DROUGHT-RELATED IMPACTS ON MUNICIPAL AND MAJOR SELF- SUPPLIED INDUSTRIAL WATER WITHDRAWALS IN TENNESSEE--PART A

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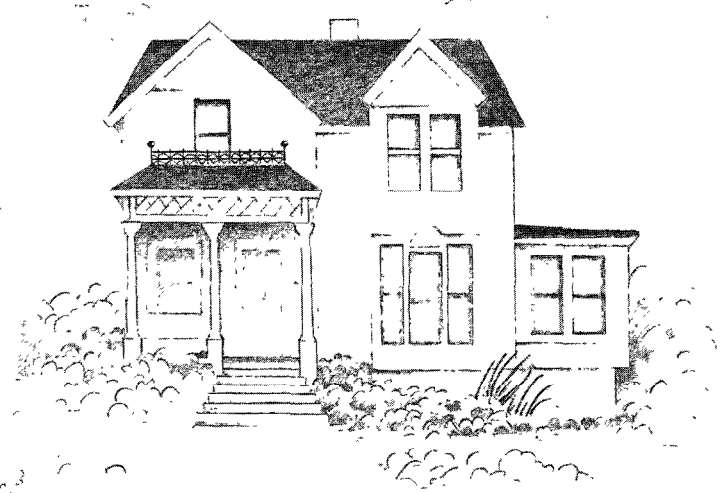

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in cooperation with
TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT, *Division of Water Management*
TENNESSEE VALLEY AUTHORITY, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Regional Water Management Program

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By Frank M. Alexander and Lee A. Keck, TDWM; Lewis G. Conn, USGS; and Stanley J. Wentz, TVA

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OFFICE OF NATURAL RESOURCES AND ECONOMIC DEVELOPMENT,

DIVISION OF AIR AND WATER RESOURCES,

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
gallon per day (gal/d)	0.0038	cubic meter per day (m^3/d)
million gallon per day (Mgal/d)	3,785	cubic meter per day (m^3/d)
square mile (mi^2)	2.590	square kilometer (km^2)

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EXECUTIVE SUMMARY

Introduction

Adequate supplies of good quality water are essential for Tennessee's continued economic growth and development, maintenance of a high-quality environment, and social well-being. While Tennessee is generally characterized as a water-rich State, the supply of water varies not only seasonally and from year to year, but also from place to place. People remember years with an extreme abundance of rainfall as "wet" years. At the other end of the spectrum, people also remember "dry" years when they were not blessed with sufficient water to meet established basic needs. Given this fact, public water-supply systems and large, self-supplied commercial and industrial water users need to be aware of the potential impacts an extended drought may have on their livelihood and lifestyle. During the past decade, many of these users have encountered periodic water-supply shortages during severe and (or) extended drought periods.

This summary provides an overview of the results and findings of a joint cooperative study effort by the Tennessee Division of Water Management, Tennessee Valley Authority, U.S. Army Corps of Engineers, and U.S. Geological Survey to evaluate existing water use and supply relations in Tennessee for all public water-supply systems and those self-supplied water users whose average daily withdrawal is equal to or greater than 100,000 gallons per day. The study was undertaken to complement, in part, the water law and policy studies requested by the Ninety-Second Tennessee General Assembly in response to concerns identified by Tennessee's Safe Growth Plan and a special joint committee established by the Ninety-First Tennessee General Assembly regarding the adequacy of the State's water resources to meet needs during the late 1980's from both a quantity and quality standpoint.

Study Goals and Objectives

The study's primary goals were to (1) provide Tennessee decisionmakers with pertinent information and data relative to existing water-use and supply availability for municipal and large, self-supplied commercial and industrial water users in Tennessee and (2) outline some broad, general conclusions and alternatives for decisionmakers' consideration in developing and implementing a viable program for dealing with water-supply shortages, particularly those which are quantity-related. Specific study objectives were to:

1. Develop current information and data for public water-supply systems and self-supplied users relative to existing water use; supply sources; source capacity; population served; treatment plant and storage capacities; and water-supply, particularly quantity-related, problems.

2. Evaluate and categorize each of these systems and user's ability to meet their current average daily water use or withdrawal according to selected categories denoting each system or user's source of water; existence or lack of adequate impoundment facilities to meet the anticipated 90-day demand; base streamflow adequacy; and ground-water availability. Essentially this resulted in these systems and users being categorized into three basic groups: those whose supply is adequate to meet average daily use, those whose supply is inadequate to meet average daily use, and those whose supply capacity is unknown.

3. Identify specific public water-supply systems and large, self-supplied users which are not experiencing or have the potential for experiencing serious water-supply quantity-related shortages, particularly during times of drought.

4. Discuss in broad, general terms the potential economic, environmental, and social implications of a severe and (or) extended drought on public water systems and self-supplied users.

5. Outline some possible alternatives for consideration by decisionmakers at all levels of government in formulating and implementing viable programs for resolving or alleviating, to the extent possible, water-supply shortages be they drought induced or otherwise.

Water use for power generation, agriculture, mining, self-supplied domestic and instream uses such as navigation and recreation were not included in this study because of strict time and budgeting limitations. It also should be noted that there are many self-supplied commercial and industrial users in Tennessee whose average daily water withdrawal is less than 100,000 gallons per day that could be adversely impacted by severe or extended drought conditions.

Basic Study Findings and Conclusions

Basic information and data compiled through this study along with the pertinent study results and findings are summarized on the following pages. More detailed information and data regarding existing water-use and supply relations for municipal and self-supplied commercial and industrial water users are provided in the main report by river basin for each of the State's 13 major river basins as delineated in figure 1. For the purpose of this summary, basic data and information relative to water use and supply are presented by the State's three major hydrologic regions as delineated below:

- Ohio region consisting of the Lower Cumberland and Upper Cumberland River basins.
- Mississippi region consisting of the Hatchie River basin, the Memphis Area basin, and the Obion-Forked Deer River basin.
- Tennessee Valley region consisting of the Clinch, Duck-Buffalo, Elk-Shoal, French Broad, Holston, Lower Tennessee, Upper Tennessee, and the Tennessee River Western Valley basins.

General study findings and conclusions include the following:

1. Currently, there are 463 public water-supply systems in Tennessee serving about 3,814,000 people or 83 percent of the State's 1980 census population

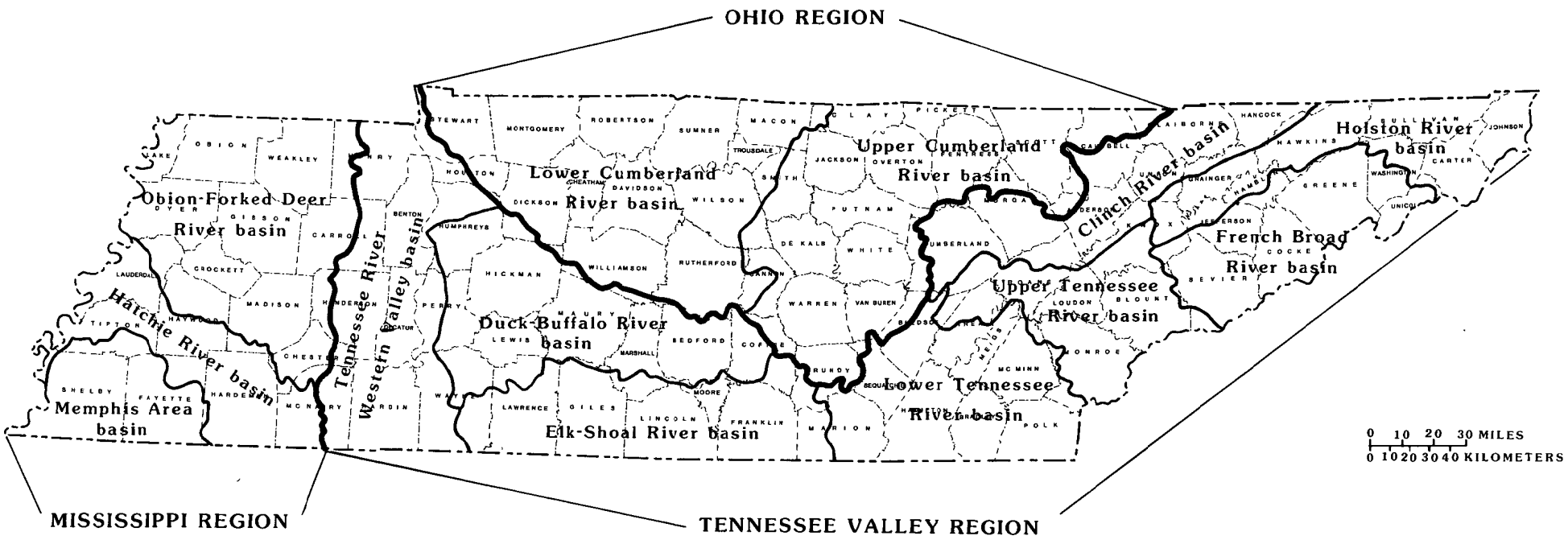

Figure 1.--Major hydrologic regions and river basins in Tennessee.

of 4,590,937. In addition, there are 129 large, self-supplied commercial and industrial water users with all but four of these being located in the Mississippi and Tennessee Valley regions. Table 1 provides basic information and data about each basin's drainage area; 1980 population and employment for county-boundary approximations of each river basin; number of public water-supply systems including the population served and large, self-supplied water users; average daily water withdrawal for each purpose; and consumptive water use by self-supplied water users.

2. Total water withdrawal for public water-supply systems in Tennessee equals about 566.1 million gallons per day (Mgal/d) of which approximately 346.8 Mgal/d, or 61 percent, is withdrawn from surface-water sources and 219.3 Mgal/d, or 39 percent, from ground-water sources. In the Mississippi region all public water supplies are served by ground-water sources compared to 3 and 19 percent in the Ohio and Tennessee Valley regions, respectively. Total water withdrawal by source of supply and major river basin for public water-supply systems in Tennessee is shown in figure 2.

3. Total average daily water withdrawal by large, self-supplied commercial and industrial water users in Tennessee equals approximately 1,106.7 Mgal/d of which 1,006.8 Mgal/d, or 91 percent, are withdrawn from surface-water sources and 99.9 Mgal/d, or 9 percent, from ground-water sources. In the Ohio region, 100 percent of all water for large, self-supplied users is supplied by surface-water sources compared to 6 and 98 percent in the Mississippi and Tennessee Valley regions, respectively. Consumptive water use, that is water which is not returned to a natural source, for large, self-supplied water users in Tennessee equals about 18.74 Mgal/d of which 71 percent occurs in the Tennessee Valley region. Total water withdrawal by source of supply and major river basin for self-supplied users in Tennessee is shown in figure 3.

4. A total of 172 water-supply, quantity and quality-related, problems were reported by various public water-supply systems and large, self-supplied water users. Basic problem types or categories and the number of times each problem was identified or reported are shown in table 2. Four types of problems: turbidity (44); inadequate storage capacity (26); water shortages during drought or low-flow periods (25); and excessive water losses due to faulty mains and distribution lines (15) account for 110, or 64 percent, of the 172 reported water supply-related problems. Currently, 107 public water-supply systems and 23 self-supplied water users are experiencing one or more of the problems summarized in table 2. The location of specific public water-supply systems and large, self-supplied users which are experiencing these problems are shown in figures 4 and 5, respectively.

5. Analysis of the State's public water-supply systems for which recent water use and supply data are available indicates that 85 systems or communities in the Ohio (25) and Tennessee Valley (60) regions are wholly or partially dependent on surface- and (or) ground-water sources whose long-term, reliable source capacity is either unknown, equal to, or less than 10 percent greater than the systems' average daily use. Similarly, 39 large, self-supplied water users, all in the Tennessee Valley region, face a similar situation in regard to their source of supply. In addition, some 41 public water-supply systems in the Ohio (10) and the Tennessee Valley (31) regions

Table 1.--Demographic and water-use data for major river basins in Tennessee

Water resource region and river basin	Drainage area (mi^2)	1980 Demographic data		Number of water users			Average daily water withdrawal (Mgal/d)		Consumptive water use (Mgal/d)
		Population	Employment	Public supply systems and population served		Large self-supplied users	Public supply systems	Self-supplied users	
Mississippi region									
Hatchie River basin	2,260	124,018	44,202	20	68,000	3	9.2	3.9	0.06
Memphis Area basin	1,559	802,418	272,171	19	666,000	27	125.1	61.4	1.31
Obion-Forked Deer River basin.	4,568	287,761	117,536	54	228,000	10	29.7	18.7	0.26
Subtotal	8,378	1,214,197	433,909	93	962,000	40	164.0	84.0	1.63
Ohio region									
Lower Cumberland River basin.	5,599	989,518	433,928	60	815,000	3	119.6	40.5	3.80
Upper Cumberland River basin.	5,505	205,106	61,043	48	162,000	1	18.4	0.8	1.01
Subtotal	11,104	1,194,624	494,971	108	977,000	4	138.0	41.3	3.81
Tennessee Valley region									
Clinch River basin	2,612	190,738	64,536	30	188,000	3	16.3	13.5	0.50
Duck-Buffalo River basin.	3,500	167,982	65,655	33	161,000	14	23.1	48.2	2.50
Elk-Shoal River basin	3,041	121,711	37,734	37	88,000	10	12.7	65.4	2.90
French Broad River basin.	2,298	172,278	55,945	22	145,000	15	17.9	28.5	1.40
Holston River basin	2,253	406,475	155,546	54	371,000	11	51.8	552.9	1.20
Lower Tennessee River basin.	3,029	484,932	221,189	39	451,000	18	69.0	177.5	2.30
Upper Tennessee River basin.	2,148	503,142	202,833	23	386,000	5	64.2	4.1	0.20
Tennessee River Western Valley basin.	3,664	134,858	43,324	24	85,000	9	9.1	91.3	2.30
Subtotal	22,545	2,182,116	846,762	262	1,875,000	85	264.1	981.4	13.30
State total	42,027	4,590,937	1,775,642	463	3,814,000	129	566.1	1,106.7	18.74

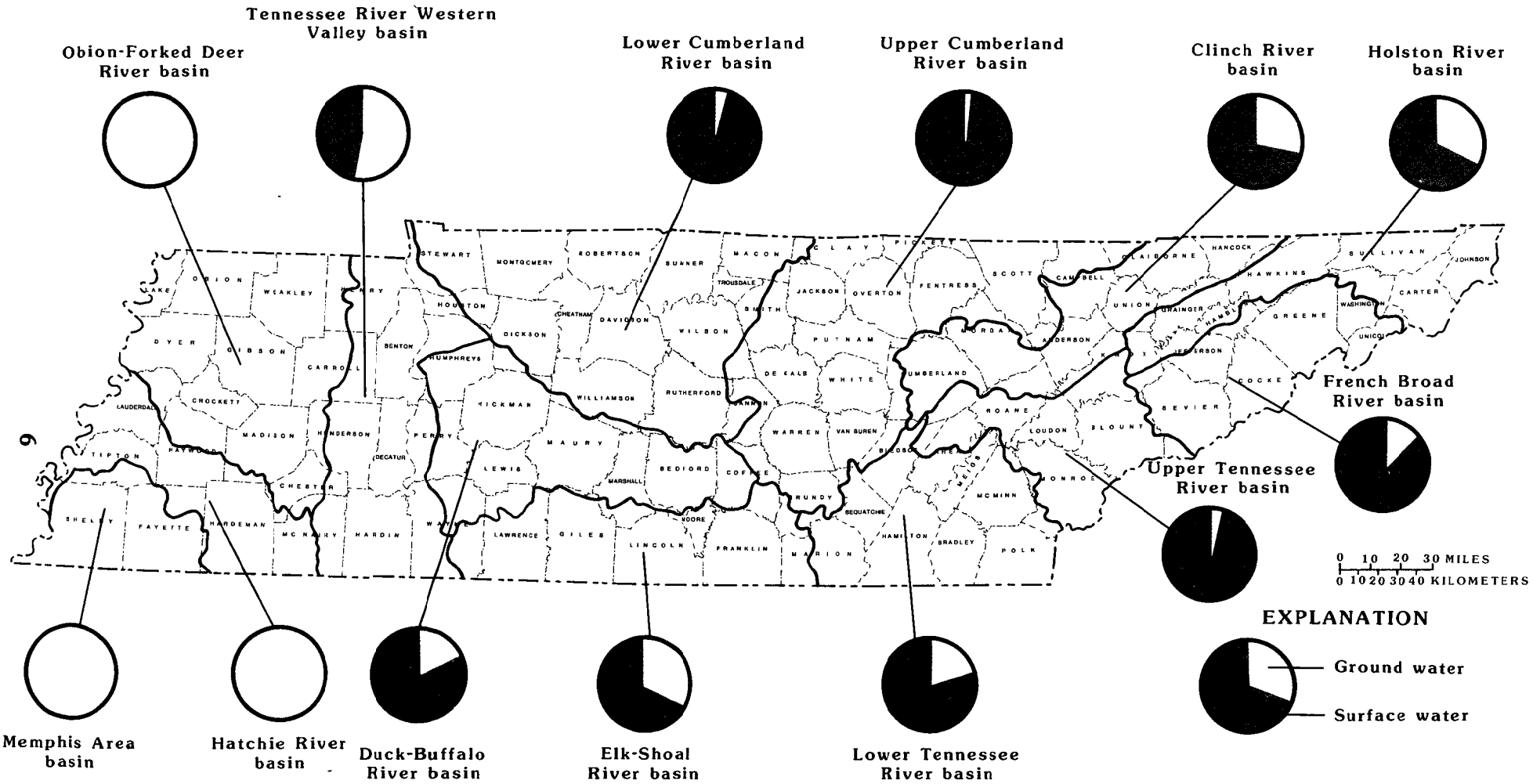

Figure 2.--Surface-water and ground-water withdrawal by public water-supply facilities during 1981 in the 13 major hydrolgic basins of Tennessee.

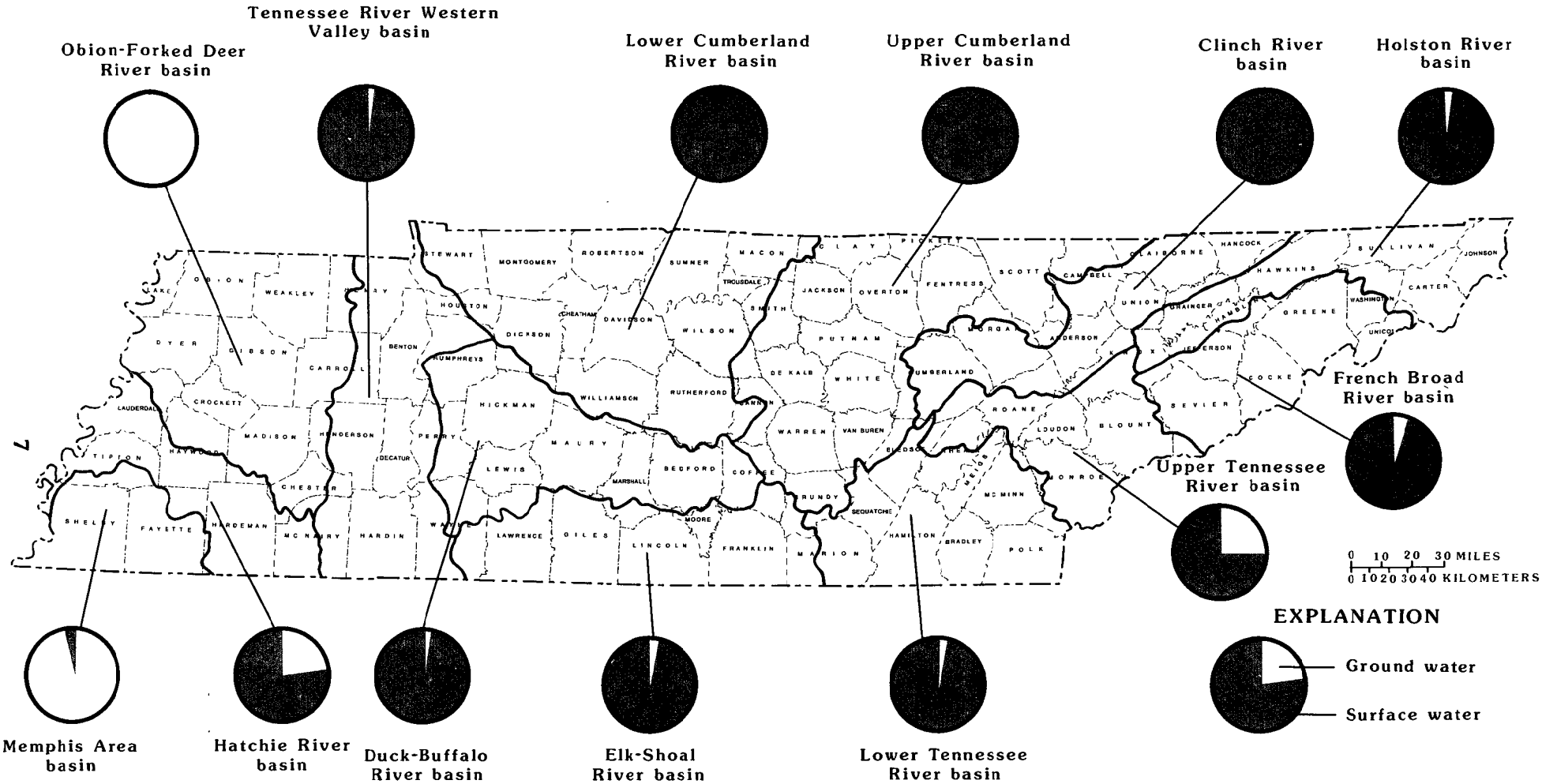

Figure 3.--Surface-water and ground-water withdrawal by self-supplied commercial and industrial water users during 1981 in the 13 major hydrologic basins of Tennessee.

Table 2.--Summary of problems reported by public water-supply systems and self-supplied users in Tennessee

Problem type or category	Number of problems reported	
	Public systems	Self-supplied users
Turbidity after heavy rainfall and flooding.	33	11
Inadequate storage capacity for treated water.	25	1
Water shortages during drought and (or) low streamflow periods.	22	3
Serious water losses due to local faulty mains and distribution lines.	15	-
Excessive concentrations of manganese and iron.	10	2
Flooding locally	8	5
Clogging of water-supply intake facilities by sediment, leaves, and other debris.	6	1
Water-quality problems locally	6	4
Low water pressure	5	1
Bad taste and odor problems	4	-
Inadequate transmission and distribution line facilities.	4	-
Periods of discoloration	3	-
Inadequate treatment-plant capacity	3	-
Excessive algae growth	2	-
Corrosive raw and treated water	2	1
Industrial spills	1	-
High chlorine demand	1	-
Fecal coliform bacterial contamination	1	-
Fluctuating river level and temperature due to reservoir discharges.	1	1
Total	142	30

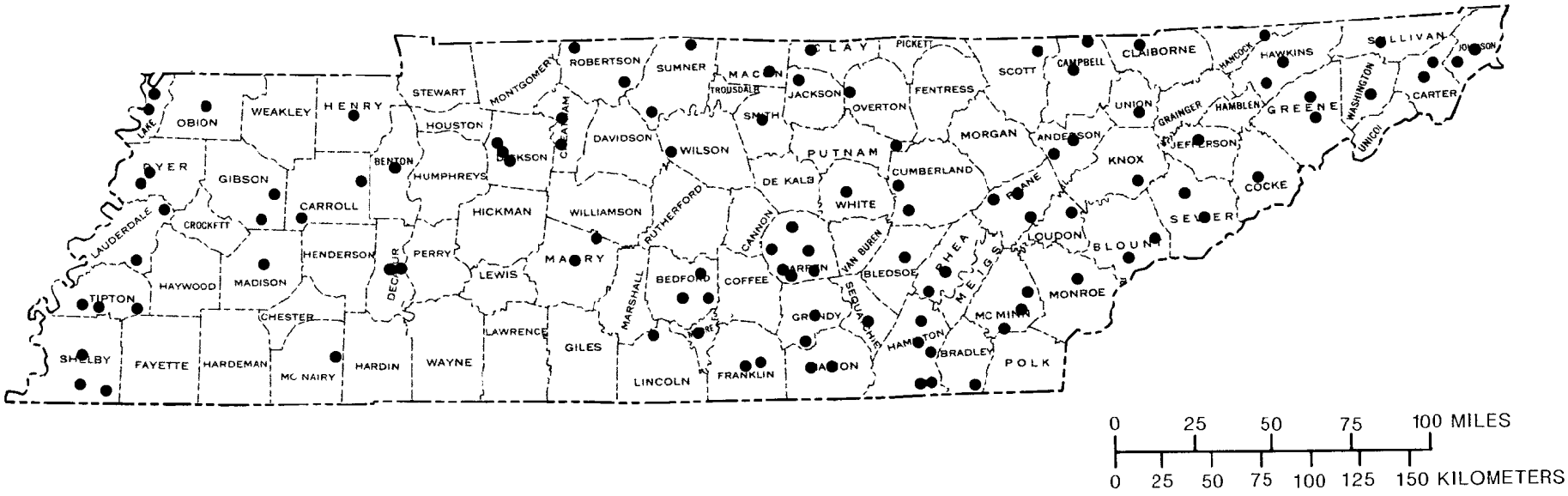

Figure 4.--Location of public water-supply facilities that have reported problems in quantity or quality of water.

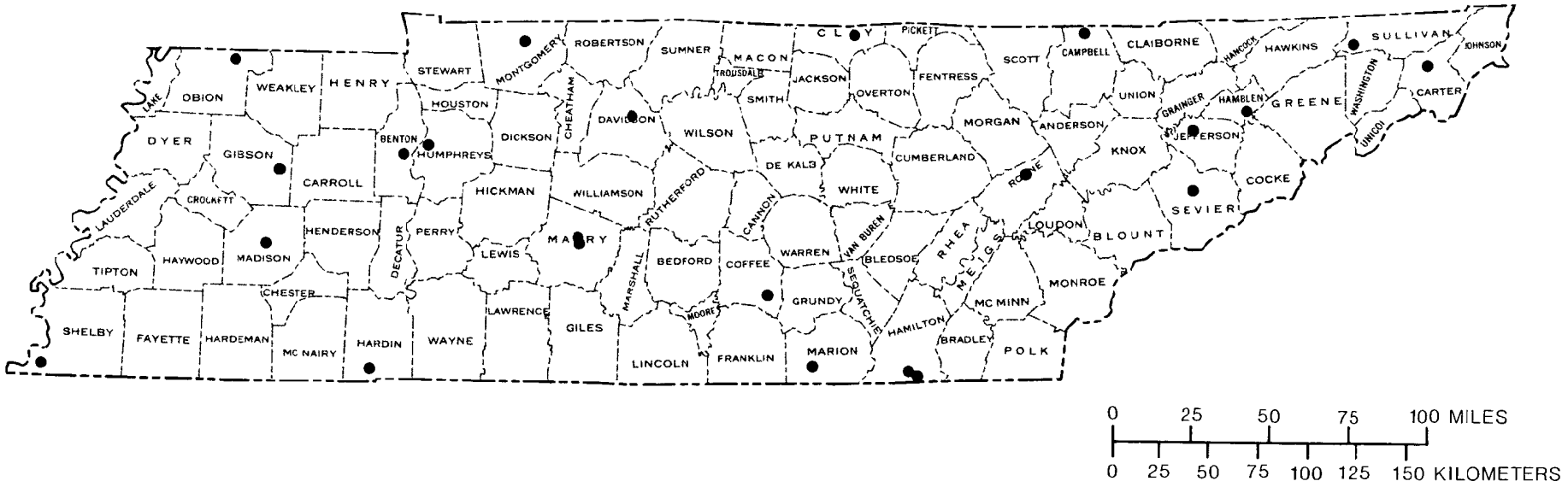

Figure 5.--Location of self-supplied commercial and industrial water users that have reported problems in quantity or quality of water.

purchase more than 25 percent, in most cases 100 percent, of their average daily water use from these public systems. Forty-four and 22 of these public systems and self-supplied users, respectively, are served by surface and (or) ground-water sources whose source capacity is unknown. All public water-supply systems and large, self-supplied water users in the Mississippi region are utilizing surface- and (or) ground-water resources, primarily ground-water, whose source capacity far exceeds their average daily use. The location of those communities and self-supplied users having a potential water-supply source problem are shown in figures 6 and 7, respectively.

While many of these potential inadequate systems and users have not reported any water-supply shortages in recent years, it is entirely plausible that some or all of these systems could expect to face occasional water-supply shortages, particularly during peak demand periods, because of severe and extended drought, increased water use due to industrial expansion, population growth, and so forth. However, it should also be noted that a number of these systems and users also withdraw a part of their average daily water use from surface-water sources or purchase water from neighboring systems whose source capacity appears adequate to provide additional water, if necessary. Nevertheless, it is possible that even these systems and users could face (1) periodic water-supply shortages during "high use" or peak demand periods, particularly in a time of drought, due to physical limitations of the system or user's intake, distribution, and (or) treatment plant facilities or (2) temporary disruption of service or reduction in the amount of water available to users plus the increased costs of acquiring or purchasing the additional water needed to meet the user's average daily water requirement.

6. Analysis of observation well data indicates that while periods of extended drought can result in seasonal water table declines and periodic problems with the adequacy of local ground-water supplies, there have been no reported long-term declines in Tennessee's regional water tables to date. Periodic local problems associated with a decline in an area's water table are caused by excessive withdrawals. To alleviate this problem, optimum ground-water withdrawal rates need to be determined during the initial test pumping of the source.

7. Water-supply problems affecting public water-supply systems and large, self-supplied users in Tennessee are not regional in nature. To date, most water-supply shortages have been "localized" in nature and characterized by the system or user's exceeding the system's physical facilities (distribution lines, treatment plant, and storage) and (or) source capacity of the supply source during peak demand periods. Water-supply shortages, that is, inadequate quantities of water to meet the user's average daily demand, are most common along the rim of and in the headwaters area of the Ohio and Tennessee Valley regions. As noted earlier, no water-supply shortages have been reported in the Mississippi region, which according to this study is almost totally dependent on ground-water supplies whose source capacity, based on the recharge rate of the major aquifer system which underlies the region, far exceeds existing use or withdrawal by public systems and large, self-supplied water users.

8. While the study made no attempt to identify and describe the specific impacts of drought-related water-supply shortages on Tennessee residents

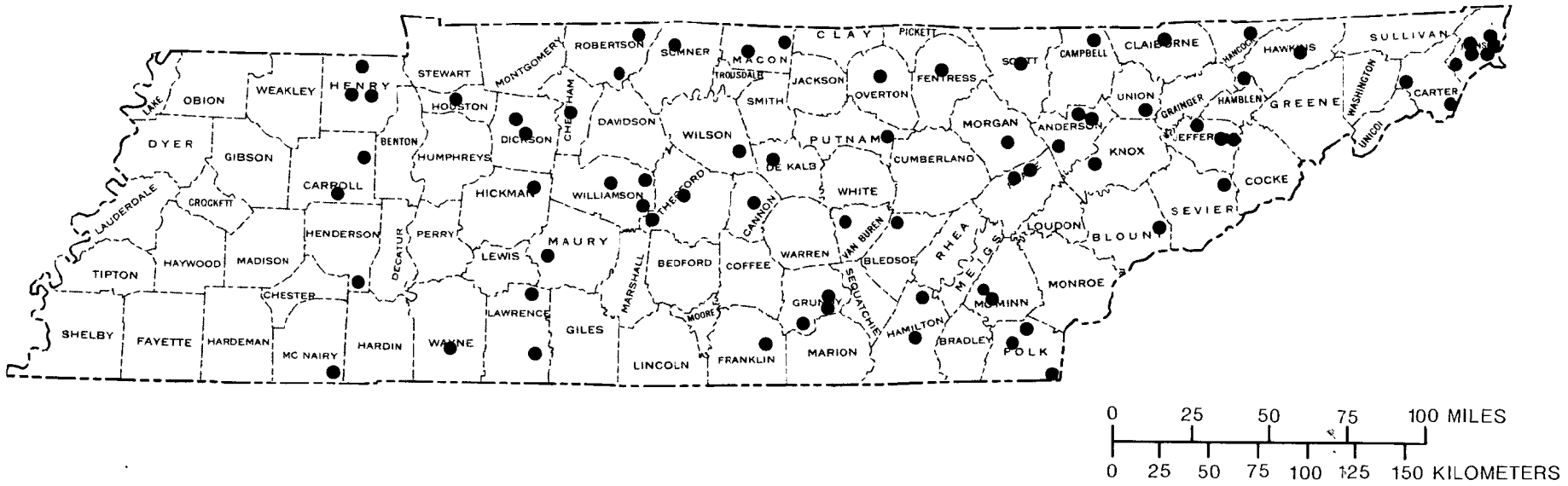

Figure 6.--Communities having potential problems in water-supply sources.

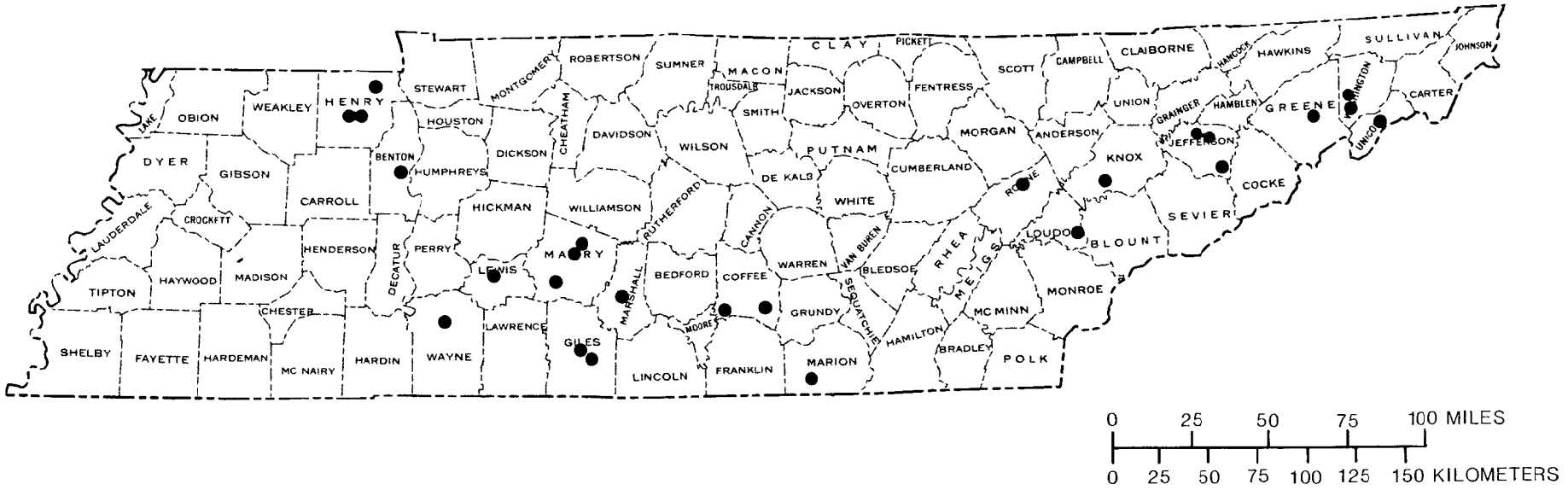

Figure 7.--Industries having potential problems in water-supply sources.

served by public water-supply systems and self-supplied water users, the study does provide a broad, general discussion of the potential economic, environmental, and social implications of a severe and extended drought on an area. Normally, the major impacts of drought-related water-supply shortages on an area's residents, business and industrial community, and institutional entities consist of (1) increased water-supply-related costs, (2) employment cutbacks and possible operational changes by business and industry, (3) reduced water availability for fire fighting and street washing, (4) increased pressure to reduce water use through the application of various water conservation measures, and (5) heightened anxiety and constant inconveniences for both water users and responsible water management officials. Extended drought conditions could also adversely affect an area's quality of life by limiting its ability to maintain adequate lake levels, instream flows, and waterfowl and wildlife habitat areas resulting in (1) increased public health concerns; (2) reduced opportunities for quality fishing and waterfowl hunting experiences; (3) water-quality degradation due to the stream's reduced capacity to assimilate municipal and industrial wastes; and (4) restricted use of surface water for water-oriented, human contact, recreation. While the impacts of drought are usually negative, there are also some positive benefits. For example, a severe drought could provide the impetus needed to motivate water-supply planners and decisionmakers at all levels of government to plan, finance, and develop or implement needed project and program measures as well as maintain and (or) improve existing water-supply facilities.

9. There are numerous solutions which decisionmakers can utilize to resolve or alleviate, to the extent possible, water-supply shortages, be they drought-induced or otherwise. To provide information that will assist Tennessee decisionmakers in formulating and promulgating viable programs and policies for responding to and dealing with water-supply, quantity-related problems and issues, the study has identified for their consideration a number of alternatives which have proven to be politically feasible elsewhere in resolving or alleviating drought-related water-supply shortages in a cost-effective, timely, and orderly manner. Included among these measures are the following: (1) water conservation techniques; (2) public information and education programs for all segments of society, particularly the youth; (3) more restrictive water use and pricing ordinances and regulations; (4) water recycling; (5) development of alternative water-supply sources via temporary pipelines, additional wells, and the hauling of water; (6) rehabilitation of existing water-supply facilities; (7) weather modification; (8) short- and long-range water resources planning; and (9) consolidation of existing water-supply systems whose source capacity is potentially inadequate to meet the system's needs, particularly during drought periods, into a regional water grid system with an adequate supply on a county or multicounty basis. The study also delineates briefly the broad, general role and responsibility of Federal, State, and local agencies in resolving water-supply shortages.

10. While this was not a water-quality study, the information and data provided by public water-supply systems and self-supplied users during recent years indicates that the quality of Tennessee's surface- and ground-water resources is quite good on an overall basis. However, cyclical water-quality problems do occur as a result of the seasonal distribution of precipitation, proximity to pollution sources, biological productivity,

and seasonal reservoir processes. While Tennessee's water resrouces are subject to contamination from a variety of sources, existing and pending Federal, State, and local statutes relative to water-quality protection and maintenance or improvement should ensure that current water quality will be maintained with little, if any, future impairment to use of the State's water resources for water-supply purposes. Sources of contamination could include (1) leachate from municipal and industrial water disposal facilities and septic tank systems; (2) agricultural pollution from fertilizers, pesticides and herbicides, and livestock wastes; and (3) runoff from surface mine lands; (4) accidental spills; and (5) urban runoff.

Next Step or Future Water-Supply Study Activities

Based on the information and data collected through this study, several future studies might be undertaken in Tennessee to facilitate and expedite the resolution or alleviation, to the extent possible, of identified water-supply problem areas.

1. Select one or more river basins such as the Holston, Clinch, or Elk-Shoal River basins which are characterized by periodic water-supply shortages during the late summer and fall months, competing and (or) conflicting water uses and serious water-quality problems, and conduct a comprehensive, coordinated study outlining each basin's overall objectives for water resources management and conservation.

2. Analyze and review existing Federal and State data bases relative to water use and supply relations in Tennessee and establish a procedure for developing and maintaining a comprehensive, integrated data base and water use survey format which meets Tennessee's data needs and reduces the potential for duplication of agency data collection activities.

3. Develop and implement a long-range comprehensive, coordinated water and related land resources planning process which considers and accommodates, to the fullest extent possible, all pertinent water uses and interests in developing a State water plan to guide planners and decisionmakers.

4. Design appropriate models to assist planners and decisionmakers in (1) simulating and describing the various aspects of water-supply availability and use in Tennessee both now and in the future and (2) planning the wise use, development, and management of the State's valuable water (surface and ground water) and related land resources.

5. Undertake appropriate studies and (or) research to (1) locate and determine the quantity and quality of the State's ground-water resources, (2) better understand the processes involved in ground-water contamination; and (3) identify alternative measures and procedures for protecting this valuable resource.

6. Develop and implement a long-range hydrologic data collection program designed to provide planners and decisionmakers with pertinent data and information regarding the physical location, quantity, quality, distribution, use, and movement of Tennessee's surface- and ground-water resources.

7. Conduct appropriate studies and research as needed to (1) identify, evaluate, and make available to developers pertinent information and data regarding low-technology, low-cost innovative septic tank systems and (2) evaluate the adequacy of existing State regulations controlling the governing and siting of septic tank systems to protect the quality of potable water supplies and prime fish and wildlife habitat (waterfowl) areas.