland sites near highway crossings in West Tennessee. The final report was completed in September 1990.

The objectives of the report were to:

- Describe spatial and temporal distribution of sediment deposition at 11 wetland sites,
- Evaluate the influence of highway crossings on sediment distribution,
- Report the development and calibration of a sediment-deposition model for predicting flood-plain sedimentation and bridge influence, and
- Evaluate the influence of deposition rates on bottomland tree growth.

This project was under the direction of Dr. Cliff R. Hupp with the assistance of hydrologist David E. Bazemore in the Nashville District office.

STATEWIDE SCOUR-CRITICAL EVALUATION OF BRIDGE SITES

Scour erosion is a major concern in the design and maintenance of bridge structures. Evaluation of the potential for scour is important in the assessment of local and contraction scour, but also in general trends of channel processes at a particular site. In sand-bed channels of Tennessee, estimates of contraction scour during a storm event may exceed 12 feet. Scour depths of this magnitude pose particular danger to those bridges on channels that have undergone considerable long-term erosion.

Sites that may have stability problems and require further study are identified using a method that rapidly assesses the potential for scour and ranks sites based on characteristics conducive for scour-critical conditions. Detailed surveying, sampling, and modeling will be undertaken at sites that rank high in terms of potential scour. Modeled scour depths at these sites can be used to assess potential foundation instability and to identify scour-critical conditions.

The USGS, in cooperation the Tennessee Department of Transportation (TDOT), is conducting an investigation of potential scour at bridges in Tennessee. Specific objectives of the project include:

- Evaluate channel conditions near river-crossing structures relative to their role in affecting local scour,
- Identify trends in channel condition in relation to region and drainage basin,
- Evaluate and rank river-crossing structures in relation to the potential for bed scour,
- Model flow and sediment through those structures ranked as being scour-critical to estimate scour depth, and
- Display trends in scour potential in a series of maps generated by a geographic information system (GIS).

Methodologies used in this study should be transferable to most alluvial-channel situations, irrespective of bed-material or bridge characteristics. A quantitative appraisal of the scour potential at evaluated bridges will serve as an indicator of the most severe problems.

GIS-based maps and data bases will provide the TDOT with detailed information about channel conditions that can be used for planning and design of structures at a site, at several sites over a reach, or for an entire river. Geographically distributed trends of channel conditions and scour potential will be accessible through these maps and will further aid in planning and design. Project chief is hydrologist Brad Bryan.

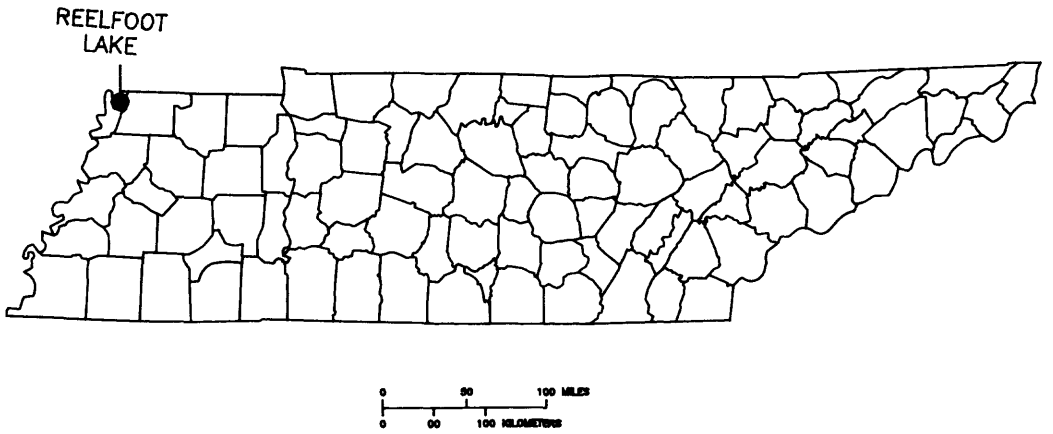
SUSPENDED SEDIMENT AND NUTRIENT INFLOW TO REELFOOT LAKE

The USGS, in cooperation with the Non-Point Source Pollution Program of the Tennessee Department of Health and Environment, completed a study of storm runoff and annual contributions of suspended sediment, nutrients, and selected triazine herbicides to Reelfoot Lake by its three main tributaries. South Reelfoot Creek contributed about 62 percent of the total sediment load for the three streams. Total suspended-sediment yields ranged from 0.32 ton per acre per year for Running Slough to 4.7 tons per acre per year for South Reelfoot Creek. About 98 percent of the total suspended-sediment load was transported by storm runoff.

Total nitrogen yields ranged from 5.9 pounds per acre per year for Running Slough to 9.3 pounds per acre per year for North Reelfoot Creek. Total phosphorus yields ranged from 1.4 pounds per acre per year for Running Slough to 2.3 pounds per acre per year for North Reelfoot Creek. About 75 percent of the total nutrient load was transported by storm runoff during the period October 1988 through March 1989.

Negative correlation was observed between nitrite plus nitrate concentrations and discharge and is attributed to dilution at high flows. Positive correlation was observed between suspended-sediment and total phosphorus concentrations and discharge. Significant differences were observed in mean nutrient concentrations in samples collected during the active spring and fall months and the inactive winter agricultural months.

Detectable levels of alachlor and atrazine were present in 32 percent and 93 percent of the samples, respectively. Most of the samples collected from April through September contained detectable levels of alachlor and atrazine. Sixteen samples contained atrazine concentrations that exceeded the lifetime health advisory concentration (0.1 microgram per liter). Concentrations of the other 9 triazine herbicides for which analyses were made generally were below the detection limit. Project chiefs were Michael E. Lewis, Anne B. Hoos, and Jerry W. Garrett.



Location of study area.

UPPER DUCK GEOGRAPHIC INFORMATION SYSTEM

The USGS and the Upper Duck River Development Agency have entered into a cooperative agreement through which the USGS will provide digital data for the Duck River Basin. Two computerized coverages are currently being put into digital form with 5-foot contour intervals for 13 maps at a 1:12,000 scale and property lines from 44 maps at a 1:500 scale.

This project has provided the Computer Section staff with an opportunity to compare digital scanning technologies with manual digitization. The staff also has learned about mapping problems that occur when working with contour lines.

URBAN HYDROLOGY FOR JOHNSON CITY, EAST TENNESSEE

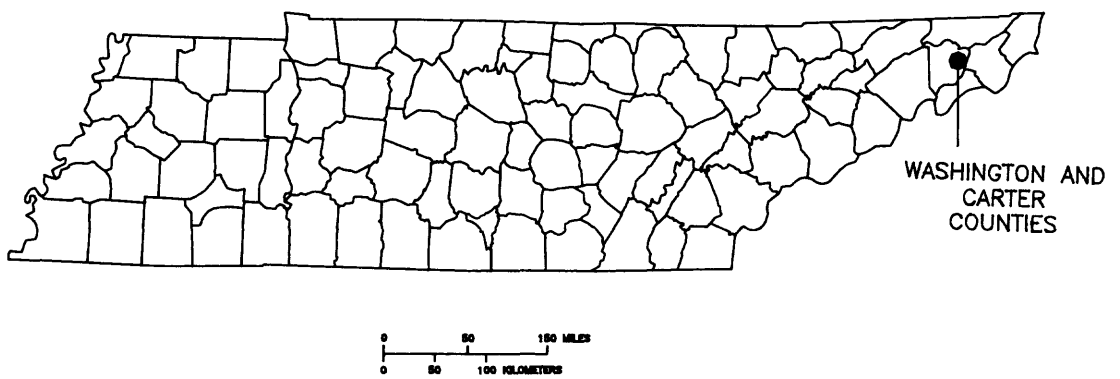
Urban development in and surrounding Johnson City, Tennessee, has increased steadily over the last two decades. Associated with this urbanization are increases in impervious areas, storm-sewer developments, and stream-channel modifications, causing significant increases in the magnitude and frequency of flooding. The effect of this increased flooding can be minimized if it is considered in the planning and design of buildings and drainage structures.

Watershed planning is a management strategy to minimize the adverse changes in runoff that may occur as a result of anticipated urbanization. To implement this strategy, the City of Johnson City plans to use rainfall-runoff models as tools to predict the hydrologic effects of specific options in urban development, such as regulations controlling density of developments, amount of impervious surfaces, setbacks from streams, and site design. In addition to their application for land-use planning, the calibrated rainfall-runoff models also will be useful in designing urban drainage systems.

In 1990, the USGS, in cooperation with Johnson City and the Tennessee Valley Authority (TVA), initiated a 4-year hydrologic and hydraulic investigation of the Johnson City area which includes the following:

- Collection of rainfall and runoff data,
- Calibration of a basin streamflow model,
- Construction of observed and computed flood profiles, and
- Determination of flood magnitude-frequency relations.

The basins to be studied are the Brush Creek, Cobb Creek, Knob Creek, and Sinking Creek basins which drain most of the area occupied by Johnson City. A network of 10 continuous streamflow gages, 7 continuous rainfall gages, and about 30 crest-stage gages were installed to collect hydrologic data for a 4-year period. USGS project leaders for the investigation are hydrologist Anne B. Hoos, Nashville, and hydrologist Jess D. Weaver, Knoxville, while TVA will provide modeling support. Kevin McElyea, Assistant City Engineer for Johnson City provides coordination for the project.



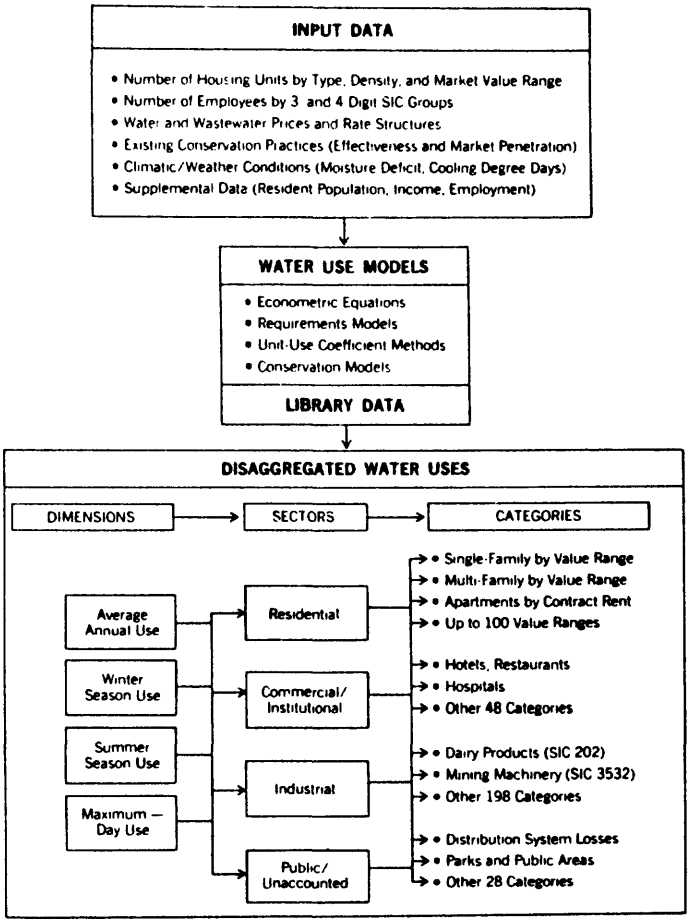
Location of Johnson City urban hydrology study area, Washington and Carter Counties, Tennessee.

WATER AVAILABILITY, USE, AND DEMAND SIMULATION FOR THE UPPER DUCK RIVER BASIN

The Tennessee District of the USGS, in cooperation with the Upper Duck River Development Agency (UDRDA) and the Tennessee State Planning Office, is conducting a study of water availability and use in the Duck River basin above Columbia, Tennessee. Currently, the Duck River is the main source of water for public supply, industry, commerce, and agriculture. The river also receives waste discharges. The members of UDRDA are concerned that existing water supplies will not meet future water demands without additional surface-water impoundment of the Duck River at Columbia.

This study will include the use of the mathematical model, Institute of Water Resources - Municipal And Industrial Needs (IWR-MAIN). This model is a long-range forecasting model used to predict annual water demand. IWR-MAIN will be calibrated from data collected on current water users within the basin, points of water withdrawal, and quantity of withdrawal. Projections will then be made for 5, 10, and 25 years, based on projected growth in the area. These projections, in conjunction with other flow-duration characteristics, will demonstrate if the Duck River can meet future water-use requirements. Potential ground-water resources also will be examined using existing surface-water seepage-analysis data, as well as conducting seepage analyses in two representative areas within the basin. Information on water use is being collected with the help of the South Central Development District.

Completion of this investigation will provide information about current water use and future water-use requirements in the Duck River basin. Water-resource managers can then make decisions whether additional surface impoundment is needed on the Duck River. The project is under the direction of hydrologists Dorothea W. Hanchar and Susan S. Hutson, and is scheduled for completion in July 1991.



IWR-MAIN Procedure and data requirements for estimating water use (Davis, W.U., Rodrigo, D. Opitz, E., Dziegielewski, B., Baumann, D.D., and Boland, J., 1988, IWR-MAIN Water use forecasting system, version 5.1: User's Manual and sysstem description. IRW-Report 88-R-6, Fort Belvoir, Virginia, U.S. Army Corps of Engineers Institute for Water Resources.).

WATER QUALITY IN THE CLINCH AND POWELL RIVERS, EAST TENNESSEE

The USGS, in cooperation with the Tennessee State Planning Office, is conducting a reconnaissance investigation to define the variability of the water quality in the Clinch and Powell Rivers in East Tennessee. This variability is suspected to be related to agricultural activities in that water-quality constituent and sediment-concentration levels are elevated during storm-runoff periods when agricultural activities are high. The project is designed to collect water-quality data mainly during storm-event periods because this is when most of the nutrients and sediment are contributed to the rivers.

Automatic samplers are installed at a downstream station on each river to collect samples during storm events. These samples are analyzed for common ions, nutrients, selected trace metals, suspended sediment, and bacteria. Manual samples are collected at upstream sites during storm periods. The suspended-sediment and nutrients data, in conjunction with continuous streamflow data, will be used to estimate annual loadings for both rivers. The project chief is hydrologist Jess Weaver.

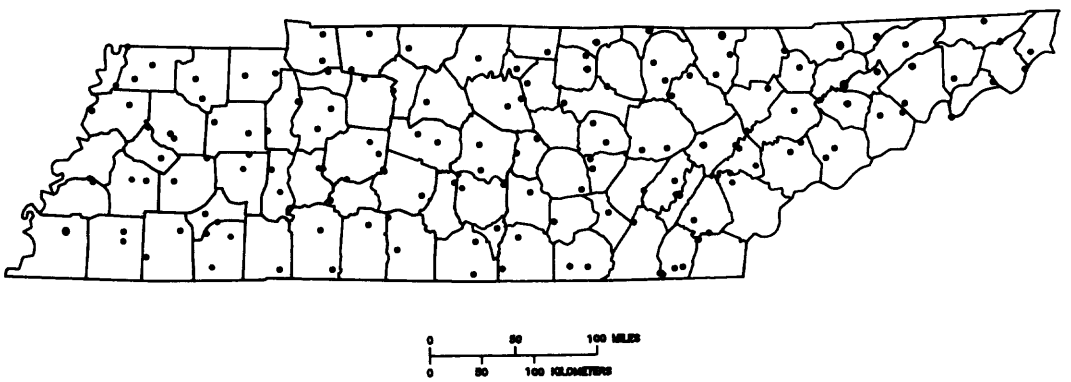
WATER QUALITY OF FARMSTEAD WELLS IN TENNESSEE

Farms in Tennessee are largely dependent on private wells for drinking water. The effect of agricultural activities on the quality of the water used by farming families is of concern to local, State, and Federal agencies. The USGS, in cooperation with the Tennessee State Planning Office, initiated a project early in 1989 to assess the quality of water in farmstead wells and to gain a better understanding of the processes causing degradation of ground-water quality in agricultural settings.

A network of 150 farmstead wells was established for sampling and analyses. Wells were chosen to provide samples representative of the principal surficial aquifers in the State as well as local aquifers that are used for water supply. Priority in selection was given to wells of known construction and where agricultural practices are documented, and where well and aquifer characteristics are known. State and local agencies assisted in the selection of the network wells, including the Tennessee Agricultural Extension Service and the Tennessee Farm Bureau.

At each well, samples were collected for analyses of major inorganic constituents, nitrogen species, and organic-indicator characteristics. Specific conductance, pH, water temperature, and alkalinity have been measured in the field. Samples for bacterial counts also were collected at each site. Hydrogeologic and land-use data near each farmstead well have been described and documented. The data are stored in a computerized file.

The project will provide the Tennessee State Planning Office and other agencies with baseline data essential for management of agricultural practices and definition of strategies for the State's "nonpoint sources of pollution" program. The project, scheduled for completion in December 1990, is under the direction of hydrologist John Carmichael and hydrologic technician Michael Bennett.



Location of sampled farmstead wells in Tennessee as of May 15, 1990.

OTHER ACTIVITIES

ADMINISTRATIVE SERVICES SECTION

Administrative services to the Tennessee District headquarters and field offices are provided by a unit of four employees directed by Nancy Tedder, Administrative Officer. Personnel management, payroll, training, procurement, inventory control, budgeting, and accounting services are efficiently handled through computerized systems.

COMPUTER SECTION AND ACTIVITIES

The Tennessee District Computer Section continued to enhance its capabilities to support District activities. Highlights during the year included:

- Installation of an additional computer assisted workstation for drafting.
- Enhancements to the electronic reports processing systsem.
- Additional memory for systems in the Publication Section,
- Installation of advanced word-processing capabilities for all project chiefs.
- Acquisition of several personal computers for individual project chiefs.
- Enhancements to the Geographic Information System Unit by addition of a digitizing station.

Plans continue for the acquisition of 32-bit workstations under a national USGS contract. A local area network was recently procured to improve efficiency of operations. Hydrologist Bill Barron directs the Computer Section.

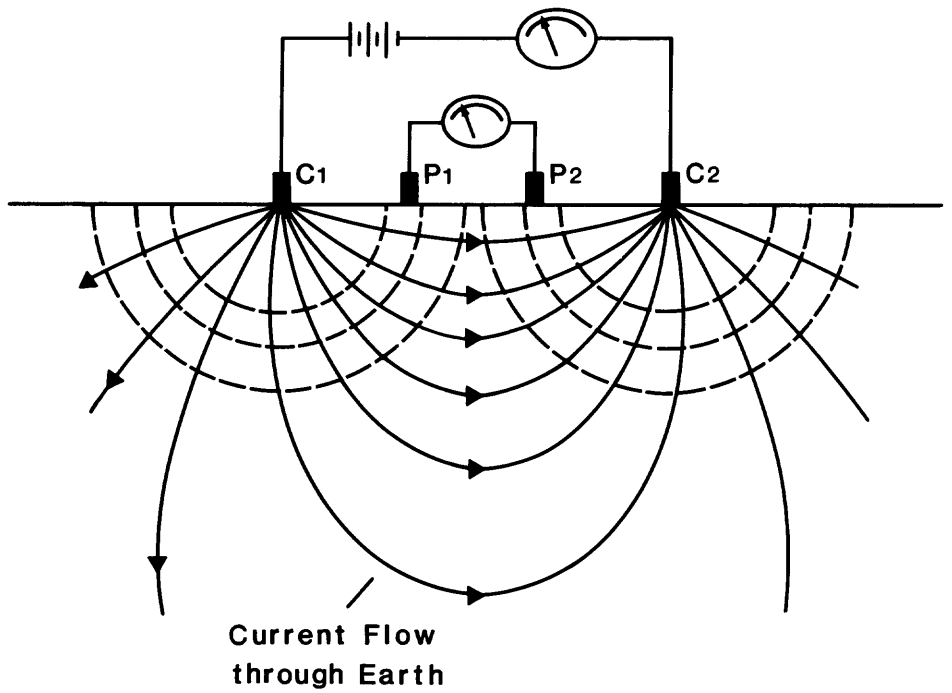
GEOPHYSICAL CAPABILITIES OF THE TENNESSEE DISTRICT

The Tennessee District of the U.S. Geological Survey has an extensive suite of equipment to collect hydrologic and geologic information through the use of surface and borehole geophysics. Terrain conductivity equipment is available from the Nashville District Office and borehole geophysical loggers are stationed in the Nashville and Memphis Subdistrict offices. Additional surface geophysical equipment is available from other USGS offices, as well as a logger with full capabilities, including nuclear probes, stationed in Atlanta, Georgia.

Terrain conductivity identifies differences in electrical properties of subsurface materials. Measured conductivity is affected primarily by lithology and water quality. Terrain conductivity has been used to identify anisotropic conditions in carbonate aquifers, to map leachate migration from landfills, and to identify an area where the confining clay overlying the Memphis Sand is absent. The District Surface Geophysical Specialist is Dorothea W. Hanchar.

The two Tennessee District geophysical loggers can run caliper, natural gamma, and spontaneous potential and resistivity logs. The logs can be used to determine subsurface lithology, identify possible water-bearing zones, and evaluate borehole conditions. In addition to producing the standard paper logs, the logger stationed in Nashville has the capability to record the logs in a digital format. The digital data can then be processed to change scale, to aid in correlation, and to aid in the preparation of illustrations.

In 1991, the Tennessee District will place into operation a drilling unit for shallow and intermediate wells. This will provide capabilities for drilling 6-inch diameter observation wells piexometers, split-spoon sampling and other core sampling. Hydrologic technician Richard A. Orr will oversee the drilling activities.



Schlumberger electrode array configuration for direct-current resistivity soundings showing both current and potential electrodes.

GROUND-WATER INFORMATION UNIT

The objectives of this support unit are to ensure maximum use of ground-water data collected in Tennessee and to provide diverse support for all ground-water activities in the District. Specific functions of the Ground-Water Information Unit are to:

- Store ground-water data on wells drilled or inventoried for new projects,
- Maintain existing ground-water data bases,
- Assist personnel in retrieving and plotting data,
- Answer information requests, and
- Operate and maintain the borehole geophysical logger.

The ground-water computer data base maintained by the Ground-Water Information Unit is part of a national system run by the U.S. Geological Survey. The stored data can be output directly in the form of tables and hydrographs. Data also can be readily transferred into a geographic information system where the data can be plotted and integrated with geologic maps and other pertinent data. The data base contains information on over 3,200 ground-water sites in Tennessee. Over 600 of these sites have been added by the Ground-Water Information Unit which was established in 1988.

The Ground-Water Information Unit also is responsible for the collection of borehole geophysical logs on wells throughout the State. The district logger has the ability to run caliper, natural gamma, and electric logs. Logs for over 50 wells have been collected by the Unit. Hydrologic technician Malcolm Dugliss oversees the operation of the Ground-Water Information Unit.

REGIONAL PUBLICATIONS CENTER

The Tennessee District operates a Regional Publications Center in support of projects within the District and 10 other states in the Southeastern Region. Barbara Balthrop is the Chief of the Publications Center.

Accomplishments for 1990:

- Acquisition of a third personal computer and graphics software for production of publication-quality illustrations for reports
- Acquisition of additional text manipulation software for use with graphics software
- Acquisition of new printer for report text
- Acquisition of new plotter for graphics production

Goals for 1991:

- Acquire advanced training for personnel preparing computer graphics and electronic report processing
- Compile and publish the National Computer Technology Meeting proceeding for Headquarters

RECENT PUBLICATIONS

The Tennessee Publications Center prepared 12 Water-Resources Investigations Reports, 8 Open-File Reports, 11 journal articles, abstracts, and symposia articles, and two annual data reports for publication. The Tennessee Center also compiled and printed two program and abstracts publications for the Second Tennessee Hydrology Symposium (containing 38 abstracts) and the National Computer Technology Meeting (containing 52 abstracts), along with printing 3 out-of-District reports, and 3 periodic bulletins. Currently, approximately 25 reports are in various stages of preparation.

Reports published:

Bennett, M.W., and Carmichael, J.K., and Roman-Mas, Angel, 1990, Water-quality and well-construction data for selected farmstead wells in Tennessee: U.S. Geological Survey Open-File Report 90-394, 23 p.

Balthrop, B.H., and Baker, E.G., compilers, 1990, U.S. Geological Survey National Computer Technology Meeting: Program and abstracts, May 7-11, 1990: U.S. Geological Survey Open-File Report 90-161, 56 p.

Broshears, R.E., and Bradley, M.W., 1990, Well-construction, geologic, and hydrologic data at the North Hollywood dump, Memphis, Tennessee, 1985-87: U.S. Geological Survey Open-File Report 90-388.

Bryan, B.A., 1989, Channel evolution of the Hatchie River near the U.S. Highway 51 crossing in Lauderdale and Tipton Counties, West Tennessee: U.S. Geological Survey Open-File Report 89-598, 59 p.

Connell, J.F., and Bailey, Z.C., 1989, Statistical and simulation analysis of hydraulic-conductivity data for Bear Creek and Melton Valleys, Oak Ridge Reservation, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4062, 49 p.

Gamble, C.R., 1989, Techniques for simulating flood hydrographs and estimating flood volumes for ungaged basins in East and West Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4076, 40 p.

Hileman, G.E., 1990, Water-quality, well-construction, and ground-water, and ground-water level data for an investigation of radionuclides in ground water, Hickman and Maury Counties, Tennessee: U.S. Geological Survey Open-File Report 90-190, 13 p.

Hollyday, E.F., and Smith, M.A., 1990, Large springs in the Valley and Ridge province in Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4205, 9 p.

Hoos, A.B., 1990, Effects of storm-water runoff on local ground-water quality, Clarksville, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 90-4044, 57 p.

Hoos, A.B., 1990, Recharge rates and aquifer hydraulic characteristics for selected drainage basins in Middle and East Tennessee: U.S. Geological Survey Water-Resources Investigations Report 90-4015, 34 p.

Hutson, S.S., 1989, Ground-water use by public-supply systems in Tennessee in 1985: U.S. Geological Survey Water-Resources Investigations Report 89-4092, 1 sheet.

Lewis, J.G., and Gamble, C.R., 1989, Flood of December 25, 1987, in Millington, Tennessee and vicinity: U.S. Geological Survey Water-Resources Investigations Report 89-4019, 2 sheets.

Lowery, J.F., and Connell, J.F., 1990, Low flows during the 1988 drought in Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4149, 1 sheet.

Lowery, J.F., Counts, P.H., Edwards, F.D., and Garrett, J.W., 1988, Water resources data, Tennessee, water year 1988: TN-88-1, 382 p.

Lowery, J.F., Counts, P.H., Edwards. F.D., and Garrett, J.W., 1990, Water resources data, Tennessee, water year 1989: TN-89-1, 283 p.

Parks, W.S., 1990, Hydrogeology and preliminary assessment of the potential for contamination of the Memphis aquifer in the Memphis area, Tennessee: U.S. Geological Survey Water- Resources Investigations Report 90-4092, 39 p.

Parks, W.S., and Carmichael, J.K., 1989, Geology and ground-water resources of the Fort Pillow Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4120, 20 p.

Parks, W.S., and Carmichael, J.K., 1990, Geology and ground-water resources of the Memphis Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4182, 30 p.

Parks, W.S., and Carmichael, J.K., 1990, Geology and ground-water resources of the Cockfield Formation in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4181, 17 p.

Parks, W.S., and Carmichael, J.K., 1990, Altitude of potentiometric surface, fall 1985, and historic water-level changes in the Memphis aquifer in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4180, 8 p.

Quinones, Ferdinand, and Baker, E.G., 1990, Water resources in Tennessee: Current Conditions: U.S. Geological Survey, February, v. 4, no. 1, 9 p.

Quinones, Ferdinand, and Baker, E.G., 1990, Water resources in Tennessee: Current Conditions: U.S. Geological Survey, May, v. 4, no. 2, 9 p.

Quinones, Ferdinand, and Baker, E.G., 1990, Water resources in Tennessee: Current Conditions: U.S. Geological Survey, September, v. 4, no. 3, 9 p.

Quinones, Ferdinand, and Balthrop, B.H., 1989, Water-resources investigations in Tennessee: Programs and activities of the U.S. Geological Survey, 1989-90: U.S. Geological Survey Open-File Report 90-, p.

Quinones, Ferdinand, Balthrop, B.H., and Baker, E.G., 1989, Water-resources investigations in Tennessee: Programs and activities of the U.S. Geological Survey, 1988-89: U.S. Geological Survey Open-File Report 89-379, 59 p.

Quinones, Ferdinand, and Gamble, C.R., 1990, Floods of February 1989 in Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4207, 15 p.

Roman-Mas, A.J., Carmichael, J.K.,and Bennett, M.W., 1990, Ground-water quality at selected wells and springs from the principal aquifers in Tennessee: U.S. Geological Survey Open-File Report 90-574.

Tucci, Patrick, Hanchar, D.W., and Lee, R.W., 1990, Hydrogeology of a hazardous-waste disposal site near Brentwood, Williamson County, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4144, 68 p.

Webster, D.A., and Bradley, M.W., 1988, Hydrology of the Melton Valley radioactive-waste burial grounds at Oak Ridge National Laboratory, Tennessee: U.S. Geological Survey Open-File Report 87-686, 115 p.

Zehner, H.H., 1989, Construction data and retrieval procedures for selected wells drilled from 1985 through 1987 at Oak Ridge National Laboratory, Tennessee: U.S. Geological Survey Open-File Report 89-61, 96 p.

USGS NATIONAL WATER-QUALITY LABORATORY SYSTEM

The USGS National Water-Quality Laboratory System provides full analytical capability in support of Tennessee District investigations activities. Analytical services for water-quality determinations are provided by the large, highly automated laboratory facility in Arvada, Colorado. Additional analytical services are provided by selected contract and research laboratories. The analytical methods used meet procedures approved by the U.S. Environmental Protection Agency (USEPA) and are documented in a series of publications called the "Techniques of Water-Resources Investigations."

Samples typically are sent directly from field sampling areas to the laboratory by air delivery. Upon delivery to the laboratory, a highly automated sample-tracking system ensures rapid turnaround. Analytical results are transmitted electronically to USGS offices for review of the results. A full suite of quality-assurance procedures are documented along with each set of analytical results. After review, analytical results are stored in the National Water Information System of the USGS, and are transmitted to the STORET national data base maintained by the USEPA.

The following are major benefits provided by the USGS National Water-Quality Laboratory System:

- Capability for analyzing for all pertinent environmental constituents and characteristics including nutrients, common ions, trace metals, volatile organic compounds, semivolatile organic compounds, pesticides, and radionuclides.
- A wide range of types of environmental samples can be analyzed including water, sediment, atmospheric deposition, and biota.
- Custom-analyses support through the methods-development staff, and state-of-the-art methodology such as pesticide biodegradation products, and lower analytical detection limits.
- Results are stored in national computerized data bases and can be accessed by all state and federal agencies, universities, and other facilities.
- Expert technical consultation is available from laboratory personnel and staff of the USGS Branch of Quality Assurance.
- Rigorous quality assurance/quality control procedures to guarantee integrity of samples and analytical procedures.

APPENDIX 1

Active Recording Surface-Water Stations in Tennessee as of 9/30/90

[mi^2, square miles; Lat, latitude; Long, longitude]

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN				
03408500	New River at New River	382	362308	843317	1934
03409500	Clear Fork near Robbins	272	362318	843749	1930
03414500	E Fork Obey River nr Jamestown	202	362458	850135	1942
03416000	Wolf River near Byrdstown	106	363337	850423	1942
03417500	Cumberland River at Celina	7,307	363315	853052	1922
03418070	Roaring River above Gainsboro	210	362104	853245	1974
03418420	Cumberland River bl Cordell Hull Dam	8,095	361712	855627	1972
03421000	Collins River near McMinnville	640	354232	854346	1924
03422500	Caney Fork near Rock Island	1,678	354826	853744	1911
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 (Tailwater)	11,673	361747	863928	1931-42, 1947
03427500	East Fork Stones River nr Lascassas	262	355506	862002	1950
03428043	Lytle Creek at Sanbyrne Drive at Murfreesboro	17.6	354938	862328	1978
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
03431000	Mill Creek near Antioch	64.0	360454	864050	1954-75, 1976
03431062	Mill Creek trib. at Glenrose Ave., at Woodbine	1.17	360702	864337	1977
03431490	Pages Branch at Avondale	2.01	361222	864624	1977
03431500	Cumberland River at Nashville	12,860	360945	854617	1892-1954,1986
03431517	Cummings Branch at Lickton	2.40	361825	864800	1975
03431700	Richland Creek at Charlotte Avenue, at Nashville	24.3	360904	865116	1964
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	1924
03435000	Cumberland River below Cheatham Dam	14,163	361926	871332	1954
03436000	Sulphur Fork Red River near Adams	186	363055	850332	1938

APPENDIX 1--Continued

Active Recording Surface-Water Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	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				
03455000	French Broad River near Newport	1,858	355854	830940	1900
03465500	Nolichucky River at Embreeville	805	361035	822727	1919
03466228	Sinking Creek at Afton	13.7	361155	824431	1977
03469175	Little Pigeon River above Sevierville	184	355155	833201	1988
03491000	Big Creek near Rogersville	47.3	362534	825707	1941-49, 1957
13491544	Crockett Creek below Rogersville	4.67	362247	830248	1988
03495500	Holston River near Knoxville	3,747	360056	834954	1930
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	1986
03528000	Clinch River above Tazewell	1,474	362530	832354	1918
03535102	Scarboro Creek Trib nr Haw Ridge nr Oak Ridge	.41	355845	841416	1989
03535103	Scarboro Creek Trib nr Oak Ridge	.41	355844	841415	1989
03535912	Clinch River at Melton Hill Dam	3,343	355307	841803	1936
03536320	White Oak Creek near Melton Hill	1.31	355556	841820	1987
03536380	Whiteoak Creek near Wheat	2.10	355530	841852	1986
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
03537050	Melton Branch trib. (East Seven) near Oak Ridge	.24	355507	841743	1987
03537100	Melton Branch near Melton Hill, nr Oak Ridge	.52	355459	841753	1985
03537200	Melton Branch trib. (Center Seven) near Oak Ridge	.07	355503	841754	1987
03537300	Melton Branch trib. (West Seven) near Oak Ridge	.15	355511	841808	1987
03538225	Poplar Creek near Oak Ridge	82.5	355955	842023	1960
035382672	Bear Creek trib. abv Bear Creek Road near Wheat	.30	355641	841927	1986

APPENDIX 1--Continued

Active Recording Surface-Water Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	TENNESSEE RIVER BASIN--Continued				
035382673	Bear Creek near Wheat	3.20	355639	841927	1986
035382677	Bear Creek tributary near Wheat	.14	355628	841955	1986
03538270	Bear Creek at St. Hwy 95 near Oak Ridge	4.34	355617	842029	1985
03538272	Bear Creek trib. at Hwy 95 near Wheat	.14	355626	842032	1986
03538273	Bear creek at Pine Ridge near Wheat	5.00	355632	842037	1986
03540500	Emory River at Oakdale	764	355859	843329	1927
03543500	Sewee Creek near Decatur	117	353453	844453	1934
03560500	Davis Mill Creek at Copperhill	5.16	345943	842256	1940-41, 1948-78, 1986
03563000	Ocoee River at Emf	524	350548	843207	1912
03564500	Ocoee River at Parksville	595	350548	843915	1911-16, 1921
03565500	Oostanaula Creek near Sanford	57.0	351939	844219	1954
03566000	Hiwassee River at Charleston	2,298	351716	844507	1898-1903, 1914-40, 1963
03567500	South Chickamauga Creek nr Chickamauga	428	350051	851235	1928-78, 1980
03568000	Tennessee River at Chattanooga	21,400	350512	851643	1874
03571000	Sequatchie River near Whitwell	402	351222	852948	1920
03580995	East Fork Mulberry Creek below Jack Daniels Distillery at Lynchburg	23.4	351656	862217	1987
03584500	Elk River near Prospect	1,784	350139	865652	1904-08, 1919
03588000	Shoal Creek at Lawrenceburg	55.4	351440	872102	1932-34, 1967
03588500	Shoal Creek at Iron City	348	350127	873444	1925
03593500	Tennessee River at Savannah	33,140	351329	881526	1930
03598000	Duck River near Shelbyville	481	352849	862957	1933
03600088	Carters Creek at Butler Rd at Carters Creek	20.1	354302	865945	1986
03602219	Piney River at Cedar Hill	46.6	355943	872622	1987
03602500	Piney River at Vernon	193	355216	873005	1925
03603000	Duck River above Hurricane Mills	2,557	355548	874435	1925
03604000	Buffalo River near Flat Woods	447	352945	874958	1920
03604500	Buffalo River near Lobelville	707	354846	874751	1927

APPENDIX 1--Continued

Active Recording Surface-Water Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	OBION RIVER BASIN				
07025500	N. Fork Obion River at Union City	480	362359	885943	1929-71, 1989
07026000	Obion River at Obion	1,852	361504	891133	1929-58, 1966
07027000	Reelfoot Lake near Tiptonville	240	362109	892507	1940
07027500	S.F. Forked Deer River at Jackson	495	353538	884852	1929-73, 1988
	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
	WOLF RIVER BASIN				
07031660	Wolf River at Walnut Grove Road, at Memphis	709	350758	895118	1969
	NONCONNAH CREEK BASIN				
07032200	Nonconnah Creek near Germantown	68.2	350259	894908	1969

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 9/30/90

[mi^2, square miles; Lat, latitude; Long, longitude; *, Operated as a continuous-record station]

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN				
03409000	White Oak Creek at Sunbright	13.5	361438	844014	1934, 1955-82, 1985
03418201	Doe Creek at Gainesboro	5.72	362123	853920	1978
03420360	Mud Creek tributary No. 2 near Summitville	2.28	353610	860133	1967
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
03425357	Darwin Branch tributary at Hartsville	.66	362354	860908	1986
03425365	Second Creek near Walnut Grove	3.47	362401	861248	1986
03425700	Spencer Creek near Lebanon	3.32	361420	862403	1955
03426800	East Fork Stones River at Woodbury	39.1	354941	860436	1962
03426874	Brawleys Fork below Bradyville	15.4	354444	861014	1983
034269424	Reed Creek near Bradyville	3.52	354444	861231	1983
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
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	464531	1965
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

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN--Continued				
03431795	Bednigo Branch trib. at Chestnut Grove	0.47	362510	865411	1986
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
03434616	Hall Branch near Charlotte	.50	361148	872030	1984
034350021	Bartons Creek near Cumberland Furnace	22.29	361502	872000	1984
0343500213	Bartons Creek tributary near Stayton	.51	361519	871912	1984
034351113	Honey Run Creek below Cross Plains	25.8	363231	864214	1986
03435770	Sulphur Fork Red River above Springfield	65.6	363047	865144	1975
03435930	Spring Creek tributary near Cedar Hill	1.40	363208	865926	1986
03436505	Cummings Creek nr Dotsonville	2.65	362918	872806	1984
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
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
03481600	Corn Creek at Mountain City	5.34	362923	814852	1959-61, 1963
03487507	Horse Creek at Sullivan Gardens	26.0	362813	823552	1983
03490522	Forgey Creek at Zion Hill	.86	362912	825308	1986
03491490	Dodson Creek tributary near Rogersville	.32	362119	825703	1983

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	TENNESSEE RIVER BASIN--Continued				
03491540	Robertson Creek near Persia	14.6	362024	830227	1986
03494714	Dry Land Creek trib. near New Market	.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
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
035999716	Rutherford Creek trib. at Moores Lane near Kedron	.25	354203	865503	1987
03602170	West Piney River at Hwy 70 nr Dickson	2.16	360521	872812	1984
03604070	Coon Creek tributary near Hohenwald	.51	353407	874002	1967
03604080	Hugh Hollow Branch near Hohenwald	1.52	353459	874036	1967
03604090	Coon Creek above Chop Hollow, near Hohenwald	6.02	353519	874109	1967
03604580	Blue Creek near New Hope	13.2	360352	873858	1984
03604595	Little Blue Creek trib. near Gorman	.62	361944	874213	1984
03605555	Trace Creek above Denver	31.9	360308	875427	1963
03605880	Cane Creek at Stewart	4.12	361909	875021	1984

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 9/30/90--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	OBION RIVER BASIN				
07024225	Neil Ditch near Henry	4.07	361019	882333	1984
07024300	Beaver Creek at Huntingdon	55.5	355956	882601	1962
07024370	Little Reedy Creek near Huntingdon	.91	355544	882950	1984
07027010	Running Reelfoot Bayou near Owl City	247	361953	892402	1982-83, 1984
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
07029840	Richland Creek at Cedar Chapel	2.17	352412	891026	1987
07030100	Cane Creek at Ripley	33.9	354525	893305	1957-70, 1986

APPENDIX 2

Active ground-water-level stations in Tennessee as of 9/30/90

Station No.	Local well No.	County	Date began
	RECORDER--60-MINUTE PUNCH INTERVAL		
360835086441100	Dv:L-10	Davidson	1985
350234085181200	Hm:G-36	Hamilton	1981
360020087573300	Hs:H-1	Humphreys	1962
353839089493500	Ld:F-4	Lauderdale	1966
350035086423100	Li:G-2	Lincoln	1988
354223088380200	Md:N-1	Madison	1949
360543084343101	Mg:F-5	Morgan	1984
360521085432601	Pm:C-1	Putnam	1968
353922083345600	Sv:E-2	Sevier	1979
350514089553700	Sh:K-75	Shelby	1948
351435090005200	Sh:O-1	Shelby	1940
350735089593300	Sh:P-76	Shelby	1928
350900089482300	Sh:Q-1	Shelby	1940
350344090130000	Ar:H-2	Crittenden (Ark.)	1983
	TAPE DOWN		
360200089280100	Dy:H-1	Dyer	1955
360147089230700	Dy:H-7	Dyer	1954
352226089330101	Fa:R-1	Fayette	1949
352226089330102	Fa:R-2	Fayette	1949
352112089571200	Sh:U-1	Shelby	1946
352112089571300	Sh:U-2	Shelby	1953
355505086541100	Wm:M-1	Williamson	1950
350958090173800	Ar:C-1	Crittenden (Ark.)	1983
351349090062800	Ar:O-1	Crittenden (Ark.)	1983
351428085003600	Hm:O-15	Hamilton	1975

APPENDIX 3

List of water-quality and suspended-sediment stations

[mi^2, square miles; Lat, latitude; Long, longitude; Q, chemical; B, bacteriological; S, sediment]

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began	Data type
	CUMBERLAND RIVER BASIN					
03418420	Cumberland River below Cordell Hull Dam	8,095	361712	855627	1980	Q
03425000	Cumberland River at Carthage	10,690	361453	855719	1975	Q,B,S
03426310	Cumberland River at Old Hickory Dam (Tailwater)	11,673	361747	863928	1979	Q
03427500	East Fork Stones River nr Lascassas	262	355506	862002	1975	Q
03428200	W Fork Stones River at Murfreesboro	177	355410	862548	1986	Q
03428500	West Fork Stones River near Smyrna	237	355625	862754	1974	Q
	TENNESSEE RIVER BASIN					
03495500	Holston River near Knoxville	3,747	360056	834954	1965, 1977	Q,B,S
03497300	Little River above Townsend	106	353952	834241	1964-82, 1986	Q,B,S
03535912	Clinch River at Melton Hill Dam	3,343	355307	841803	1973	Q,B,S
03593005	Tennessee River at Pickwick Landing Dam	32,820	350354	881508	1975	Q,B,S
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
	OBION RIVER BASIN					
07026000	Obion River at Obion	1,852	361504	891133	1975	Q,B,S
	HATCHIE RIVER BASIN					
07029500	Hatchie River at Bolivar	1,480	351631	885836	1964, 1968, 1977	Q,B,S

OFFICE OF THE DISTRICT CHIEF

Ferdinand Quiñones
District Chief

Michael C. Yurewicz
Assistant District Chief

Lori R. Mercer
Secretary

ADMINISTRATIVE SERVICES SECTION

Nancy C. Tedder
Administrative Officer

Teresa D. Holt
Personnel Clerk

M. Vicky Brantley
Accounting Clerk

Debby P. Tully
Receptionist Clerk

COMPUTER SECTION

William R. Barron
Chief, Computer Section

Joseph F. Connell
Hydrologist GIS Manager

Letitia A. Ables
Computer Technician

Pamela J. Norris
Computer Programmer

PUBLICATIONS SECTION

Barbara H. Balthrop
Chief,
Publications Unit

Wayne T. Ashmore
Scientific
Illustrator

Eva G. Baker
Writer Editor

James E. Banton
Cartographic
Technician

Joel C. Smith
Cartographic
Technician

DATA MANAGEMENT SECTION

Charles R. Gamble
Assistant
District Chief

Anne B. Hoos
Hydrologist

GEOMORPHOLOGIC/ECOLOGICAL INVESTIGATIONS

Bradley A. Bryan
Chief,
G-E Unit

Timothy N. Diehl
Hydrologist

George S. Outlaw
Hydrologist

David E. Bazemore
Hydrologist

William J. Wolfe
Hydrologist

HYDROLOGIC INVESTIGATIONS SECTION

Michael C. Yurewicz
Chief

Este F. Hollyday
Hydrologist

Michael W. Bradley
Hydrologist

David A. Webster
Hydrologist

Arthur D. Bradfield
Hydrologist

John K. Carmichael
Hydrologist

Dorothea W. Hanchar
Hydrologist

Connor J. Haugh
Hydrologist

Elizabeth N. Mahoney
Geologist

Dianne J. Pavlicek
Hydrologist

Gregg E. Hileman
Hydrologist

Michael W. Bennett
Hydrologic Technician

Angel J. Roman
Hydrologist

Malcolm A. Dugliss
Hydrologic Technician

KNOXVILLE SUBDISTRICT

Jess D. Weaver
Chief, Knoxville Subdistrict

Patrick H. Counts
Hydrologic Technician

James G. Lewis
Hydrologic Technician

Gordon B. Smith
Hydrologic Technician

John C. Barnett
Hydrologic Technician

Andy C. Hickey
Hydrologic Technician

Terry D. Phillips
Hydrologic Technician

Gregory C. Johnson
Hydrologist

Patricia Powers
Hydrologic Clerk

Richard J. Connor
Hydrologic Technician

Rachel C. Merwin,
Tenn. Tech. U
Student

Ray T. Webber,
Tenn. Tech. U
Student

MEMPHIS SUBDISTRICT

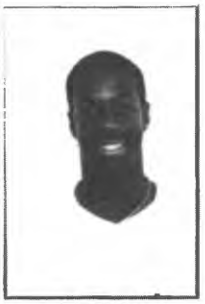
W. Harry Doyle
Chief, Memphis Subdistrict

William S. Parks
Hydrologist

Richard A. Orr
Hydrologic Technician

Susan S. Hutson
Hydrologist

Jerry W. Garrett
Hydrologic Technician



Randy Thomas
Civil Engineer

W. Kevin Kelly
Hydrologic Technician

B. Larry Thomas
Hydrologic Technician

Katherine S. McCain
Hydrologic Technician

James A. Kingsbury
Hydrologist

Robert W. Stogner
Hydrologic Technician

Juné E. Mirecki
Hydrologist

Carolyn F. Glover
Hydrologic Clerk

Paul W. Moore
Hydrologic Technician
(Volunteer)

NASHVILLE SUBDISTRICT

Jerry F. Lowery
Chief, Nashville
Subdistrict

F. Derward Edwards
Hydrologic
Technician

Jesse T. Hamilton
Hydrologic
Technician

Arthur K. Brachmann
Hydrologic
Technician

Donna F. Flohr
Hydrologic
Technician

Beri N. Fraley
Hydrologic
Technician

Ron L. Kemp
Hydrologic
Technician

David E. Butner
Hydrologic
Technician

John T. Pankey
Civil
Engineer

Katrina L. Hoadley
Hydrologic
Clerk

Aaron T. Oaks,
Tenn. Tech. U
Student

CO-OP STUDENTS

Robin F.
Blackman,
MTSU

Shanna N.
Curley,
TTU

Mark W.
Davis,
Tenn. Tech. U

Jason E.
Duke,
Tenn. Tech. U

Nicole D.
Glafka,
Vanderbilt U

David C.
Greene,
Tenn. Tech. U

Patrick A.
Harrell,
Tenn. Tech. U

Romona L.
Hunt,
TSU

John A.
Robinson,
TSU

Jozsef T.
Simon,
Tenn. Tech. U

Carrie M.
Wright,
Hume-Fogg

pag 75 follows

INDEX