WATER-RESOURCES INVESTIGATIONS IN TENNESSEE: PROGRAMS AND ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, 1988-89

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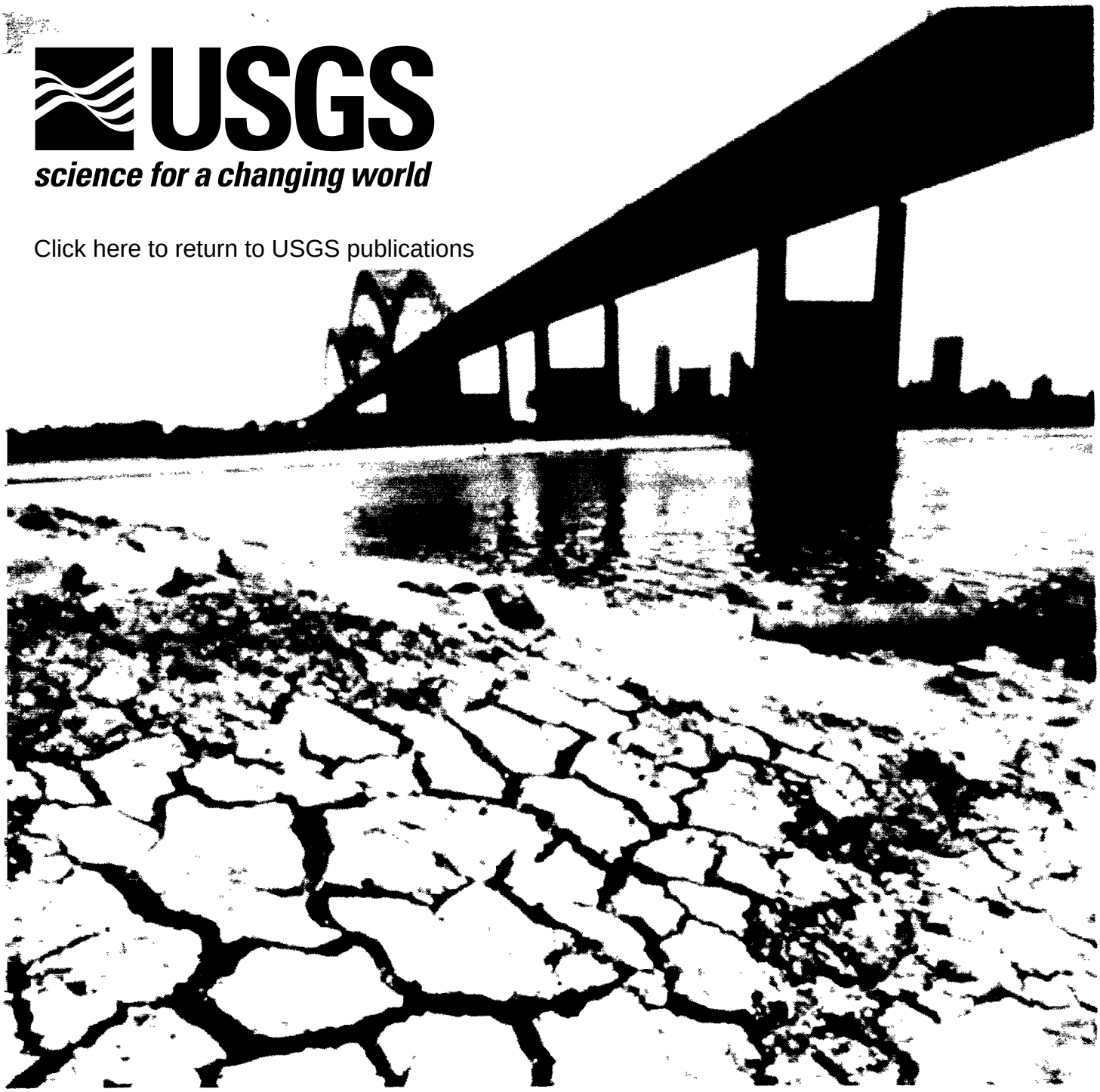

U.S. GEOLOGICAL SURVEY
Open-File Report 89-379

ACKNOWLEDGEMENTS

Illustrations: Joel C. Smith and James E. Banton

Exposed riverbed at Mississippi River bridge at Memphis, Tenn., during the height of the 1988 drought. Photograph courtesy of the U.S. Army Corps of Engineers, Memphis

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by Ferdinand Quinones, Barbara H. Balthrop, and Eva G. Baker

U.S. GEOLOGICAL SURVEY

Open-File Report 89-379

Nashville, Tennessee
1989

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

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A MESSAGE FROM THE TENNESSEE DISTRICT CHIEF:

The following report is the most current in a series of reports published by the Water Resources Division of the U.S. Geological Survey describing the ongoing water-resources programs and activities in the Tennessee District. These reports provide general information about the projects conducted by the Tennessee District in cooperation with state, local, and other federal agencies. In addition to describing the principal objectives of each program and project, information about the progress of each investigation is provided. The variety of projects conducted by the Tennessee District's staff normally results in significant new findings.

Each year the focus of the programs conducted by the U.S. Geological Survey in Tennessee varies in response to local, state, and federal interests. The local and state interests are addressed through our cooperative investigations program, in which the U.S. Geological Survey provides as much as 50 percent of the funds to conduct investigations. Almost two thirds of the projects in the District are in the cooperative program; the U.S. Geological Survey contributed almost 1.5 million dollars in matching funds to cooperative programs in Tennessee in fiscal year 1989. Federal funds from within the U.S. Geological Survey and other federal agencies financed additional programs at a cost of about 1 million dollars.

Technical focus of local and federal programs has shifted during the last few years towards issues addressing hazardous-wastes and ground-water contamination. Many of the projects presented in this report address those issues. Emerging issues such as concerns about wetlands, scour of bridges, quality of storm-water runoff, and droughts, are well represented in the scope of the investigations described in this report.

The results of these programs provide significant input to many other activities of the State of Tennessee and the Federal Government that have a direct impact on the quality of life. The information and conclusions obtained from these data-collection programs and investigations are crucial to meet many of the water-supply needs, regulatory, and other water-related issues that the local, state, and federal governments must address. The ability of the U.S. Geological Survey to provide the data to meet these needs resides with the support that the program receives by the State and Federal cooperators.

I am pleased with the extent and degree of cooperation that the program receives across the State and from other federal agencies. This report is a testimony to this support. I wish to share these achievements with the dedicated employees of the Tennessee District as well as with the cooperating agencies and their representatives that make this program feasible.

Ferdinand Quinones
District Chief
Tennessee District USGS-WRD

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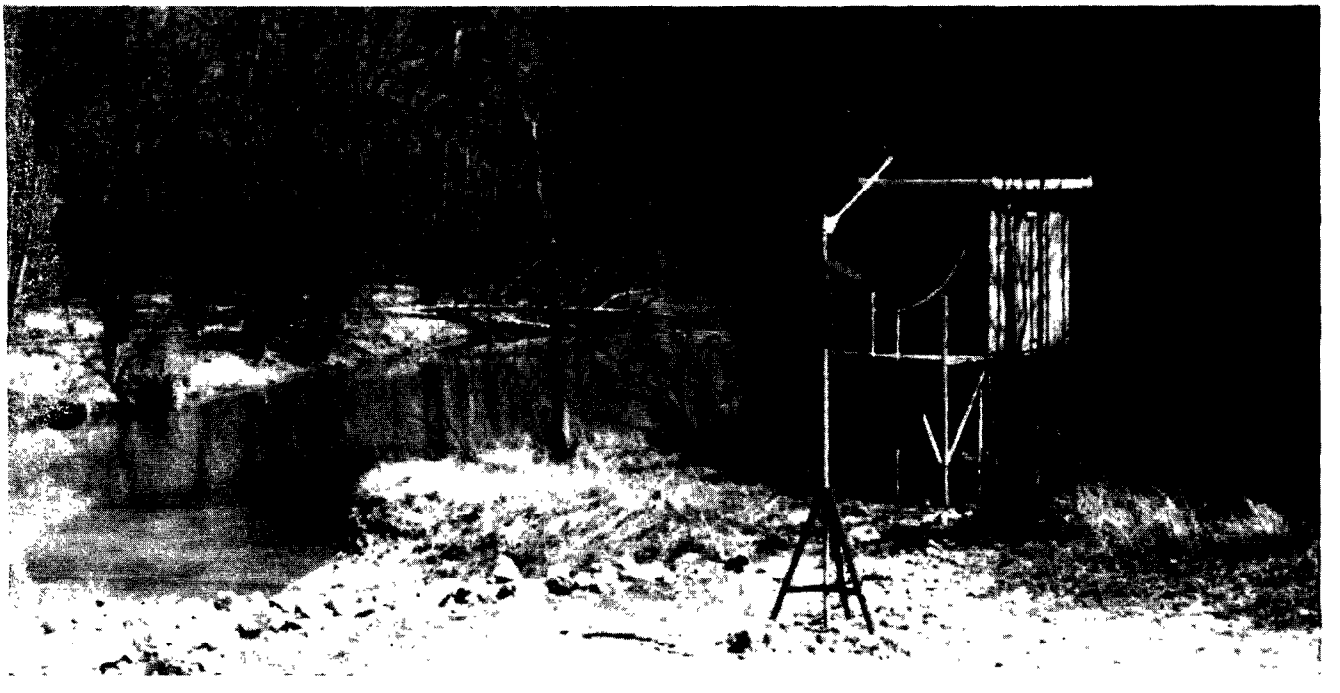
HYDROLOGIC DATA SECTION

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 levels information essential to the assessment and management of the State's water resources. Long-term streamflow, quality of water, and ground-water levels 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 network 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."



SURFACE-WATER MONITORING NETWORK

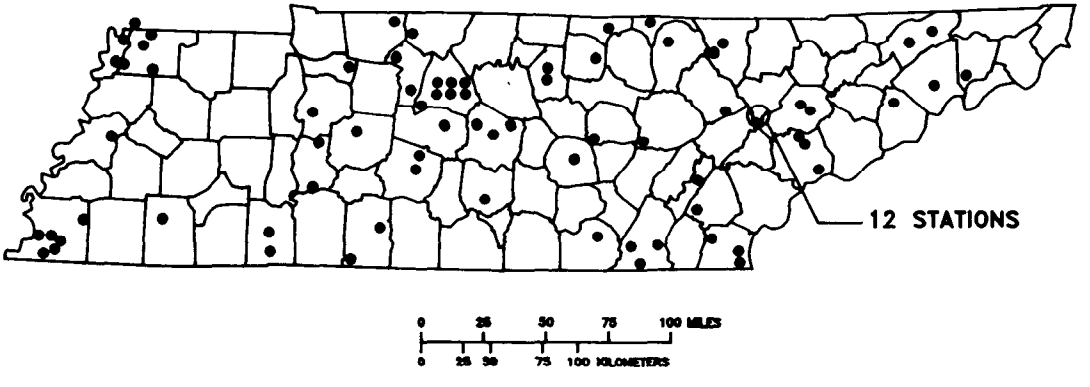
The Tennessee District operates a network of continuous streamflow-gaging stations throughout Tennessee. In 1989, the network includes 100 continuous streamflow gages and 13 continuous stream or lake water-level only gages. Additionally, 20 continuous rainfall stations were operated in conjunction with other research or lake-level gages. Continuous streamflow data are recorded and disseminated for many purposes, including:

- Assessment of water available for many and varied 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

Changes to this network in 1988 include adding 5 stations and discontinuing 22 stations.

Program cooperators supporting this network are:

Tennessee Valley Authority (TVA)
U.S. Army Corps of Engineers, Nashville District (COE)
Tennessee Department of Health and Environment (TDHE)
Tennessee Wildlife Resources Agency (TWRA)
U.S. Department of Energy (DOE)
Memphis Light, Gas and Water (MLGW)
Shelby County
Cities of: Alcoa, Bartlett, Lawrenceburg, Memphis, Metropolitan Government of Nashville and Davidson County, Rogersville, Dickson, Franklin, Murfreesboro, Spring Hill, Sevierville, and Union City

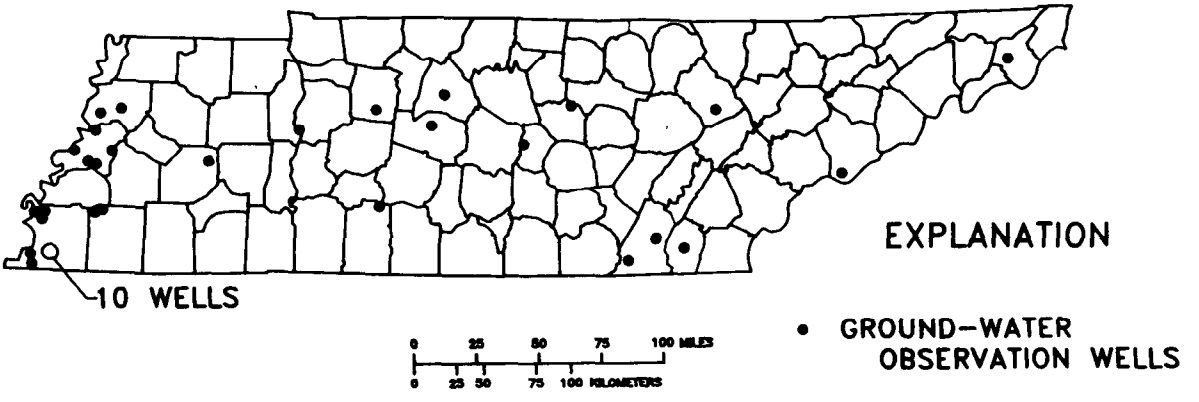


Location of streamflow stations in Tennessee.

GROUND-WATER LEVEL NETWORK

The U.S. Geological Survey 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 32 observation wells are part of the statewide ground-water-level network. These wells are used to monitor water-level fluctuations in response 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.

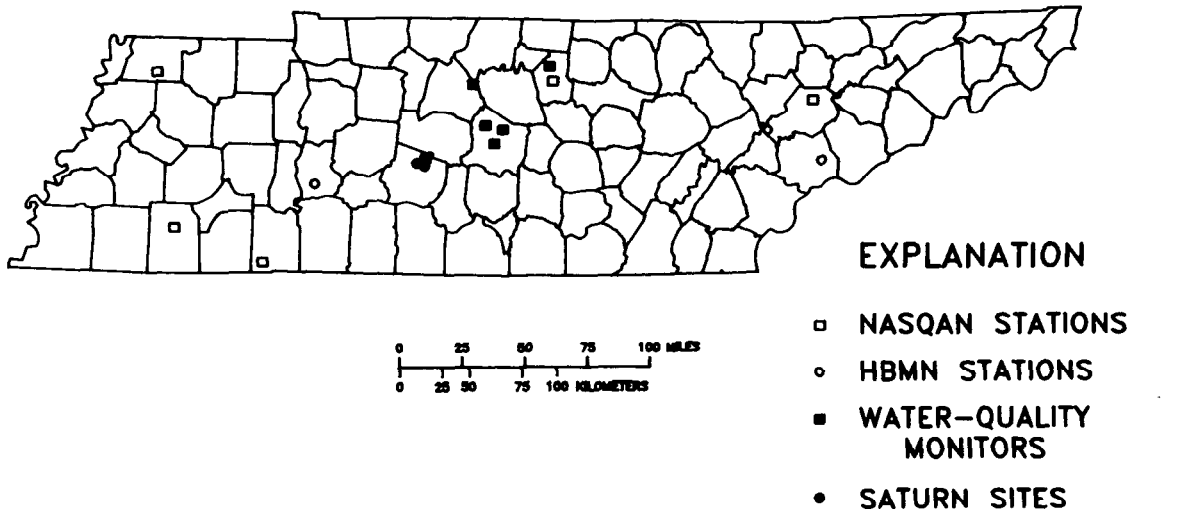


Location of observation wells in Tennessee.

WATER-QUALITY NETWORK

The U.S. Geological Survey monitors water quality at numerous surface-water stations in Tennessee. Six 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 Survey assesses natural streamflow and water quality of small 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 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.

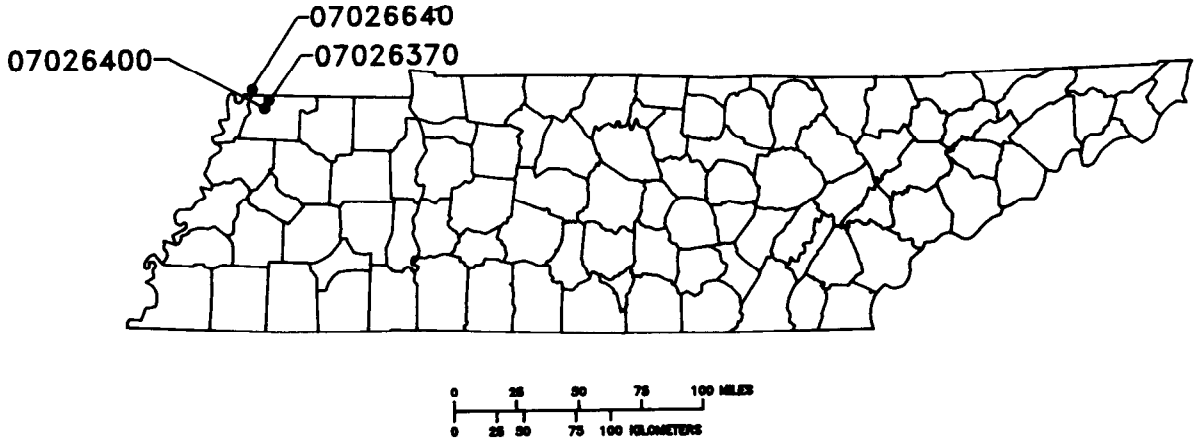


Water-quality data-collection sites in Tennessee.

SUSPENDED-SEDIMENT INVESTIGATIONS

The collection of suspended-sediment data in Tennessee was curtailed significantly during the last year. The daily-sampling stations operated in the Reelfoot area in West Tennessee were discontinued with the completion of the scheduled project. No other daily suspended-sediment stations are operated by any organization in the State. The U.S. Geological Survey continued to collect miscellaneous samples at selected sites throughout the State. Samples were collected seasonally at six National Stream Quality Accounting Network (federally-funded network of water- quality stations) sites throughout the State. Miscellaneous samples are also collected from a hydrologic benchmark station (HBM) at the Buffalo River near Flat Woods. Storm-runoff samples were also collected in the Reelfoot 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, is urgent.



Location of sediment stations in Tennessee.

WATER-USE PROGRAM

Collecting water-use information is one of the most important basic data programs conducted by the U.S. Geological Survey. In cooperation with the Tennessee Department of Health and Environment, the Tennessee water-use program 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
- Prepare and publish reports about water use in Tennessee and its importance as part of the hydrologic cycle

During 1988, water-use data were collected for agriculture, industry, public supply, hydroelectric and thermoelectric power generation. Reports were prepared describing: the water-use program; an inventory of public-supply withdrawals; and an inventory of irrigation water use. Hydrologist Susan Hutson, from the Memphis Subdistrict office, directs the Tennessee Water-Use Program with the assistance of Janine Morris, from the TDHE.

FLOOD INVESTIGATIONS

In cooperation with the Tennessee Department of Transportation (TDOT) and the Metropolitan Government of Nashville and Davidson County, the U.S. Geological Survey 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

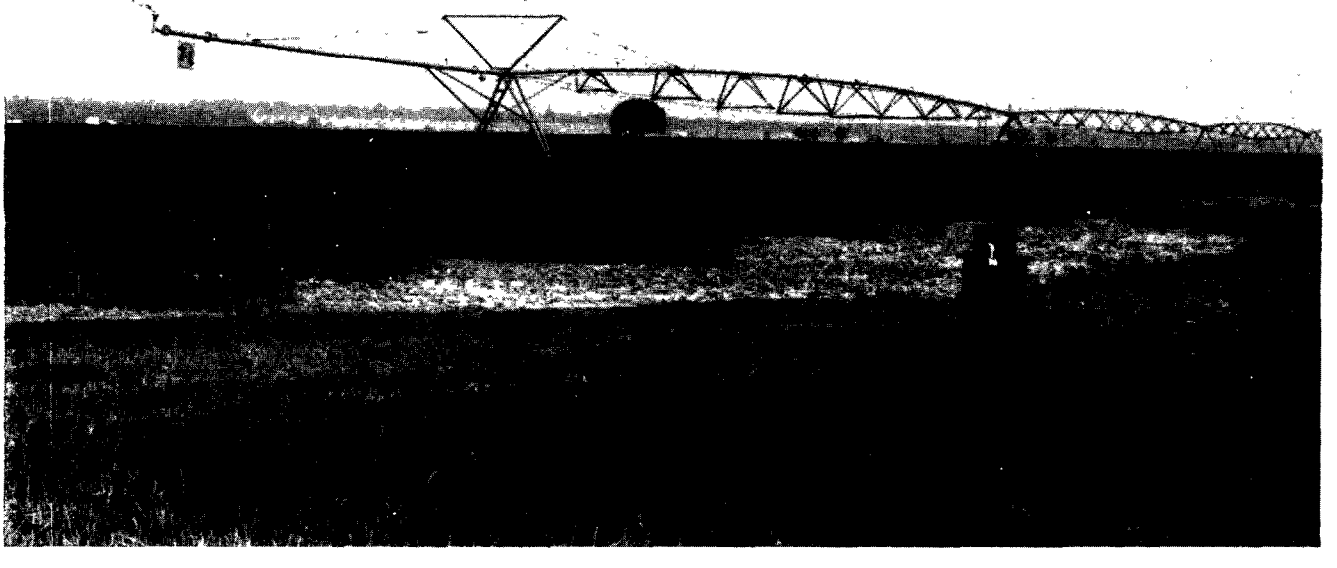
The areal extent of the project is statewide. The project chief is hydrologist Charles Gamble.

HYDROLOGIC INVESTIGATIONS SECTION

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 14 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 (9), 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 utilized in computer hydrological investigations.

In 1988, the Hydrologic Investigations Section was involved in 14 areal studies. Four projects were completed and four were initiated. The Section staff produced more than 32 reports, journal papers, and symposia articles.



GROUND-WATER QUALITY NETWORK IN TENNESSEE

In cooperation with the Tennessee Department of Health and Environment, Divisions of Construction Grants and Loans, Groundwater Protection, and Superfund, and the Tennessee State Planning Office, the U.S. Geological Survey began a long-term statewide ground-water quality monitoring network. 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 network will also provide information of interest to federal ground-water quality definition programs.

Approximately 90 sites will be sampled annually beginning in 1989. The sites include springs and wells representing the principal aquifers across the State. About 10 percent of the sites will be sampled for short-term monitoring of water quality in select areas and another 10 percent of the sites will be sampled quarterly to determine short-term changes in water quality.

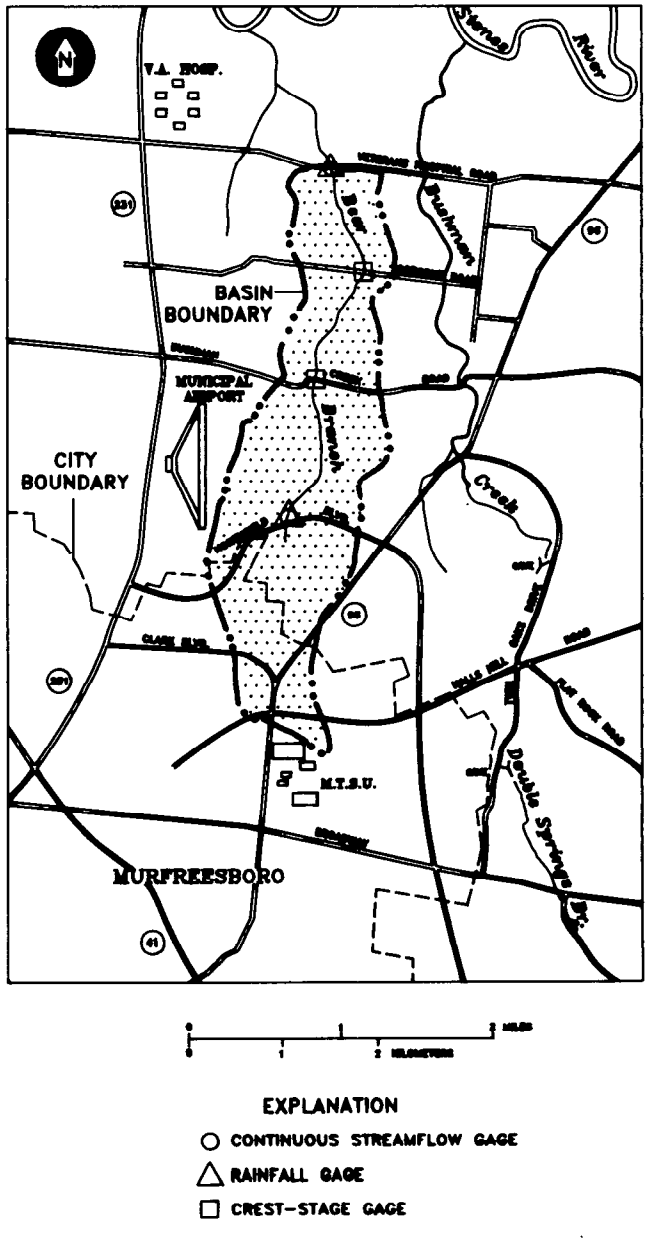
At each site, samples will be collected, and shipped to a laboratory for analyses of major and trace inorganic constituents, contamination-indicator parameters, and select organic compounds. The organic analyses will rotate annually between volatile compounds, acid and base/neutral extractable compounds, and pesticides. In addition, samples from six sites will be analyzed each year for geochemical parameters. Field parameters including specific conductance, pH, and alkalinity will also be measured at each site. The project is under the direction of hydrologist John Carmichael.

EFFECTS OF URBANIZATION AND DETENTION STORAGE ON FLOOD-PEAK DISCHARGES IN MURFREESBORO, TENNESSEE

The U.S. Geological Survey, in cooperation with the City of Murfreesboro, is investigating methods and tools to aid in planning and managing future development in and near flood-prone areas around the city. The project includes:

- Collection of rainfall and streamflow data at selected sites
- Development of a basin streamflow model for use in estimating runoff for proposed future development for planning purposes in the Bear Branch basin
- Definition of flood profiles of actual floods
- Definition of flood profiles for various recurrence-interval floods for use in delineating flood-prone areas for specific-frequency floods
- Installation of crest-stage gages at several selected large sinkholes in the Bushman Creek (Double Springs) basin. The flood-elevation collected at these sinkholes will be related to the area flooded and will be used to develop flood-prone-area frequency relations
- Collection of areal photos during flood periods to define the areas flooded

The project chief is David Canaan, engineer.



Basin outline and location of data collection points for Bear Branch basin.

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 State and Federal regulatory agencies. The U.S. Geological Survey, in cooperation with the Tennessee State Planning Office, initiated early in 1989 a project 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 will be selected for sampling and analyses. Wells will be 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 will be given to wells of known construction and where agricultural practices are documented and well and aquifer characteristics are known. State and local agricultural agencies will assist in the selection of the network of wells.

At each well, samples will be collected for analyses of major inorganic constituents, nitrogen species, and organic-indicator parameters. In addition, several parameters including specific conductance, pH, and alkalinity will be measured in the field. Samples for bacterial counts will be collected. Hydrogeologic and land-use data near each farmstead well will be described. The data collected will be stored in a computerized file.

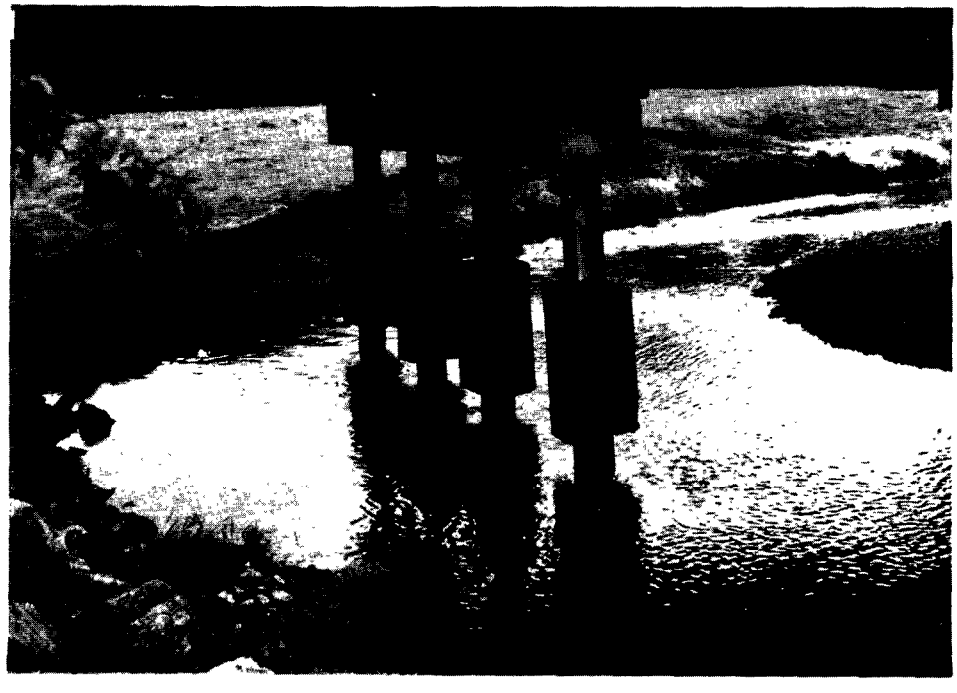
The project will provide the Tennessee State Planning Office and other agencies with baseline data essential for management of agricultural practices and definition of strategies in the "nonpoint sources of pollution" program. The project is under the direction of hydrologist John K. Carmichael.

SEDIMENT CHEMISTRY AT REELFOOT LAKE EVALUATED FOR U.S. FISH AND WILDLIFE SERVICE

The Tennessee District is evaluating the chemistry of sediments in Reelfoot Lake in cooperation with the U.S. Fish and Wildlife Service. Sediments on the lake bottom are potentially a major sink for environmentally hazardous materials, including toxic metals and organic compounds. Should these sediments be dredged in connection with a water-level management program, hazardous constituents could be released into the water column. In November 1988, the U.S. Geological Survey collected sediment cores up to 4 feet in depth at five locations in the lake. Discrete vertical increments from these cores were analyzed for the presence of organochlorine pesticides and priority-pollutant metals. In addition, an elutriate test was performed. For this test, the sediments were mixed with column water, and after a quiescent period, the water was analyzed for dissolved oxygen and toxic metals. Boxplots for lake water before and after the elutriate test will be used to demonstrate the high oxygen demand of the sediments of Reelfoot Lake.

INVESTIGATION OF SCOUR AT BRIDGES THROUGHOUT TENNESSEE

The U.S. Geological Survey in cooperation with the Tennessee Department of Transportation (TDOT) initiated a 2-year statewide study to identify bridges with potential for critical scour of the channel and foundations adjoining the structures. Channel scour at bridges is a severe problem, particularly in West Tennessee where the nature of the soils (wind-deposited loose "loess" material) results in frequent bank failures and channel instability. Numerous studies have produced site-specific solutions for the prediction of scour at bridges. Because many of these solutions have been designed for ideal conditions, there has been considerable debate as to their usefulness for regional types of investigations. The approach for this study includes initial field inspections at about 3,000 state bridges with an overall length greater than 50 feet and with a well defined stream channel crossing. Data are collected over a broad range of disciplines for the purpose of identifying current channel processes and potential instabilities. Bridges are ranked by scour potential and scour-prone bridges studied in more detail. Detailed analyses require additional field-data collection, computer modeling of hydraulics and sediment transport, and further ranking of scour-critical bridges. Benefits of the study are both immediate and long-term. Immediate benefits include the identification of potentially dangerous situations, while long-term benefits involve assisting TDOT with establishing a standard bridge scour modeling approach. Initial inspections at each bridge include obtaining a set of color prints and completing a standard inspection form developed by the Geomorphic and Ecologic Research Unit. Inspection information constitutes the basis for independent comparison of bridges by scour potential. A computer program is utilized to produce a table of composite scour-potential index numbers of the inspected bridges. After identification of the scour-prone sites, data of sufficient detail for modeling is obtained. Modeled bridges are then

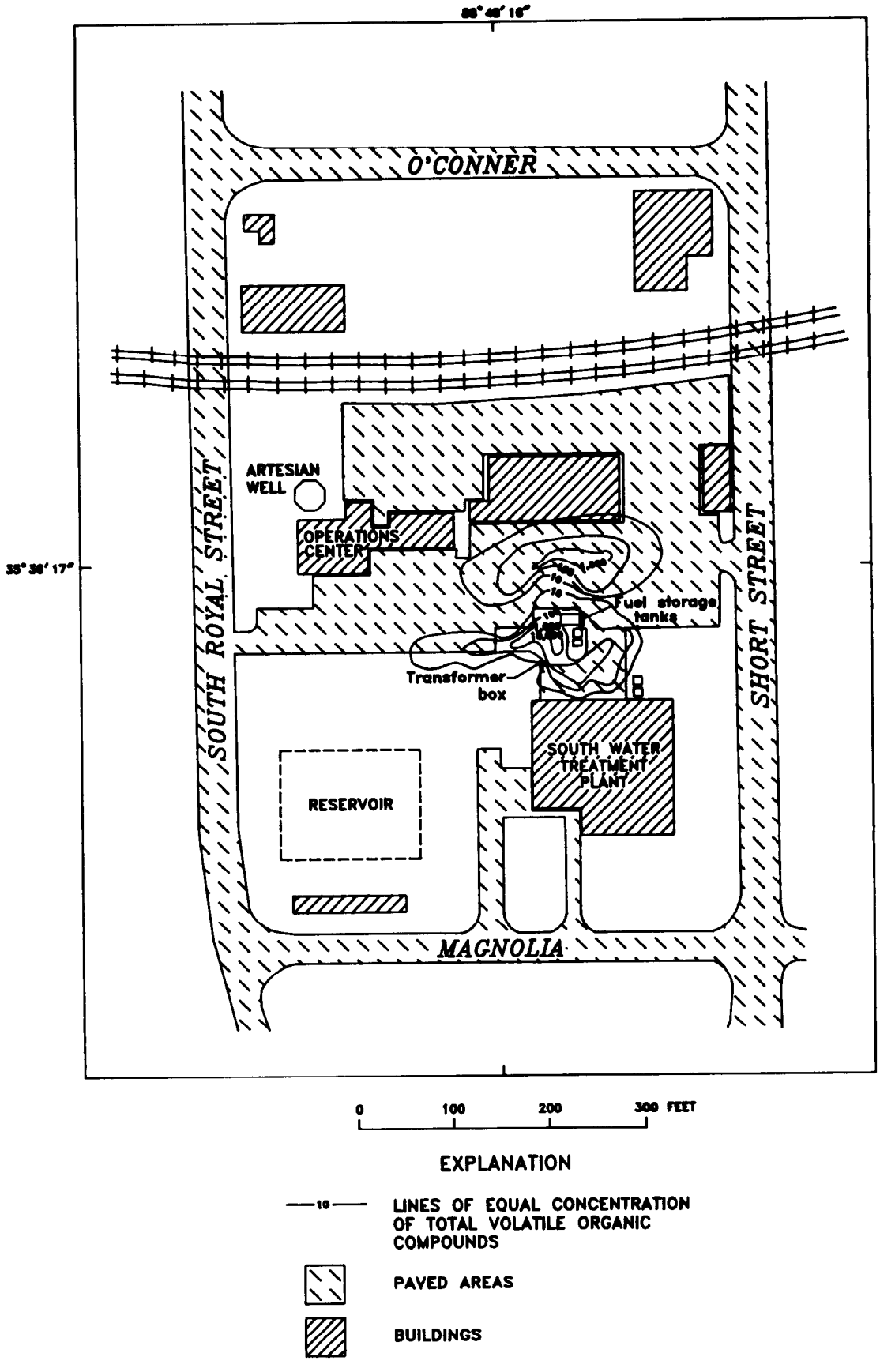


ranked in terms of the estimated depths of scour relative to the design elevations of the bridge pier footings or pile bent depths. The study is proceeding from west to east across the state. Due to the easily eroded sand and silt channels in West Tennessee, this region may develop the largest number of scour-critical bridges. The remainder of the state is likely to have fewer problems due to the presence of bedrock stream channels. The results of the study will be beneficial to TDOT by providing a standard procedure to be utilized when studying the effects of sediment transport on proposed and existing bridges. Benefits also include the identification of problems of an immediate nature affecting Tennessee bridges.

APPLICATION OF SOIL-GAS ANALYSIS FOR DETECTION OF VOLATILE ORGANIC COMPOUNDS AND DELINEATION OF AREAS OF SUBSURFACE CONTAMINATION

Gas chromatography has become an excellent tool for the analysis of soil gases produced by volatile hydrocarbons discharged to the subsurface. Soil-gas techniques are being used to detect the occurrence of contaminants ranging from engine fuels from leaking storage tanks to chlorinated hydrocarbons used as degreasers and discharged into aquifers. Highly sensitive detectors are available for sampling, analyses, and reporting under field conditions.

The U.S. Geological Survey, in cooperation with the Jackson Utility District and the Tennessee Division of Superfund used soil-gas techniques at two sites in the State. In Jackson, leakage from an underground fuel storage tank was investigated. Soil-gas samples were collected indicating the area affected by the leakage. At a State superfund site near Brentwood, the location and distribution of volatile organic compounds was investigated using soil-gas techniques. Samples were collected from the subsoil and from a spring near the hazardous-waste site. In both investigations, the field techniques were valuable and cost effective. Roger W. Lee, hydrologist, was in charge of the projects.



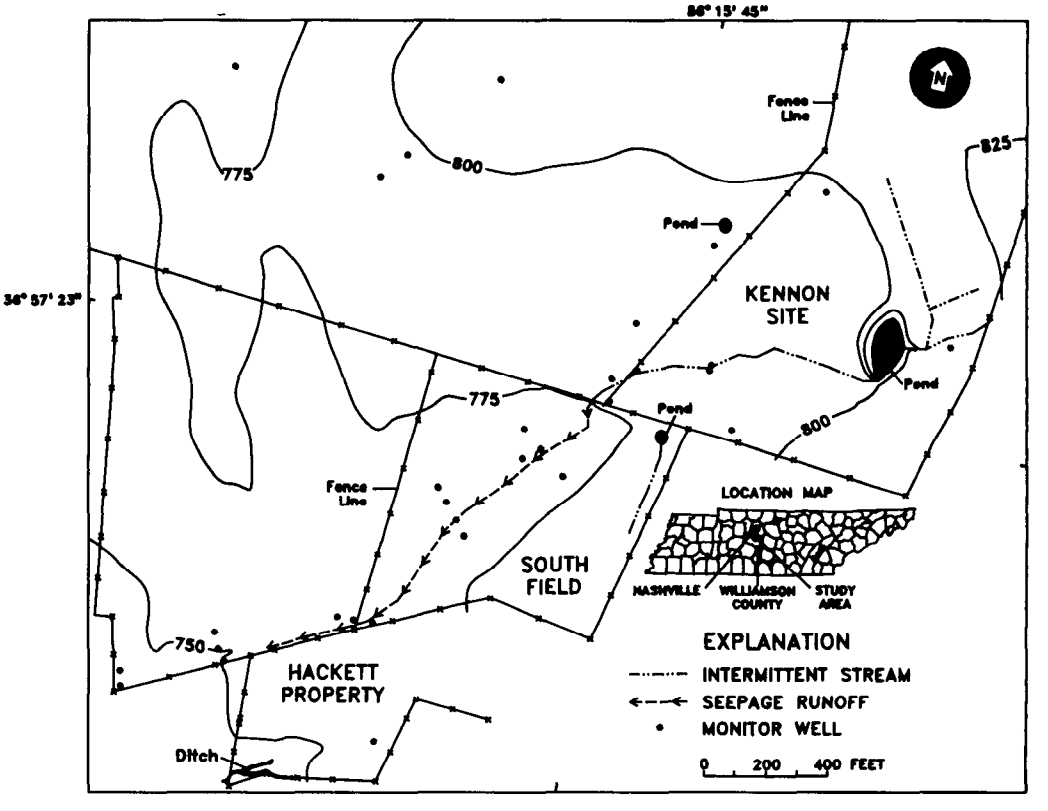
Areal distribution of total volatile organic compounds showing unleaded fuel plume and plume from unknown source in Jackson, Tennessee.

SOURCE OF RECHARGE AND TRANSPORT OF VOLATILE ORGANIC COMPOUNDS TO HACKETT'S SPRING, BRENTWOOD, TENNESSEE

In 1978, approximately 44,000 gallons of industrial wastes were disposed in pits on a farm in Williamson County, Tennessee. The waste products consisted primarily of semi-solid adhesive-process waste containing solvents, hexane, toluene, chloroethylenes, organic fillers, and water-soluble adhesives. These materials were poured into an open pit from a former phosphate strip mine and four excavated trenches.

Preliminary investigations in 1985 by personnel of the Tennessee Department of Health and Environment, Division of Superfund, determined the presence of many of these organic compounds in soil and shallow ground water below the site. Additionally, trichloroethylene (TCE) was detected in water from a spring used as a domestic water supply (R. Bowers, Tennessee Department of Health and Environment, Division of Superfund, personal commun., 1986). Investigations of the geology and hydrogeology of the general area surrounding and including the site were performed by several consultants to determine the potential for vertical and lateral transport of the contaminants from the site. The site was declared a U.S. Environmental Protection Agency Superfund Site in 1984 under the Resource Conservation and Recovery Act (RCRA). Remedial action for removal of the source contaminants and collection of laterally moving leachates from the site is scheduled for late in 1989.

The investigation will determine the source and transport mechanism for contaminants, especially TCE, to Hackett's spring, about one-half mile south of the disposal pits. The approach used for the project involves three principal field methods to locate contaminants and trace their movement from a source to the contaminated spring. The three methods are: (1) field



Kennon site in Williamson County.

determination of volatile organic compounds (VOC) in soil gas and water, (2) field determination of contaminants in water and shallow subsurface hydrogeologic features from a surface electromagnetic survey, and (3) field determination of subsurface pathways of water movement using fluorescein dye. This project is in cooperation with the Tennessee Department of Health and Environment, Division of Superfund, and under the direction of hydrologist Roger W. Lee.

WATER QUALITY IN THE CLINCH AND POWELL RIVERS, EAST TENNESSEE

The U.S. Geological Survey, in cooperation with the Tennessee State Planning Office has begun an investigation to determine the quality of water during periods of high flow of the Clinch and Powell Rivers in East Tennessee. The project is designed to determine differences in the quality of water between upstream and downstream stations at both streams. Headwater stations are located near the Tennessee-Virginia State line. Downstream stations are located at key bridge sites close to the junction of the two streams and at the Tennessee River near Knoxville.

Automatic samplers are installed at the two downstream stations to collect samples during storm events. Samples will be analyzed for common ions, nutrients, selected trace elements, suspended sediment, and bacteria. Manual samples will be collected at the upstream sites during storm events. The suspended-sediment and nutrients data, in conjunction with continuous streamflow information, will be used to estimate annual loadings at both streams.

INVESTIGATION OF THE OCCURRENCE OF RADIONUCLIDES IN GROUND WATER FROM HICKMAN AND LEWIS COUNTIES, TENNESSEE

Black shales and phosphate ore-bearing limestones in Hickman and Lewis Counties in Middle Tennessee contain potential radionuclide sources. The U.S. Geological Survey, in cooperation with the Tennessee Department of Health and Environment (TDHE), Office of Groundwater Protection, is conducting a survey of the occurrence of radon-222 and other radionuclides in ground water in Hickman and Lewis Counties. Objectives are to:

- Describe the variation in water chemistry and concentrations of radionuclides
- Investigate the effects of varied hydrogeologic and geochemical environments in the occurrence of radionuclides
- Investigate potential associations of chemical constituents and radionuclides

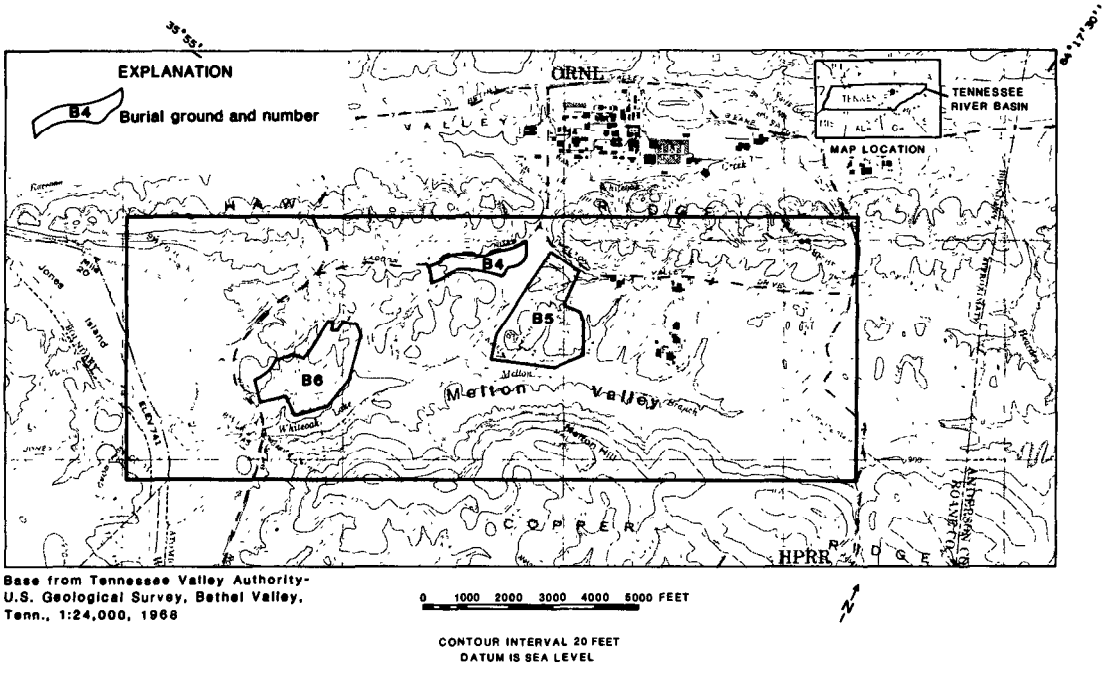
Ground water from 40 wells associated with black shales and phosphatic limestones will be sampled during the investigation. The geochemistry and distribution of radionuclides including radon-222 gas will be determined. This one year project is being conducted by hydrologists Gregg Hileman and Roger Lee in collaboration with hydrologist Don Rima from the TDHE.

HYDROGEOLOGY OF RADIOACTIVE-WASTE BURIAL GROUNDS AT THE OAK RIDGE NATIONAL LABORATORY

The ground-water and surface-water systems are being studied for an area at the southeastern end of the Oak Ridge National Laboratory called Melton Valley, in cooperation with the U.S. Department of Energy. The objective of the study is to provide hydrologic information that will be used to refine the water-quality monitoring network in the valley. Radioactive waste was buried in shallow trenches at three areas of the valley from 1951 to the present. Waste radionuclides have been transported by ground water and discharged to local tributaries of the Clinch River. Whiteoak Creek is the principal local stream. The investigation began in 1975 and will be completed in 1989.

Surface water and ground water are sampled by Oak Ridge National Laboratory to determine source and concentration of radionuclide leakage from the burial grounds, and to evaluate possible health risks from the leakage. A lack of detailed hydrologic information, particularly on ground-water flow at depths greater than about 100 feet, has limited accurate location of some sampling points.

Geologic, subsurface and surface-geophysical, water-level, hydraulic, stream-discharge, precipitation, and water-quality data were collected to meet the objective of the study. Drilling logs from 500 shallow wells were used to determine thickness of the weathered-rock regolith, which covers the hills in the area and is the uppermost aquifer in the ground-water flow system. About 200 feet of rock cores from each of 4 sites provided local geologic information. Subsurface geophysical logs were used to determine geologic contacts, and surface geophysical methods provided information on hydrologic boundaries at areas with no well information. Continuous water-level data from 65 wells, and periodic water-level data from 400 wells, were used to determine directions of



Study area and location of burial grounds.

ground-water flow and magnitude of hydraulic gradients. Slug tests of 26 wells provided hydraulic-conductivity values. Stream-discharge and precipitation data were used to determine streamflow characteristics and approximate annual ground-water recharge based on percent of precipitation. Water-quality data were used as an aid in describing ground-water flow and hydrologic boundaries. The USGS "Geographic Information System" is used for construction of base and hydrogeologic maps, and for data-base management. Harold H. Zehner, hydrologist at the Knoxville Subdistrict, is the project chief.

RESEARCH EXAMINES BEHAVIOR OF ORGANOCHLORINE PESTICIDES IN GROUND WATER

The Tennessee District, in cooperation with the Environmental Health and Toxicology Research Institute at Memphis State University, is engaged in research to determine the potential mobility of organochlorine pesticides in ground water. The work is being coordinated with a hydrogeologic investigation at the North Hollywood Dump in Memphis, which is the State's top-ranked Superfund site. The potential movement of pesticides from the dump and through the local aquifer is a function of the solubility, sorptive behavior, and persistence of these compounds. Experimental results to date indicate that chlordane, a representative organochlorine pesticide, has limited potential for migration in ground water. Chlordane adheres to soils, sediments, and other geologic materials. At any given time most of the chlordane in a contaminated ground-water system will adhere to aquifer solids, and its mobility will be much slower than the velocity of the ground water. The results of incubations of chlordane for 6 months in aerobic and anaerobic microcosms suggest that the compound degrades very slowly, if at all, under simulated aquifer conditions. Thus, although chlordane mobility may be retarded, the pesticide will probably persist in the aquifer for a long period. The research is being conducted by Dr. Linda Logan and Dr. Stephen J. Klaine at Memphis State University. Dr. Robert E. Broshears of the USGS coordinates their work with the investigation at the North Hollywood Dump.

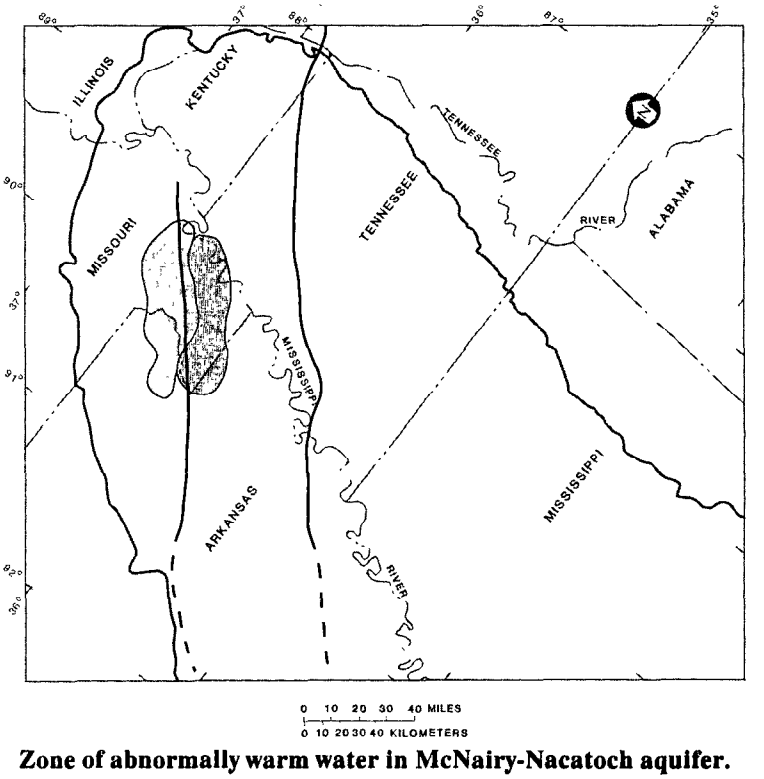
REGIONAL AQUIFER-SYSTEM ANALYSIS OF AQUIFERS IN WEST TENNESSEE

An ongoing study of the regional aquifers of West Tennessee and the northern Mississippi embayment is nearing completion. As part of the federally funded Gulf Coast Regional Aquifer-System Analysis (GC RASA) project, the Tennessee subproject has two remaining objectives: (1) a compilation of atlas-style reports describing the geology and hydrology of the Cockfield Formation, the Memphis Sand, and the Fort Pillow Sand within West Tennessee, and (2) a regional study describing the hydrology of the McNairy-Nacatoch and related aquifers in the northern Mississippi embayment.

Hydrologist William S. Parks of the Memphis Subdistrict is responsible for the first objective, and hydrologist John Van Brahana of Nashville is responsible for the second. Results from their studies have provided insight into the geologic framework, ground-water flow, and water quality in the Tertiary and Cretaceous aquifers, including:

- The tectonic framework of the northern Mississippi embayment influences younger, nonindurated sediments. Faulting affects aquifers and confining layers, and is thought to focus interaquifer leakage at some locations
- With the exception of the Memphis Sand in the Memphis area, the aquifers are virtually untapped and all aquifers have much potential for future use
- Newly developed age dating techniques using radioisotopes of tritium, carbon-14, and chlorine-36 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.

Major accomplishments included publication of (1) flow-modeling results, (2) documentation of hydrologic interpretations, (3) tables of data collected especially for this study, and (4) numerous abstracts for professional meetings summarizing significant conclusions. Three atlas reports and a potentiometric map have received Director's approval and are awaiting publication, and five interpretive reports are in review. New research techniques being used in this study hold promise for widespread application to hydrologic problems in other areas of similar hydrogeology.



Zone of abnormally warm water in McNairy-Nacatoch aquifer.

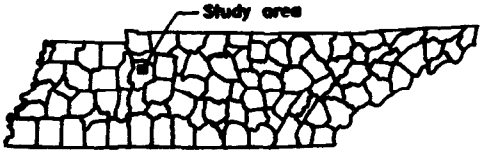
GEOHYDROLOGY OF DEEPLY BURIED ROCKS IN THE WESTERN HIGHLAND RIM OF TENNESSEE

A well to conduct a geohydrologic survey of deeply buried rocks in Humphreys County, West Tennessee, is being drilled by E.I. DuPont De Nemours Co. The well will eventually reach a depth of about 8,500 feet. The U.S. Geological is participating in the study in cooperation with Humphreys County.

Continuous cores are collected and hydrologic tests are conducted on each aquifer and confining layer encountered in drilling. Coring has progressed to about 2,400 feet below land surface. The results of the tests, water-quality analyses, and examination of the cores will be used to determine the hydrology of the deep formations in the area. This will provide insight into regional ground-water flow systems and geochemical processes.

Drill site preparation began in December 1987. The drilling rig was erected and coring began in late February 1988. The first formation cored was the Mississippian-age Fort Payne Limestone Formation. Coring has averaged about 12 feet per day, but is extremely slow when dense chert layers are encountered. Deeper units that have been cored and tested include the Chattanooga Shale, Devonian limestones, Silurian limestones and shales, the Hermitage Formation, and the Carters and Lebanon Limestones. Approximately 24 separate zones will be tested to determine their hydrologic characteristics.

Small amounts of water were produced by the well during the initial tests. The Fort Payne Formation and the Chattanooga Shale were the highest yielding zones. The Fort Payne Formation produced about 0.3 gallons per minute over a 21-day test with a specific capacity of 0.0024 gallons per minute per foot of drawdown. The Chattanooga Shale underlining the Fort Payne Formation was cored from 250 to 284 feet below land surface. This zone was pumped at a rate of 0.3 gallons per minute and had a specific capacity of 0.0034 gallons per minute per foot. The project is directed by hydrologist Mike Bradley.

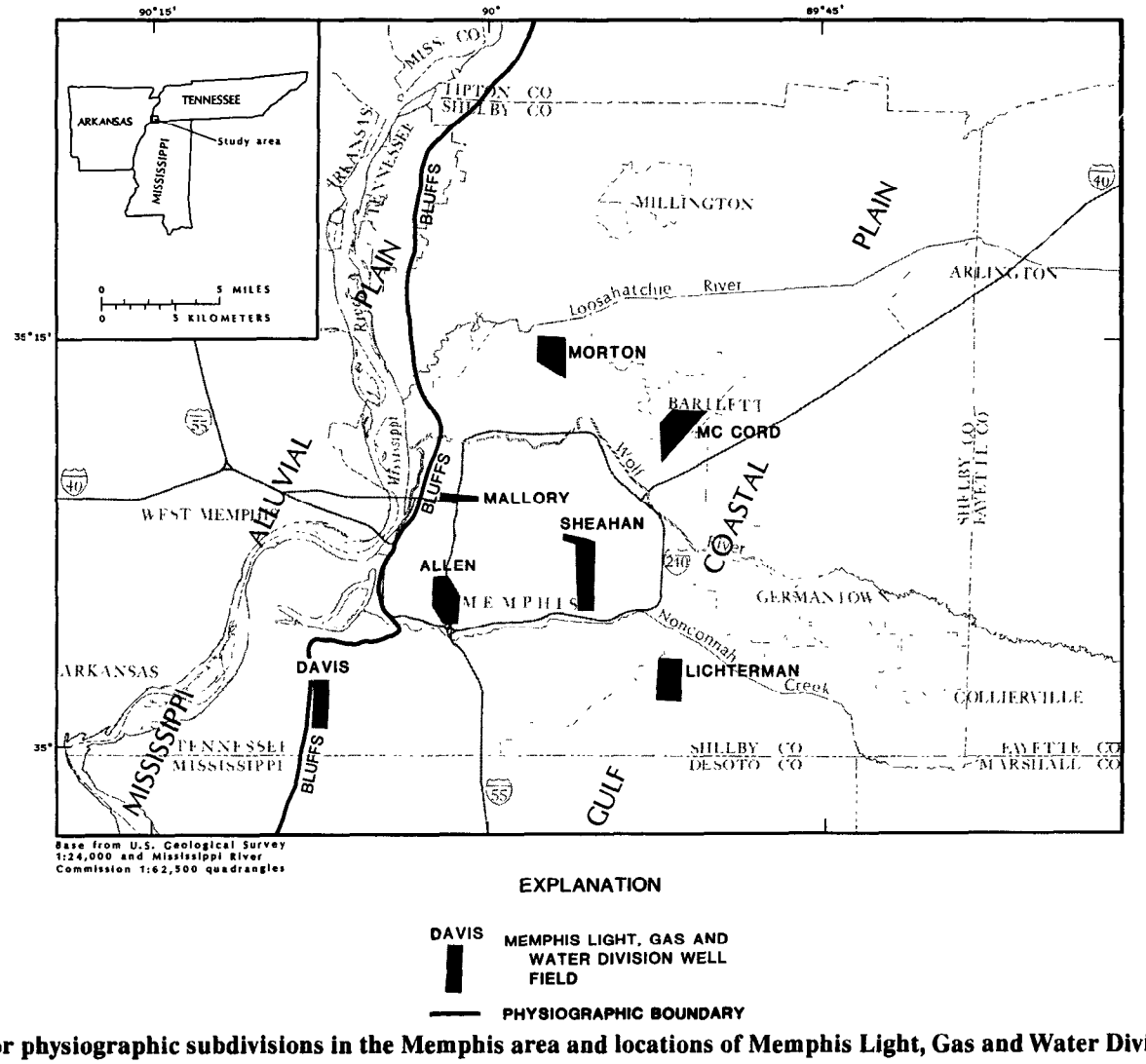


Location of Humphreys County study area and drill site.

PRELIMINARY ASSESSMENT OF THE POTENTIAL FOR CONTAMINATION OF THE MEMPHIS SAND AQUIFER IN THE MEMPHIS AREA, TENNESSEE

The City of Memphis and most of Shelby County depends entirely on the Memphis Sand aquifer for water supply. Traditionally, the Memphis Sand has been thought of as an ideal artesian aquifer overlain by a thick, impermeable clay bed that serves as the upper confining layer and protects the aquifer from contamination from near surface sources. Studies, however, have shown that the confining layer locally is thin or absent, or it contains sand "windows" that could provide "pathways" for contaminants to reach the Memphis Sand aquifer. Studies also have shown that downward leakage occurs from the water-table aquifers (alluvium and fluvial deposits) to the Memphis Sand aquifer.

The U.S.Geological Survey, in cooperation with the Memphis Light, Gas and Water Division (MLGW) of the City of Memphis is conducting preliminary assessment of the potential for contamination of the Memphis Sand aquifer in the Memphis area. Potential sources of contamination will



Major physiographic subdivisions in the Memphis area and locations of Memphis Light, Gas and Water Division well fields. (Modified from Brahana and others, 1987).

be identified and their location relative to direction of ground-water flow and thickness of the confining layer separating the water-table aquifers from the Memphis aquifer. Hydrologist William S. Parks from the Memphis Subdistrict office, is the project leader.

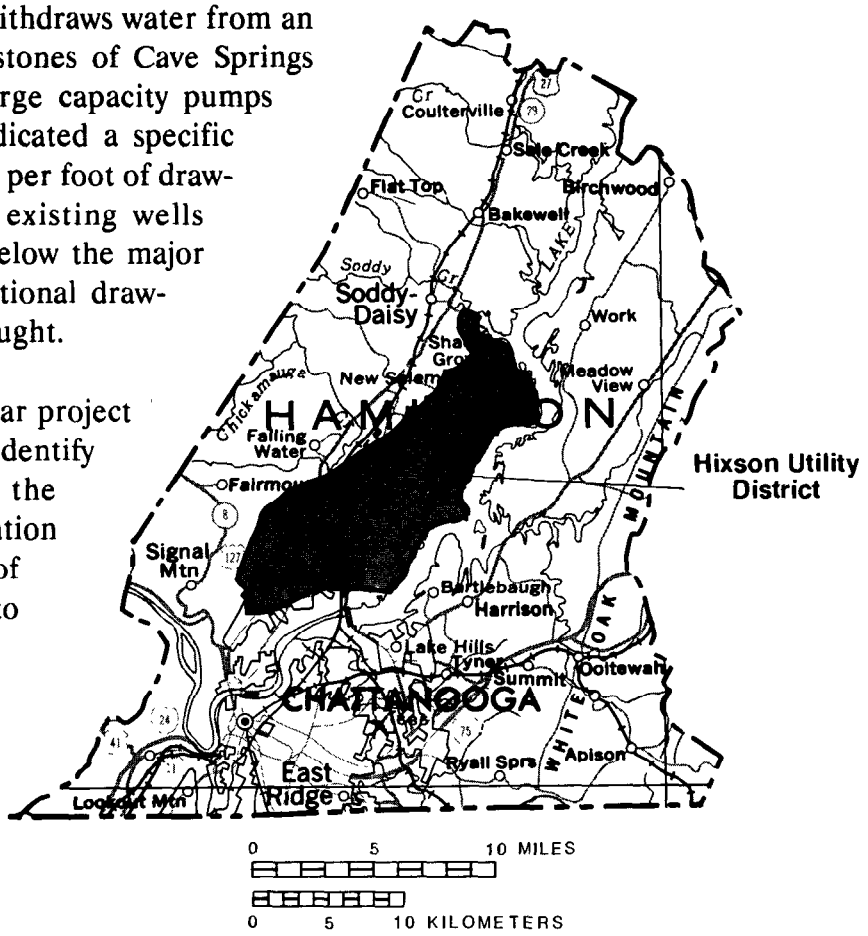
WATER-SUPPLY POTENTIAL OF THE GROUND-WATER SYSTEM OF THE HIXSON UTILITY DISTRICT, HAMILTON COUNTY

In cooperation with the Hixson Utility District (HUD), the U.S. Geological Survey is conducting an appraisal of the availability of ground-water in the HUD service area. Objectives are to:

- Provide a conceptual model of the ground-water reservoir and its recharge area
- Assist the HUD in augmenting their water supply by locating additional wells at facilities at Cave Springs
- Locate additional sources of water within the HUD service area

The utility district currently withdraws water from an extensive cave system in the limestones of Cave Springs Ridge. Aquifer tests using the large capacity pumps operated by the utility district indicated a specific capacity of 2,800 gallons per minute per foot of drawdown. Additional drilling near existing wells revealed more solution openings below the major cave system that will provide additional drawdown capacity during periods of drought.

The second phase of this 2-year project includes a seepage investigation to identify streams that are losing water to the ground-water system. This information along with a potentiometric map of the ground-water table will be used to select areas that may provide auxiliary water supplies in the HUD service area. The project is under the direction of hydrologist Arthur Bradfield and is scheduled for completion in late 1989.



Location of the Hixson Utility District in Hamilton County, Tennessee.

DEVELOPMENT OF GROUND-WATER RESOURCES IN THE EASTSIDE UTILITY DISTRICT

The Chattanooga-Eastside Utility District is one of the larger utilities in the State, supplying 3 to 4 million gallons of water per day to 26,000 customers in southeastern Hamilton County. Since 1936, Eastside has obtained its water supply from Carson Spring, which historically has had a discharge ranging from a low of 2 million gallons per day to an unknown high, and from wells nearby.

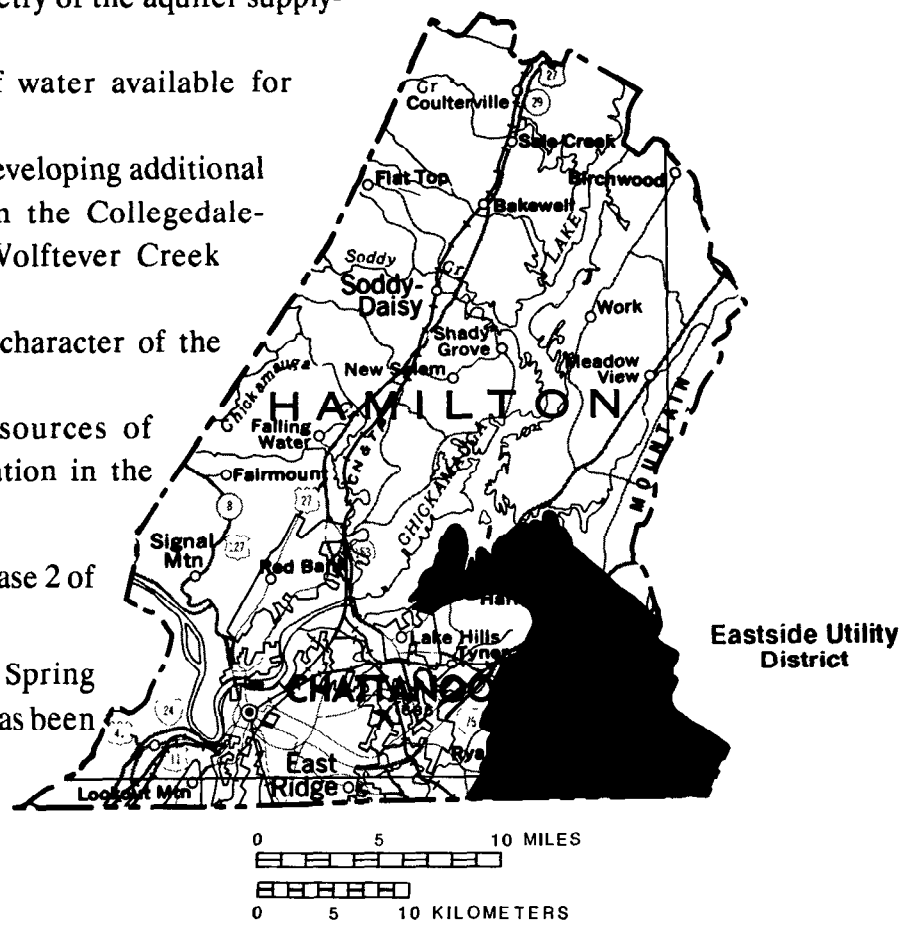
As the population in Eastside's service area has grown, the demand for water has increased to the level where it taxes available supplies during peak hours of use. The U.S. Geological Survey, in cooperation with the Eastside Utility District, is continuing an investigation of the ground-water potential of the Carson Spring drainage basin and part of the adjacent Wolftever Creek drainage basin.

Objectives of the study are to:

- Determine the average daily flow and seasonal variations in the daily flow from Carson Spring
- Define the size and geometry of the aquifer supplying the spring
- Estimate the amount of water available for withdrawal
- Assess the potential for developing additional ground-water supplies in the Collegedale-Ooltewah area of the Wolftever Creek drainage basin
- Document the chemical character of the ground water
- Identify non-domestic sources of ground- water contamination in the Carson Spring watershed

During the initial part of Phase 2 of this investigation,

- Discharge from Carson Spring and pumpage from wells has been monitored
- A new production well yielding 2,000 gallons per minute was drilled, logged, tested, and sampled



Location of Eastside Utility District in southeastern Hamilton County, Tennessee.

- A potentiometric map showing hydraulic gradients and boundaries of the recharge area, where definable, was prepared for the fall 1988 period
- Documented sources of nondomestic ground-water contamination within the watershed were identified

The project leader is David Webster, hydrologist.

GROUND-WATER AVAILABILITY IN THE WEBB CREEK AREA, SEVIER COUNTY

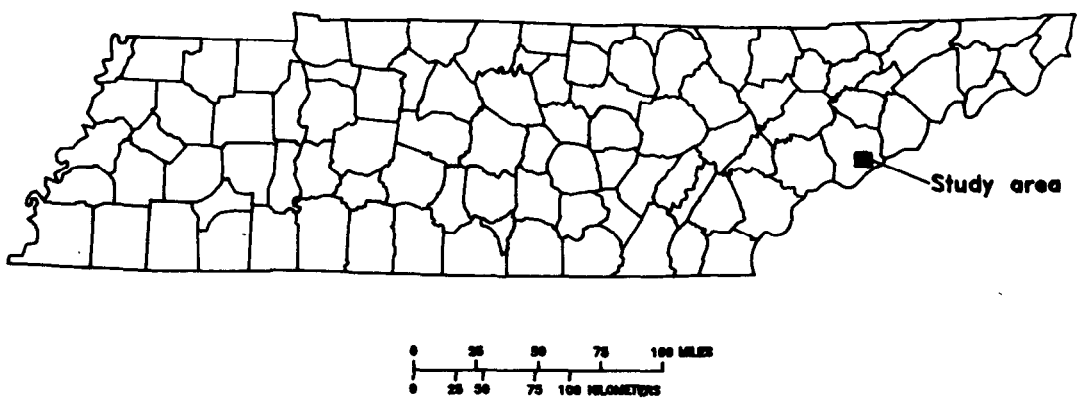
In cooperation with the Webb Creek Utility District, a study was completed of the ground-water resources of Greenbrier Valley on the northern flank of the Great Smoky Mountains National Park. The purposes of the project were to:

- Define the occurrence and movement of ground water in the Greenbrier Valley area
- Identify areas of higher ground-water yields to wells as a potential supply source

Six candidate sites were selected for exploratory drilling, based on the following:

- Low-flow seepage investigation of Webb Creek
- High-altitude photography
- Geologic structure and characteristics of the geologic materials underlying the valley
- Results of previous investigations in the Blue Ridge terrane

Three exploratory wells were drilled to depths of about 300 feet each at one site, located on the toe of an alluvial fan close to the National park boundary. It was found that the alluvium at each site was dry, following four consecutive years of drought. Yields of 7, 11, and 27 gallons per minute were derived from poorly developed fracture networks in the metasiltstone bedrock. Field conductivities of water from each well were less than 100 microsiemens per square centimeter, reflecting overall excellent quality. The relatively low yields of the test wells precluded development and prompted the termination of the project. David Webster, hydrologist, was the project leader.



Location of Webb Creek Utility District study area in Tennessee.

EFFECTS OF STORM-WATER RUNOFF ON LOCAL GROUND-WATER QUALITY, CLARKSVILLE, TENNESSEE

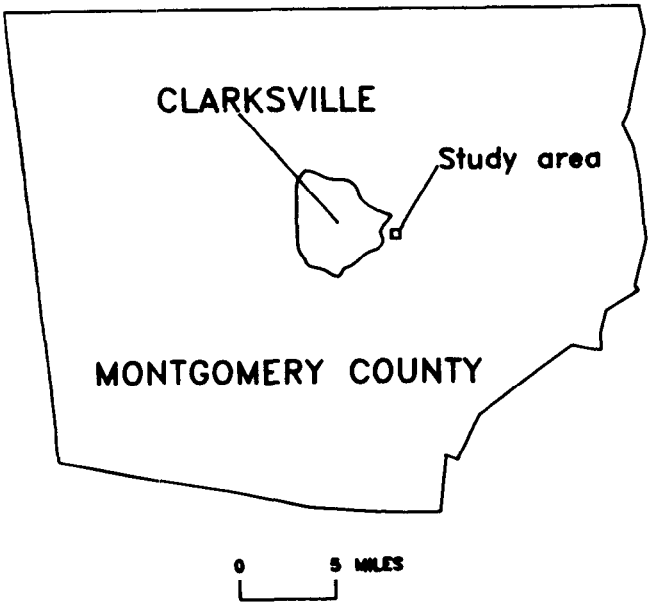
Storm-water runoff from urban areas has been recognized as a source of contamination to receiving surface- and ground-water bodies. In many karst areas, drainage wells have been installed to accept storm-water runoff from urban areas in order to reduce surface flooding. This diversion can introduce contaminants into the ground-water system, and thus alter the quality of ground water downgradient from drainage wells.

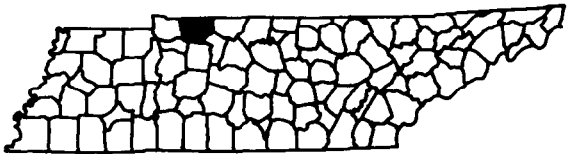
In 1987 the U.S. Geological Survey, in cooperation with the Tennessee Department of Health and Environment, Division of Construction Grants and Loans, began a 15-month investigation of the impacts to ground-water quality from diverting urban runoff to drainage wells. The rapidly urbanizing area of Clarksville was selected as the site for this investigation. Specific objectives of the study were to:

- Characterize the quality of urban storm-water runoff entering a selected drainage well
- Characterize the quality of the receiving ground-water body, during base flow as well as stormflow conditions
- Estimate the storm-loading rates of selected constituents to the local ground water from runoff entering the drainage well

Evaluation of the impact on local ground water caused by storm-water runoff is complicated by the presence of other sources of contaminants in the area.

Concentrations and loads of most constituents in storm-water runoff at a station near the Clarksville Hospital were much lower than concentrations and loads at the Mobley Spring station. This suggests that the principal loads of these constituents originate either from natural sources, or from some other source(s) of contamination in the ground-water basin. Exceptions are for constituents detected at the sites associated with roadway runoff, including arsenic, copper, lead, organic carbon, and oil and grease. Data indicates that the Hospital Sinkhole watershed may be contributing relatively large amounts of these constituents to local ground water during storms. The





Location of study area near Clarksville, Tennessee.