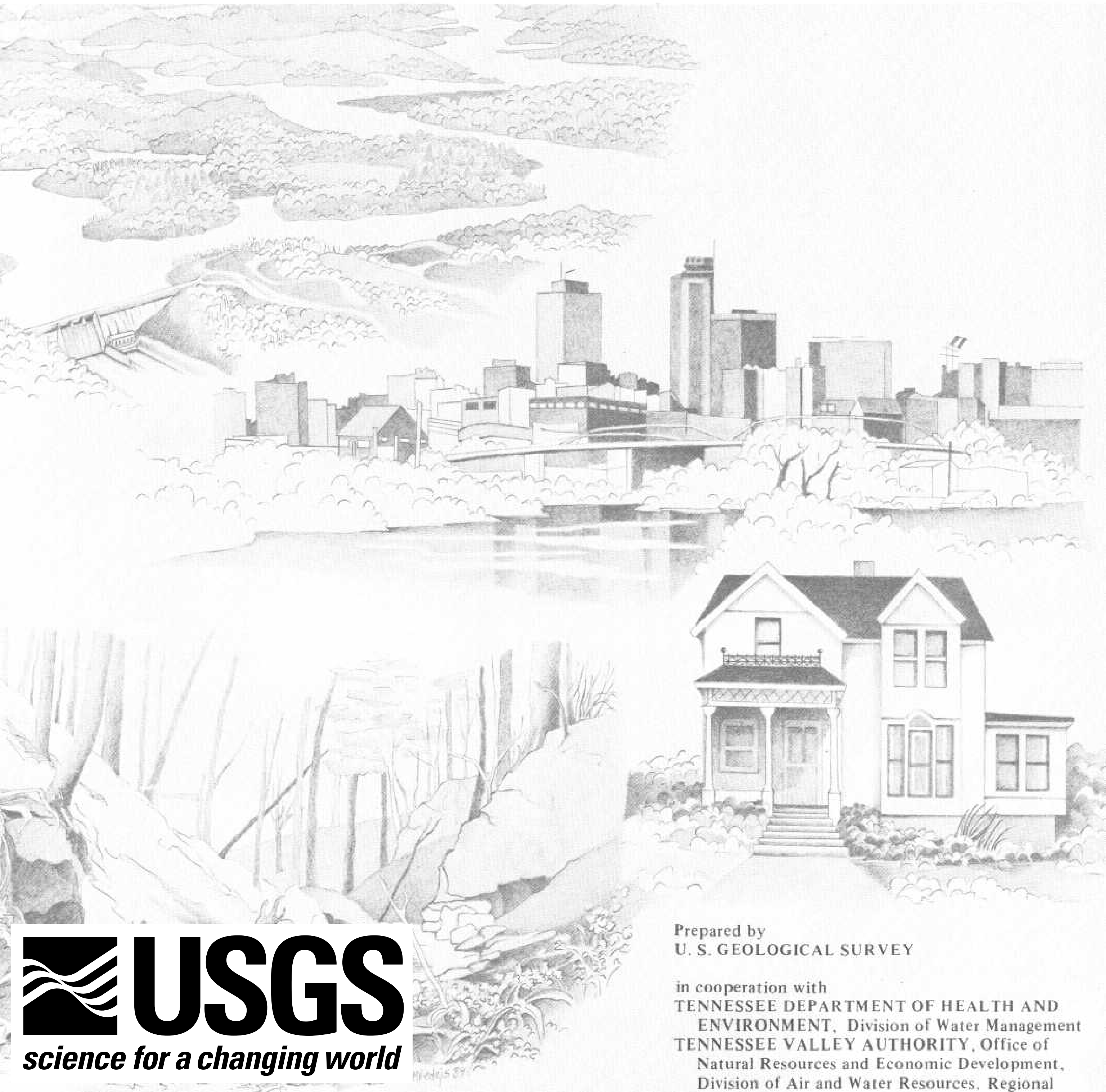
WATER-RESOURCES INVESTIGATIONS REPORT 84-4074

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



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TENNESSEE VALLEY AUTHORITY, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Regional

parentheses following each identified problem indicates the number of communities and (or) self-supplied water users who are now or have experienced this problem in the past. Note, these are not listed in order of frequency of occurrence or overall severity.

- Occasional turbidity following heavy rainfall and flooding. (6)
- Inadequate storage capacity. (4)
- Periodic water-supply shortages during the late summer and fall months. (2)
- Serious water losses due to breaks in deteriorating water mains and distribution lines. (6)
- Occasional pumping problems at water-supply intake facilities along the Hiwassee River due to low river levels during periods of nonpower generation at Apalachia Dam. (1)
- Clogging of water-supply intake facilities as a result of the buildup of leaves and mud around the intake pumps. (1)

Water Supply Adequacy Analysis

The Lower Tennessee River drains approximately 3,029 mi^2 or 1,939,000 acres of land and water area. Surface- and ground-water resources in this basin are fed by an abundant rainfall whose long-term (1941-70) average varies from 51.10 inches above Chattanooga on the Tennessee River to 57.90 inches above Charleston on the Hiwassee River. Average annual runoff in the Lower Tennessee River basin ranges from 22 to 32 inches with the heaviest runoff occurring in the Hiwassee River gorge area along the Tennessee State line. In general, the months of September, October, and November are the driest months in this area with March having the highest rainfall.

Average daily water use or withdrawal for public and large, self-supplied water users in the Lower Tennessee River basin equals about 246.6 Mgal/d. Approximately, 69.0 Mgal/d of this amount is withdrawn for public water-supply purposes with 56.2 Mgal/d or 81 percent being withdrawn from surface water supplies and 12.8 Mgal/d or 19 percent from ground-water supplies. Commercial and industrial water users utilize some 177.5 Mgal/d of which 174.6 Mgal/d or 98 percent are withdrawn from surface-water sources and 2.9 Mgal/d or 2 percent from ground-water sources. Major self-supplied industrial water users include DuPont Co. (10.400 Mgal/d) in Hamilton County; Bowaters Southern Paper Co. (80.000 Mgal/d) in McMinn County; and Cities Service Co. (72.000 Mgal/d) in Polk County. Consumptive water use by self-supplied commercial and industrial water users equals only 2.3 Mgal/d exclusive of Southern Cellulose Products' consumptive use which is less than 0.1 Mgal/d.

While many of this basin's public and self-supplied water users are served via surface- and (or) ground-water sources whose long-term, dependable source capacity is well in excess of or amply adequate to meet the community or user's water withdrawal demands, others listed below are utilizing water sources whose source capacity is either unknown or less than or nearly equal to their average daily withdrawal. The figure in parentheses following each source indicates what percentage of that facility or user's total water demand is supplied by that source.

Facility and county	Water source (percent)	Source capacity (Mgal/d)	Average daily use (Mgal/d)
	Public Water Supply Systems		
Big Creek UD (Grundy)	Ranger Creek (100)	Unknown	0.500
Mowbray Mountain UD (Hamilton)	Mont Lake (100)	Unknown	0.120
Sale Creek UD (Hamilton)	Wells (100)	0.090	0.086
Union Fork - Bakewell UD (Hamilton)	Wells (99)	0.215	0.175
Jasper WS (Marion)	Blue Spring (98)	0.325	0.440
Benton WS (McMinn)	Springs (99)	0.014	0.187
Riceville UD (McMinn)	Spring (100)	Unknown	0.044
Cherokee Hills UD (Polk)	Pleasant Hill Springs (100)	Unknown	0.086
Copper Hill WS (Polk)	Springs (100)	Unknown	Unknown
Delano WS (Polk)	Wells (100)	0.100	0.100
	Self-Supplied Commercial and Industrial Users		
Hardwick Stove (Bradley)	Wells (81)	0.197	0.197
Magic Chef (Bradley)	Springs (70)	0.334	0.334
Alco Chemical Corp. (Hamilton)	Well (77)	0.230	0.230
Chattem Drug (Hamilton)	Wells (78)	0.850	0.850
Cumberland Corp. (Hamilton)	Wells (94)	0.238	0.238

Facility and county	Water source (percent)	Source capacity (Mgal/d)	Average daily use (Mgal/d)
Self-Supplied Commercial and Industrial Users--Continued			
Dixie Yarns (Hamilton)	Wells (62)	0.535	0.535
Scholze Tannery (Hamilton)	Wells (81)	0.156	0.156
Southern Cellulose (Hamilton)	Wells (98)	4.000	4.000
Cities Service Co. (Polk)	Ocoee River (99) Spring (1)	43.000 0.382	72.000 0.382

Many of the public water systems and users listed should actively seek additional and (or) alternative sources. In those parts of the Lower Tennessee River basin underlain by the Valley and Ridge province and Cumberland Plateau, ground-water yields ranging from 0.150 to 0.200 Mgal/d on the average are not uncommon. Wells intersecting the solution cavities in the carbonate bedrock could be expected to yield up to 1.200 Mgal/d. However, for best results these wells should be located by trained ground-water hydrologists.

Those communities and self-supplied users served by ground-water sources of unknown or limited source capacity should consider seeking alternative cost-effective water sources. For example, Benton in McMinn County and Copperhill in Polk County might consider utilizing the Hiwassee and Ocoee Rivers, respectively, as alternative sources of water. While the Ocoee River at river mile 37.5 near Copperhill has a minimum daily average flow of about 66.5 ft^3/s (43.0 Mgal/d), the river has a very high acidity level due to runoff from the area's highly acidic soils. Recognizing the abundance of water available in the Hiwassee River, communities and self-supplied industries in McMinn and surrounding counties might seriously consider the development of a regional water-grid system on a county or multicounty basis to alleviate current shortages and enhance opportunities for continued economic growth and development.

Although the Cleveland and Ocoee water-supply systems in Bradley County appear to have adequate water supplies from ground-water sources, these systems should seek an alternative or backup, cost-effective source to accommodate future domestic, commercial, and industrial growth.

Most self-supplied commercial and industrial water users listed in the preceding chart, with the exception of Cities Service Co., also receive a part of their average daily water use from major public water-supply systems (Cleveland Utilities Board and Tennessee - American Water Co.) which utilize the Hiwassee and Tennessee Rivers, respectively, as their source of supply. Since both of these sources are characterized by water supplies whose source capacity far exceeds each system's average daily use, it would seem feasible to assume that in the event of a serious and extended drought these self-supplied users could increase their purchase of water from the Cleveland Utilities Board and Tennessee - American Water Co. to supplement and meet their water demands. However, Cities Service Co. could have a more serious problem should a severe and extended drought occur. While the company has experienced no water-supply shortages which necessitated any cutback in production or plant shutdown, there have been occasions when the available supply has become critical. Consequently, the company should consider seeking additional sources of water to supplement their existing water sources.

Water systems which are currently utilizing surface- and (or) ground-water resources which are inadequate or of unknown capacity should consider exploring the availability of alternative, cost-effective water-supply sources to augment or meet their future water needs if necessary. While the basin's water resources 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 degradation of the basin's water resources. Potential sources of contamination 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) urban runoff.

Although there are periods of extended drought which cause seasonal water table declines and periodic local problems resulting from inadequate ground-water supplies, observation-well data indicate there are no long-term regional water table declines. 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 should be determined during the initial test pumping of the source.

UPPER TENNESSEE RIVER BASIN

Basin Description

The Upper Tennessee River basin covers 2,148 mi^2 of land and water area and consists of all or parts of the following tributary basins as delineated by the U.S. Geological Survey and Tennessee Department of Water Management in 1982.

Tributary basin No. (fig. 35)	Basin description	Tennessee drainage area (square miles)
17	Tennessee River minor tributaries from the river's head to Fort Loudoun Dam.	650
18A	Little Tennesssee River from the Tennessee State line to Ninemile Creek and the Tellico River.	261
18B	Tellico River	275
18C	Little Tennessee River from Ninemile Creek to the river's mouth.	245
21A	Tennessee River south and east-side minor tributaries below the Clinch River to Watts Bar Dam.	256
21B	Tennessee River west-side minor tributaries below the Clinch River to Watts Bar Dam.	365
21C	Tennessee River north-side minor tributaries above the Clinch River.	96

The Upper Tennessee River basin encompasses all or major parts of Blount, Knox, Loudon, Monroe, and Roane Counties plus minor parts of Bledsoe, Cumberland, Meigs, Rhea, and Sevier Counties. A map of the east Tennessee part of the Tennessee River basin highlighting the Upper Tennessee River basin is shown in figure 35.

Topography

This basin's topography, particularly in the Little Tennessee and Little River drainage areas, is very mountainous in nature. With the exception of the lower 30 miles, the Little Tennessee River is characterized by rugged mountain topography and considerable topographic relief with elevations ranging from about 850 feet where the river emerges from the mountains to over 6,600 feet above sea level at Mt. Guyot on the divide between the Little Tennessee and French Broad Rivers. Throughout most of this area, the Little Tennessee River flows in a steep, narrow, and precipitous gorge. Just below Fontana Dam in east Tennessee, the ridges and peaks rise some 2,000 to 3,000 feet above the river.

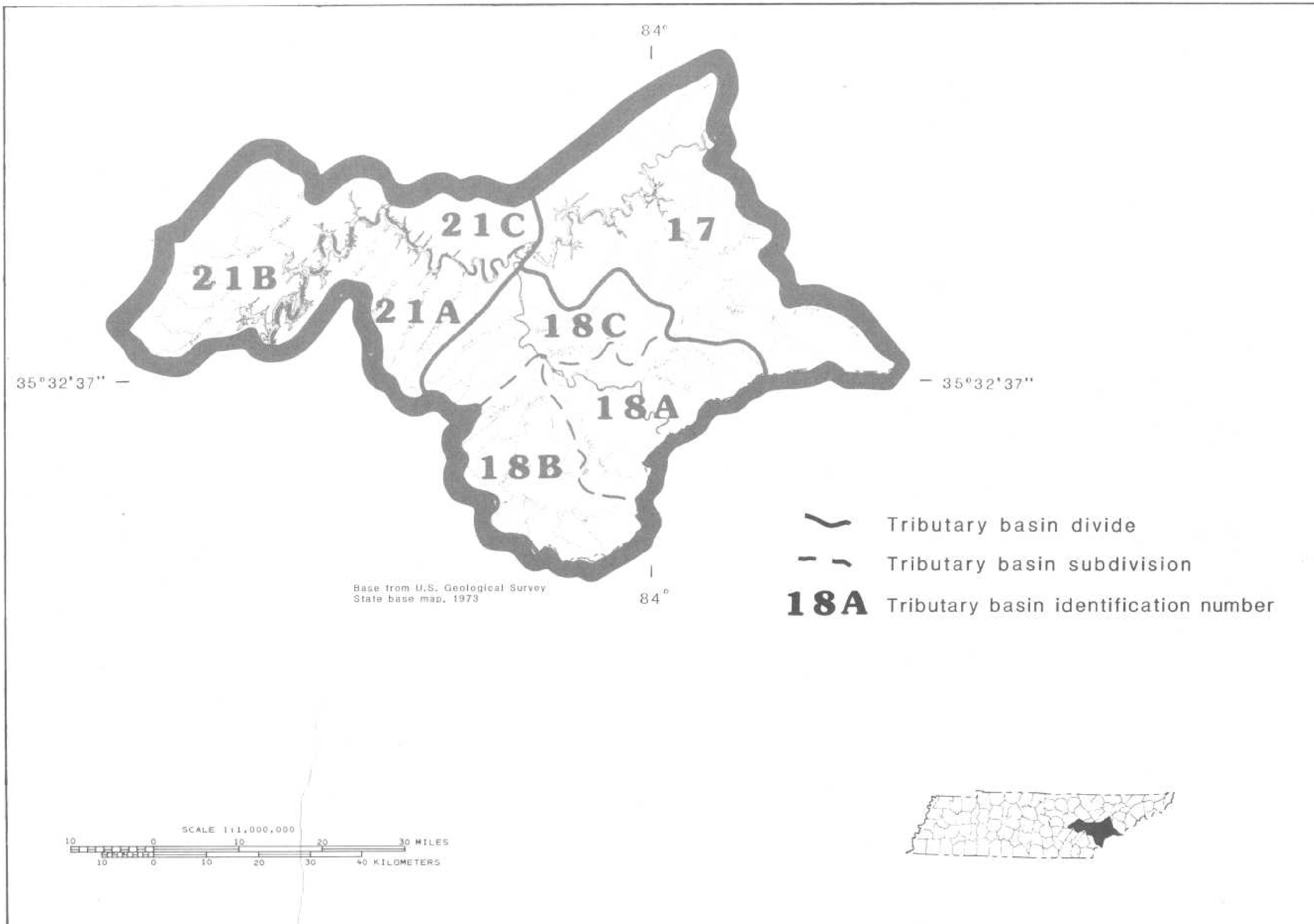


Figure 35.--Upper Tennessee River basin.

Similarly, the Little River which rises on the northern slope of the Smoky Mountains near Clingmans Dome is characterized by a rapid fall in elevation from 6,000 feet to 900 feet above sea level within a distance of 15 miles. The lower reaches of these streams and the Tennessee River minor tributaries drainage area are characterized by comparatively narrow, parallel ridges and somewhat broader, intervening valleys of northeast-southwest trend.

Principal streams and tributaries draining the Upper Tennessee River basin are delineated below by drainage area:

- Little Tennessee River. Tellico River plus numerous smaller streams including Abrams, Baker, Bat, Citico, Fork, Island, and Ninemile Creeks.

- Little River. Several smaller streams such as Crooked, Ellejoy, Hesse, Knob, Nails, Pistol, and West Laurel Creeks.

- Tennessee River Minor Tributaries. Piney River plus a number of smaller streams including Black, Caney, Cave, Hines, Lackey, Paint Rock, Piney, Pole Cat, Pond, Richland, Riley, Steekee, Sweetwater, Ten Mile, Turkey, Whites, and Wolf Creeks.

Average stream slopes in the Little Tennessee River basin equal about 2.81 ft/mi from river mile 0 to 42 and 17.30 ft/mi from river mile 42 to the Tennessee-North Carolina State line. In the Little River basin, stream slopes average about 5.30 ft/mi from river mile 0 to 24 and 15.80 ft/mi from river mile 24 to 35. The average stream slope along the Tennessee River mainstem equals about 0.96 ft/mi. Basin elevations range from 800 to 4,500 feet in the Little Tennessee River drainage area; 850 to 3,500 feet in the Little River drainage area; and 300 to 5,000 feet above sea level along the Tennessee River mainstem between Watts Bar Dam and Knoxville.

Hydrology

Surface Water

Surface- and ground-water resources in this basin are fed by ample rainfall whose long-term (1941-70) average above McGhee on the Little Tennessee River equals 59.90 inches. Over the 10-year period from 1970-79, average annual precipitation above McGhee in the Little Tennessee River drainage area was 65.07 inches with a low of 51.57 inches in 1978 and a high of 73.51 inches in 1979. Average precipitation data for watershed subdivisions of the Upper Tennessee River basin during the 10-year period from 1970-79 is summarized in table 45. Annual 1979 and long-term (1941-70) precipitation data for selected TVA, Aluminum Company of America (ALCOA), NWS, Tennessee Division of Water Management (TDWM); and U.S. Department of Agriculture (USDA) rainfall stations in the Little Tennessee River and the Tennessee River and its minor tributaries above Watts Bar Dam are presented in table 46.

Above McGhee in the Little Tennessee River drainage area, the driest months of the year are usually May, September, and October with average annual rainfall ranging from 3.49 to 4.23 inches. During the rest of the year rainfall generally averages about 4.42 to 6.47 inches above McGhee with March being the

Table 45.--Precipitation data by watershed subdivision for the period 1970-79, Upper Tennessee River basin

Watershed description	Precipitation (inches)				
	High	Year	Low	Year	10-year average
Little Tennessee River from Calderwood to Fontana and Santeetlah.	72.70	1972	50.60	1978	62.13
Little Tennessee River from McGhee to Calderwood.	71.70	1972	46.70	1978	60.47
Tennessee River from Fort Loudoun to Knoxville.	63.50	1972	46.20	1970	54.66
Tennessee River from Watts Bar to Fort Loudoun.	72.40	1973	49.80	1970	58.80

Table 46.--Precipitation data for 1979 and for the period 1941-70 for selected rainfall stations, Upper Tennessee River basin

Station location	Station owner	Elevation above sea level (feet)	Period of record (years)	1979 Precipitation (inches)	Long-term annual precipitation (inches)
Little Tennessee River					
McGhee	TVA	930	75	61.28	51.78
Tellico Plains	TVA	900	66	62.98	55.38
Stratton Meadows	TVA	4,640	25	82.30	78.71
Calderwood powerhouse	ALCOA	950	49	63.72	54.30
Clingmans Dome	TVA	6,250	25	94.40	82.40
Tennessee River and Minor Tributaries upstream from Watts Bar Dam					
Watts Bar Dam	TVA	830	40	66.87	52.57
Jewett	TVA	1,920	22	66.67	56.97
Roddy	TVA	810	44	67.18	52.11
Rockwood	NWS	780	18	77.14	60.17
Mt. Roosevelt	TDWM	2,000	15	65.20	53.89
Lenoir City	NWS	785	785	56.43	50.64
Fort Loudoun Dam	TVA	845	39	53.44	48.02
U.S. cotton field station	USDA	885	45	52.61	48.78
Knoxville Airport	NWS	980	41	53.80	46.18
Providence	TVA	1,100	41	53.08	47.25
Wildwood	TVA	1,040	29	55.53	51.17
Townsend	TVA	1,070	29	53.11	50.92
University of Tennessee Geology Building	UT	974	109	52.71	46.14
Knoxville (Evans Building)	TVA	970	26	51.05	45.60

wettest month. Review of long-term precipitation data at selected hydrologic data stations (Townsend, Knoxville, Fort Loudoun Dam, Rockwood, and Watts Bar Dam) in the Tennessee River and minor tributaries drainage area indicates that the driest months of the year are usually August, September, and October with rainfall ranging from 2.70 to 3.83 inches. During other months, precipitation ranges from 3.95 to 6.91 inches with March and July being the wettest months.

Average annual runoff in the Tennessee part of the Upper Tennessee River basin ranges from 20 to 24 inches in the Knoxville - Watts Bar Dam area to 32 to 38 inches along the Tennesseee-North Carolina State line. Average discharge data for selected hydrologic data stations in the Upper Tennessee River basin is given in table 47. Much of this runoff occurs during the winter and spring months.

Major Reservoirs

Major reservoirs located in this basin and their total storage in acre-feet at normal minimum pool are Calderwood Reservoir (39,490), Chilhowee Reservoir (42,450), Fort Loudoun Reservoir (282,000), and Tellico Reservoir (321,300). While Watts Bar Reservoir with 796,000 acre-feet of storage at normal minimum pool is located within this basin, the effect of releases from this reservoir are realized in the Lower Tennessee River basin which encompasses the downstream reach of the Tennessee River below Watts Bar Dam. Detailed information describing the location and operation pattern of each reservoir, with the exception of Watts Bar Reservoir, follows. Similar information for Watts Bar Reservoir is included in the water-supply adequacy analysis for the Lower Tennessee River basin.

Calderwood Reservoir

Location and drainage area.--Calderwood Reservoir is formed by Calderwood Dam which is located on the Little Tennessee River at river mile 43.7 in Blount and Monroe Counties. Calderwood Dam controls 1,856 mi^2 of drainage area.

Reference period.--1960-81.

Reservoir discharge (minimum daily average flow).--Minimum daily average discharge from Calderwood Dam during the reference period ranged from a low of approximately 9.0 ft^3/s (5.8 Mgal/d) in 1967 to a high of approximately 1,679 ft^3/s (1,085.2 Mgal/d) in 1979. The average, 1-day minimum discharge during the reference period was approximately 452.3 ft^3/s (292.3 Mgal/d).

Average number of days of zero flow.--During the reference period, Calderwood Dam has averaged less than 1 day of zero discharge per year. From 1960-81, there were only 9 days in which zero discharge occurred and then only for 1 or 2 days per year.

Existing agreements regarding reservoir releases.--None.

Table 47.--Average discharge data for selected hydrologic data stations operated by the U.S. Geological Survey, Upper Tennessee River basin

Station name and location (county)	River mile	Drainage area (square miles)	Period of record (years)	Average discharge		
				Cubic feet per second	Inches per year	Cubic feet per second per square mile
Tennessee River at Knoxville (Knox).	651.4	8,934	81	13,150	-	1.47
Little River upstream from Townsend (Blount).	35.3	106	17	294	37.66	2.77
Little River near Maryville (Blount).	17.3	269	29	539	27.21	2.00
Tellico River at Tellico Plains (Monroe).	28.2	118	55	287	33.03	2.43
Tennessee River at the Watts Bar Dam tailwater (Rhea).	529.9	17,310	11	29,940	-	1.73

Chilhowee Reservoir

Location and drainage area.--Chilhowee Reservoir is formed by Chilhowee Dam which is located on the Little Tennessee River at river mile 33.6 in Blount and Monroe Counties. Chilhowee Dam controls 1,977 mi^2 of drainage area.

Reference period.--1960-81.

Reservoir discharge (minimum daily average flow).--Minimum daily average discharge from Chilhowee Dam during the 1960-81 time period has been very consistent ranging from a low of about 1,311 ft^3/s (847.3 Mgal/d) in 1969 to a high of about 1,693 ft^3/s (1,094.2 Mgal/d) in 1962. The average, 1-day minimum discharge during the reference period was about 1,377 ft^3/s (890.1 Mgal/d).

Average number of days of zero flow.--Zero flow from Chilhowee Dam occurred only once during the reference period and that was for 2 days in 1964.

Existing agreements regarding reservoir releases.--Chilhowee Dam is operated to provide a minimum instantaneous flow of about 1,360 ft^3/s (879.0 Mgal/d) below the dam.

Fort Loudoun Reservoir

Location and drainage area.--Fort Loudoun Reservoir is formed by Fort Loudoun Dam which is located on the Tennessee River at river mile 602.3 in Loudon County. Fort Loudoun Dam controls 9,550 mi^2 of drainage area.

Reference period.--1960-81.

Reservoir discharge (minimum daily average flow).--Minimum daily average discharge from Fort Loudoun Dam during the 1960-81 time period ranged from a low of about 100 ft^3/s (64.6 Mgal/d) in 1965 and 1970 to a high of about 3,700 ft^3/s (2,391.4 Mgal/d) in 1974 and 1977. The average, 1-day minimum discharge during the 1960-81 time period was about 1,382.8 ft^3/s (893.1 Mgal/d).

Average number of days of zero flow.--During the period from 1960-70, Fort Loudoun Dam has averaged slightly over 2 days of zero discharge per year ranging from a low of no days of zero discharge in 1967 and 1969 to a high of 9 days of zero discharge in 1963. Since 1970, there have been no days of zero discharge from Fort Loudoun Dam. Prior to 1970, there was only one instance of zero discharge for 3 or more consecutive days from Fort Loudoun Dam and that occurred in 1968 for 3 days.

Existing agreements regarding reservoir releases.--None.

Tellico Reservoir

Location and drainage area.--Tellico Reservoir is formed by Tellico Dam which is located on the Little Tennessee River about river mile 0.3 in Knox and Loudon Counties. Tellico Dam controls 2,627 mi^2 of drainage area.

Reference period.--While statistical streamflow data is available for the Little Tennessee River at river mile 0.3 for the 1960-1980 time period, it should be noted that the construction of Tellico Dam was only recently completed and the dam closed in November of 1979.

Reservoir discharge (minimum daily average flow).--Minimum daily average streamflow at river mile 0.3 on the Little Tennessee River during the 1960-79 time period ranged from a low of approximately 342 ft^3/s (221.0 Mgal/d) in 1964 to a high of approximately 2,420 ft^3/s (1,564.1 Mgal/d). During the period from 1960-79, the average, 1-day minimum discharge equaled about 1,606 ft^3/s (1,038.0 Mgal/d). Since closure of Tellico Dam in 1979, all reservoir releases from Tellico Dam are made through a navigable canal connecting Tellico Reservoir with Fort Loudoun Reservoir. During 1980, the 1-day minimum discharge from Tellico to Fort Loudoun Reservoir was about 4,000 ft^3/s (2,585.3 Mgal/d).

Average number of days of zero flow.--None.

Existing agreements regarding reservoir releases.--None.

Ground Water

The eastern part of the Upper Tennessee River basin lies in the Blue Ridge physiographic province and includes parts of Sevier, Blount, and Monroe Counties. The extreme western part of the basin lies on the Cumberland Plateau and includes parts of Roane, Cumberland, Bledsoe, and Rhea Counties. All of the remainder of the Upper Tennessee River basin lies in the Valley and Ridge province. Ground water is confined to fractures and openings in the underlying rock formations caused by severe folding and faulting of the rocks by the Unaka Mountain building forces. The number and size of these openings are controlled both by the composition of the rock, the distance from the Unaka Mountains, and the solutional enlargement of cavities in the soluble carbonate rocks.

The Blue Ridge part of the Upper Tennessee River basin is underlain primarily by noncarbonate rocks such as sandstone, siltstone, shale, and conglomerate. Fractures in these rocks are not significantly enlarged by solution that may be caused by percolating ground water. Consequently, the yields of wells drilled on the mountains are generally low, ranging from 1 to 25 gal/min. Wells encountering little or no water are common on the mountain tops. The valleys often have a relatively thick regolith consisting of sand, clay, and rock fragments. Here, dug wells commonly furnish domestic supplies. Some wells have been located on the basis of geologic data and supply 100 gal/min or more. These were located near faults or a series of faults. Normally, wells drilled on the mountains and in the valleys do not exceed 250 feet in depth. Springs are common but furnish relatively small amounts of water in comparison with those in areas underlain by carbonate rocks. Ground-water quality is usually acceptable.

The area of the Upper Tennessee River basin lying in the Valley and Ridge province is primarily underlain by carbonate rock formations such as limestone and dolomite together with calcareous shale and limy sandstone. Ground water occurs in fractures and bedding plane openings in the limestone and dolomite formations which have been enlarged in varying degrees by the dissolving action of circulating ground water. Water occurs in fractures in the sandstone which may be enlarged somewhat by solution but to a much lesser degree than the openings in the carbonate rocks. Ground water in quantities sufficient for domestic purposes are generally found in the limestones and dolomites. Domestic supplies can usually be found in the sandstone at depths of 100 feet or less. Wells in dolomite and limestone are deeper on the average with the majority ranging from 50 to 200 feet in depth. These enlarged openings generally become smaller and less numerous with depth and it is generally not advisable to drill deeper than 300 to 350 feet on the basis of presently available information. Most of the wells reported in the Valley and Ridge province yield from 3 to 50 gal/min. However, yields from 100 to 250 gal/min are common. One well located in the city of Maryville reportedly produces 250 gal/min from a cavity at a depth of 630 feet. This suggests that it may be possible for open fractures to yield water at depths greater than 350 feet in some local areas. Moderately large to large springs are common in the limestone and dolomites. Water quality is usually acceptable.

The western part of the Upper Tennessee River basin lying in parts of Roane, Cumberland, Rhea, and Bledsoe Counties is located in the Cumberland Plateau physiographic province. Ground water in the Cumberland Plateau province occurs in fractures in tightly cemented sandstones. As these siliceous rocks have not been structurally disturbed to the extent of those in the Valley and Ridge province, with the exception of the eastern escarpment of the Plateau, fractures are not as numerous. Also, fractures in the Plateau rocks are resistant to enlargement by the solvent action of ground water. Consequently, ground water is more difficult to obtain in significant quantities. Yields to drilled wells are generally low. However, in areas of more severe faulting and fracturing near surface streams, well yields of 100 gal/min or more have been recorded. Well depths are usually 200 feet or less. However, some unpublished well logs indicate that the Sewanee Conglomerate can yield good-quality water from depths of at least 500 feet in Cumberland County and other areas of the Cumberland Plateau. With the exception of water produced from the Sewanee Conglomerate, ground water from Plateau wells of less than 150 feet in depth is usually rather high in iron. In most cases, the water is acidic due to dissolved carbon dioxide. Water encountered at or near coal seams or carbonaceous shale is usually high in sulfates and sometimes very acidic due to the decomposition of pyrite to sulfuric acid. Springs generally have low yields and often go dry in times of low rainfall.

Ground water in the Upper Tennessee River basin is essentially confined to fractures in the rocks. In areas where fractures are numerous and particularly where they have been enlarged by solution, relatively large yield wells are possible. Most of the wells listed in the existing ground-water data base were drilled for domestic use and were not located as the result of local geologic investigation. Therefore, the true ground-water potential of the Upper Tennessee River basin cannot be accurately assessed at present.

Demography

Historical (1970) and recent (1980) population, total wage and salary employment including both full- and part-time workers, and per capita personal income data for the county boundary approximation of the Upper Tennessee River basin are presented in table 48. Specific counties included in this approximation are Blount, Knox, Loudon, Monroe, and Roane. Note, both Blount and Knox Counties are also part of the Knoxville Standard Metropolitan Statistical Area which encompasses Anderson, Blount, Knox, and Union Counties with the majority of its population located in the Upper Tennessee River basin. Principal urban or metropolitan areas in the Tennessee part of the basin and their 1980 census population include Alcoa (6,870), Knoxville (175,045), Lenoir City (5,446), Loudon (3,943), Madisonville (2,884), Maryville (17,480), Rockwood (5,767), and Sweetwater (4,725).

Public and Self-Supplied Commercial and Industrial Water Users

Currently, there are a total of 23 public water-supply facilities and five large, self-supplied commercial and industrial water users whose use exceeds 0.1 Mgal/d in the Upper Tennessee River basin. Detailed inventories containing pertinent information and data relative to each community or self-supplied user's source of water, average daily water use, source capacity, population served, treatment plant and storage capacities, and water-supply shortage problems are found in tables 23 and 24 of appendix I, respectively. Total water use or withdrawal for public and large, self-supplied commercial and industrial users in the basin currently equals about 69.2 Mgal/d. The general location and water-supply source of all public and large, self-supplied commercial and industrial water users inventoried in the Upper Tennessee River basin are depicted in figures 36 and 37, respectively.

Public water systems currently serve about 386,000 people or 77 percent of the basin's 1980 population. Average daily water use or withdrawal for public purposes equals about 64.2 Mgal/d of which approximately 62.5 Mgal/d or 97 percent is withdrawn from surface-water sources and 1.7 Mgal/d or 3 percent from ground-water sources. Major public water-supply facilities whose average daily use exceeds 1.0 Mgal/d include the following:

Facility name	Average water use (Mgal/d)
Alcoa WS	11.506
South Blount County UD	1.233
Maryville WS	2.300
First UD of Knox County	4.045
Knoxville Utilities Board	34.000
West - Knox UD	2.500
Lenoir City Utility Board	1.000
Loudon UD	4.325
Sweetwater Board of Public Utilities	1.000
Rockwood WS	1.500

In all, these systems account for approximately 99 percent of the total water withdrawn for public purposes.

Self-supplied commercial and industrial users use or withdraw about 4.1 Mgal/d with all but slightly over 1.0 Mgal/d being withdrawn from the Tennessee River at river mile 591.8. All but 1.1 Mgal/d of the total self-supplied water use

Table 48.--County population, employment, and per capita personal income data, Upper Tennessee River basin

[Per capita income based on 1970 income converted to 1980 dollars]

County	Population		Employment		Per capita personal income 1980 dollars	
	1970	1980	1970	1980	1970	1980
Blount	63,744	77,770	19,499	22,378	$6,507	$7,801
Knox	276,293	319,694	112,088	155,553	6,887	8,357
Loudon	24,266	28,553	6,516	7,335	5,412	7,156
Monroe	23,475	28,700	6,043	6,561	4,817	5,126
Roane	38,881	48,425	11,313	11,006	5,310	5,848
Total	426,659	503,142	155,459	202,833	-	-

Figure 36--Explanation

Site No.	Facility name
1	Alcoa WS
2	Calderwood Village WS
3	Maryville WS
4	Walland WS
5	First UD of Knox County
6	Knoxville Utilities Board
7	West - Knox UD
8	Lenoir City Utility Board
9	Dixie Lee UD
10	Loudon UD
11	Piney UD
12	Sweetwater Board of Public Utilities
13	Tellico Area Services System
14	Tellico Plains WS
15	Spring City WS
16	Kingston WS
17	Rockwood WS

occurs at Union Carbide, Films Packaging Division, in Loudon. Consumptive water use by these large, self-supplied commercial and industrial users equals about 0.2 Mgal/d.

Summarized below is a list of the specific water-supply problems now being experienced by individual communities and self-supplied commercial and industrial water users in the Upper Tennessee River basin. Note, these are not listed in order of frequency of occurrence or overall severity.

- Inadequate storage and limited pumping and line capacities. (2)
- Pressure losses at higher elevations. (1)
- Extensive water losses due to leaking mains and distribution lines. (1)
- Some turbidity after periods of intense rainfall. (2)

Water Supply Adequacy Analysis

The Tennessee part of the Upper Tennessee River basin covers approximately 2,148 mi^2 or about 1,375,000 acres of land and water area. This basin's surface- and ground-water resources are amply supplied by abundant rainfall whose long-term (1941-70) average above McGhee on the Little Tennessee River is 59.90 inches. Average annual runoff ranges from 20 to 24 inches in the area between Knoxville and Watts Bar Dam to 32 to 38 inches in the eastern part of the basin along the Tennessee-North Carolina State line. The months of August, September, and October are usually the driest with July and March being the wettest months.

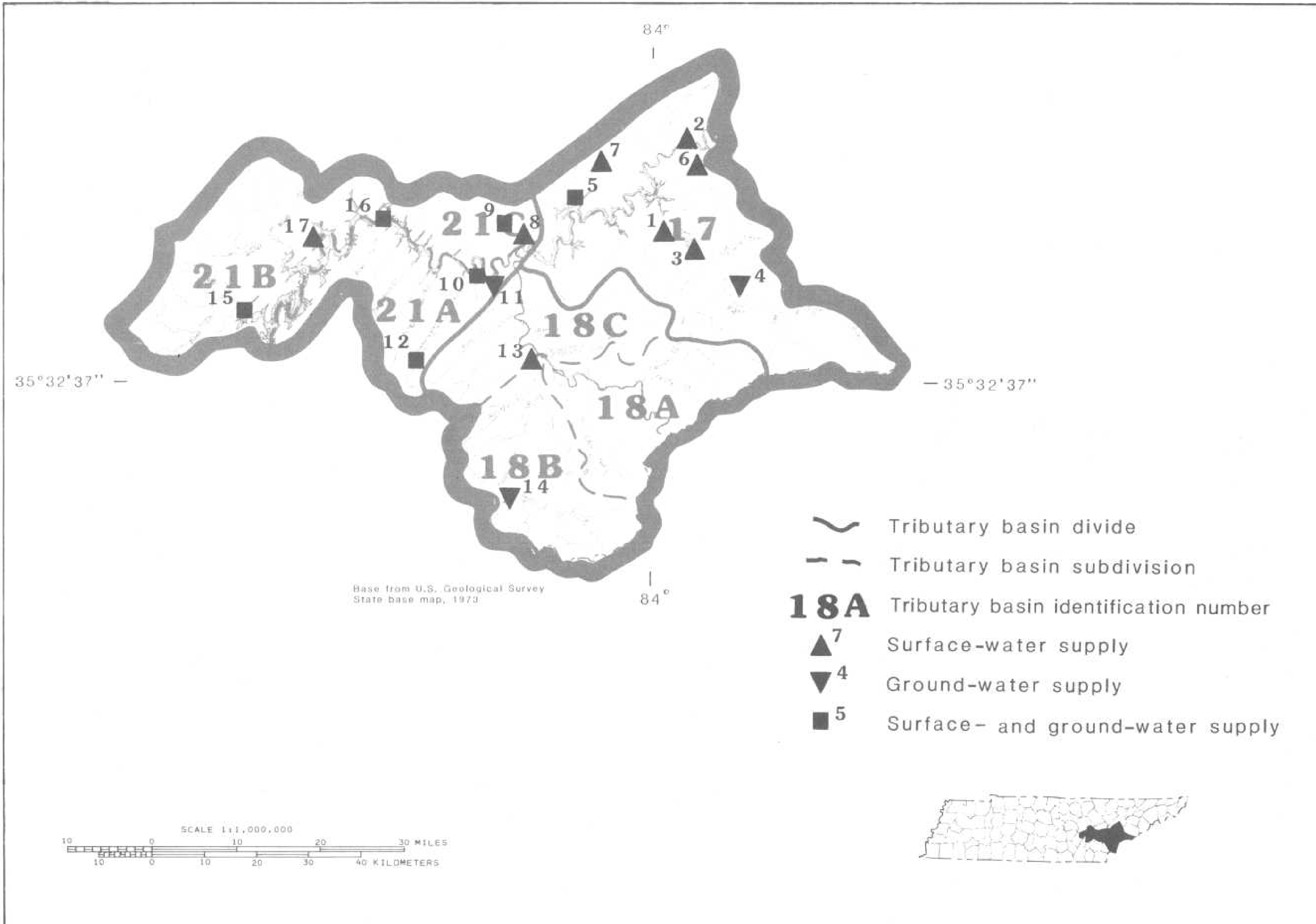


Figure 36.--Public water-supply facilities, Upper Tennessee River basin.

Figure 37--Explanation

Site No.	Facility name
1	Candora Marble Co. (Knoxville)
2	East Tennessee Packing Co. (Knoxville)
3	Southern Cast Stone Co., Inc. (Knoxville)
4	Greenback Industries, Inc. (Greenback)
5	Union Carbide Corp., Films Packaging Division (Loudon)

Total present water use or withdrawal for public and large, self-supplied commercial and industrial purposes in the Upper Tennessee River basin equals approximately 69.2 Mgal/d. Of this amount, about 64.2 Mgal/d are used by public water systems with 62.5 Mgal/d or 97 percent being withdrawn from surface-water sources and 1.7 Mgal/d or 3 percent from ground-water sources. Large, self-supplied users use about 4.1 Mgal/d with all but about 1.0 Mgal/d being withdrawn from the Tennessee River at river mile 591.8. All but 1.1 Mgal/d of the total self-supplied water use occurs at Union Carbide, Films Packaging Division, in Loudon. Consumptive water use by large, self-supplied commercial and industrial users equals about 0.2 Mgal/d.

While some public water-supply systems and a few self-supplied industries utilize springs and wells for their water supply, most of the basin's public and self-supplied users are served via surface-water resources. The ready availability of large quantities of surface water in contrast to the uncertainty of the underlying strata to supply large quantities of ground water is the reason most public and self-supplied users in the basin are utilizing surface-water resources. However, in favorable well locations selected by trained ground-water hydrologists, test wells intersecting solution cavities in carbonate bedrock generally could be expected to have a dependable, long-term yield ranging from 0.080 to 0.150 Mgal/d.

Analysis of the public water supply and self-supplied water user inventories indicates only a few public systems (Dixie Lee and Loudon UD's and Spring City WS) and self-supplied users (Southern Cast Stone and Greenback Industries) whose dependable, long-term source capacity for all or part of their water supply is less than or nearly equal to their average daily water use. However, each of these systems and users is also served in part by either a surface-water source (Tennessee River) or purchased water from another system (Knoxville and Lenoir City Utility Boards and Tellico Area Services System) whose dependable, long-term source capacity is ample to meet the system or user's total water demand on an interim basis. All of this basin's public water-supply systems, with the exception of the Piney UD and Walland WS, that utilize ground water as a supply source also receive at least a part of their average daily water use from a surface-water source or another public system which is supplied by a surface-water source.

Water systems which are currently utilizing surface- and (or) ground-water resources which are inadequate or of unknown capacity should consider exploring the availability of alternative, cost-effective water-supply sources to augment or meet their future water needs if necessary. While the basin's water resources are subject to contamination from a variety of sources, existing and

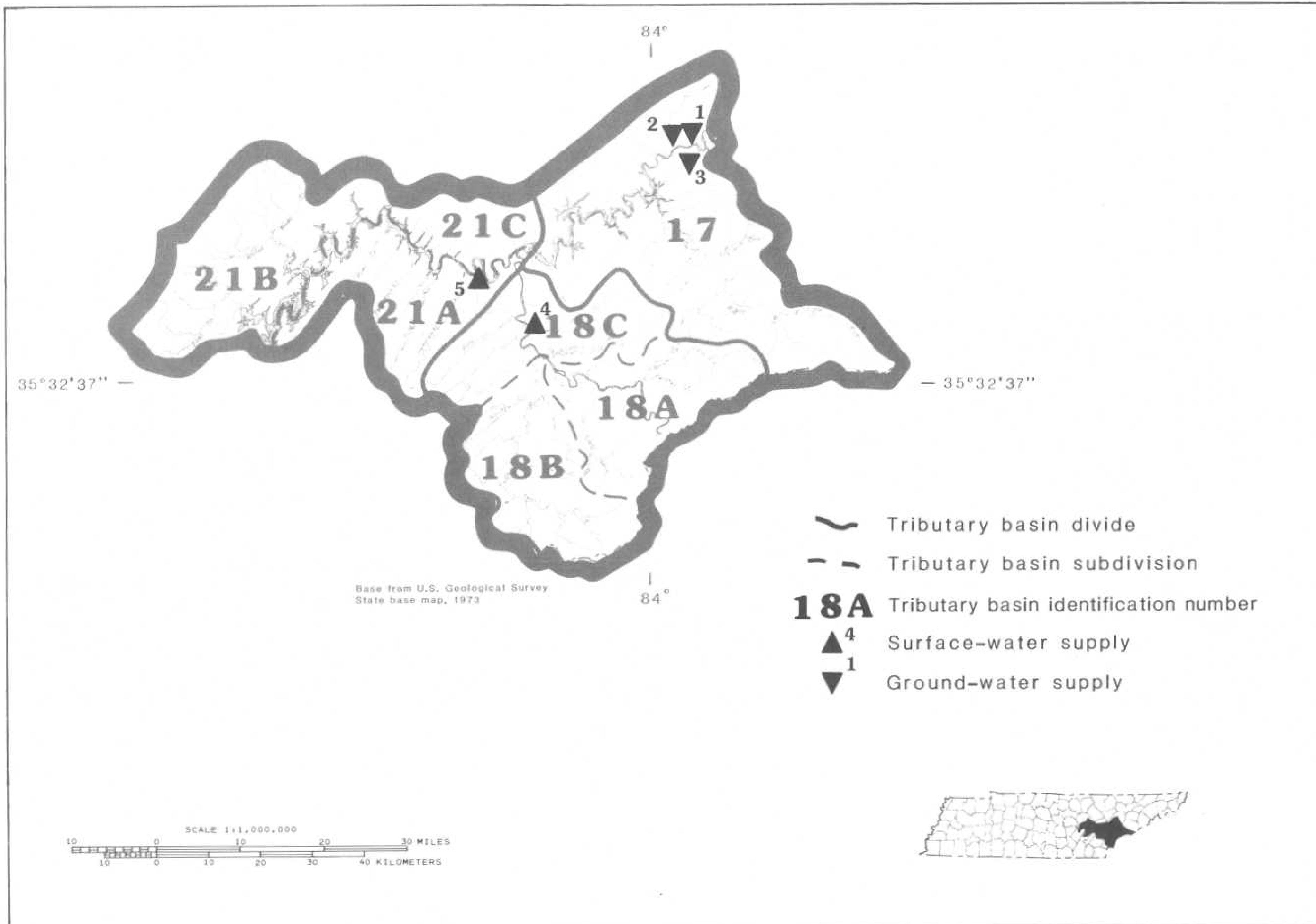


Figure 37.--Self-supplied commercial and industrial water users, Upper Tennessee River basin.

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 degradation of the basin's water resources. Potential sources of contamination 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 and quarries.

Although there are periods of extended drought which cause seasonal water table declines and periodic local problems with adequate ground-water supplies, observation-well data indicate there are no long-term, regional water table declines. 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 should be determined during the initial test pumping of the source.

TENNESSEE RIVER WESTERN VALLEY BASIN

Basin Description

The Tennessee River Western Valley basin encompasses 3,664 mi^2 of land and water area in Tennessee and consists of all or parts of the following tributary basins as delineated by the U.S. Geological Survey and Tennessee Department of Water Management in 1982.

Tributary basin No. (fig. 38)	Basin description	Tennessee drainage area (square miles)
29	Tennessee River east-side minor tributaries from Pickwick Landing Dam to just below Horse Creek.	241
30	Tennessee River west-side minor tributaries from Pickwick Landing Dam to just above Beech River.	612
31	Tennessee River east-side minor tributaries from below Horse Creek to below Cypress Creek.	534
32	Beech River	302
33A	Birdsong Creek	93
33B	Tennessee River west-side minor tributaries from below the Beech River to below Birdsong Creek.	210
33C	Tennessee River east-side minor tributaries upstream from the Duck River.	175
33D	Tennessee River small east-side minor tributaries area downstream from the Duck River.	4
36A	Tennessee River west-side minor tributaries from below Birdsong Creek to just above the Big Sandy River.	176
36B	Tennessee River east-side minor tributaries from below Birdsong Creek to the Tennessee-Kentucky State line.	470
37	Big Sandy River	629
45A	Tennessee River west-side minor tributaries including the Blood River and tributaries from the Big Sandy River to the Tennessee-Kentucky State line.	40

Tributary basin No. (fig. 38)	Basin description	Tennessee drainage area (square miles)
45B	Tennessee River west-side minor tributaries including the Clarks River and tributaries from the Big Sandy River to to the Tennessee-Kentucky State line.	16
46	Tennessee River west-side minor tributaries from Pickwick Landing Dam to the Tennessee-Alabama State line.	16
50	Tennessee River north-side minor tributaries from Pickwick Landing Dam to the Tennessee-Alabama State line.	146

Essentially, this basin encompasses all or major parts of Benton, Decatur, Hardin, Henderson, Henry, Houston, Humphreys, Perry, and Wayne Counties and minor parts of Carroll, Chester, and McNairy Counties. A map of the west-central Tennessee part of the basin which highlights the Tennessee River Western Valley basin is shown in figure 38.

Topography

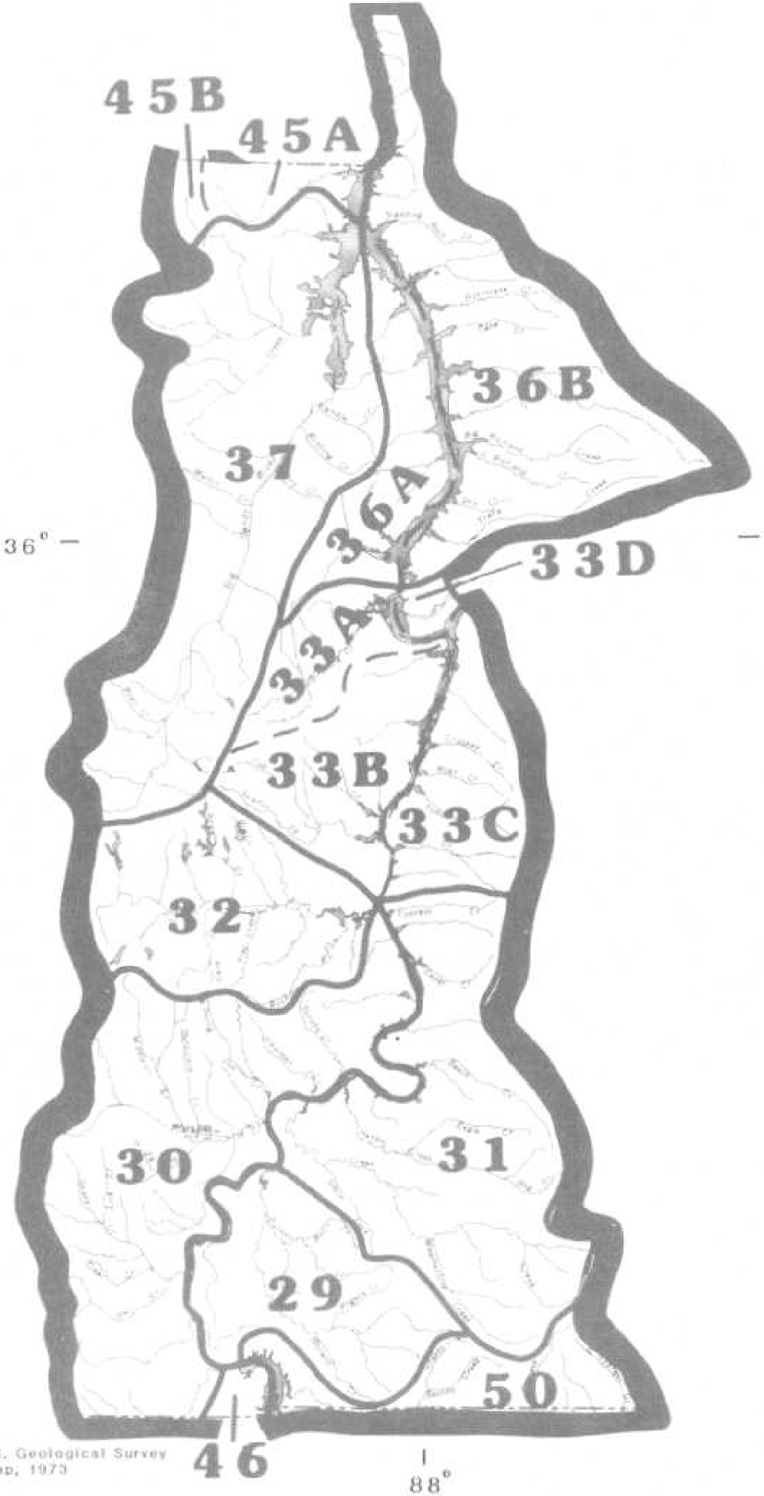
The Tennessee River in west Tennessee flows northward across the entire State for approximately 110 miles. While the sides of the river valley are dissected by many small tributaries, the Tennessee Valley itself is up to 20 miles in width. The Valley's flood plain ranges in width from 3.5 miles in Hardin County to only 1.5 miles in Houston and Benton Counties. Among the major streams and tributaries draining this basin are the Beech and Big Sandy Rivers plus Big, Birdsong, Cedar, Crooked, Cypress, Grassy, Hardin, Horse, Hurricane, Indian, Lick, Little Richland, Owl, Rushing, Snake, Standing Rock, Turkey, West Sandy, and White Oak Creeks. Throughout this part of the basin, the average stream slope is approximately 0.35 ft/mi. Watershed elevations in this area range from about 400 to 600 feet above sea level.

Hydrology

Surface Water

Surface- and ground-water resources in this part of the basin are fed by ample rainfall whose long-term (1941-70) average equals 52.01 inches. From 1970-79, the 10-year average precipitation equaled 58.81 inches with a low of 47.57 inches in 1978 and a high of 68.48 inches in 1973. A summary of average precipitation data for the basin's watershed subdivisions during the period from 1970 to 1979 is presented in table 49. Annual 1979 and long-term (1941-70) precipitation data for selected TVA and NWS rainfall stations in the Tennessee River Western Valley basin are presented in table 50.

The months of August, September, and October are usually the driest with the average rainfall ranging from 2.57 to 3.54 inches. During the remainder of



Base from U.S. Geological Survey
State base map, 1973

EXPLANATION

Tributary basin divide

Tributary basin subdivision

36A Tributary basin identification number

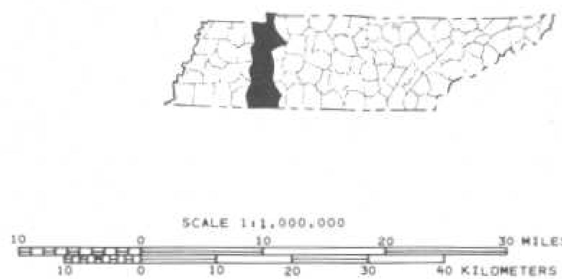


Figure 38.--Tennessee River Western Valley basin.

Table 49.--Precipitation data by watershed subdivision for the period 1970-79, Tennessee River Western Valley basin

Watershed description	Precipitation (inches)				
	High	Year	Low	Year	10-year average
Tennessee River from the Tennessee-Kentucky State line to New Johnsonville.	71.50	1979	44.30	1976	55.14
Tennessee River from New Johnsonville to the Pickwick Landing Dam.	74.00	1979	45.10	1976	59.85
Tennessee River from Pickwick Landing Dam to the Tennessee-Alabama State line.	70.20	1979	46.60	1976	59.52

Table 50.--Precipitation data for 1979 and for the period 1941-70 for selected rainfall stations, Tennessee River Western Valley basin

Station location	Station owner	Elevation above sea level (feet)	Period of record (years)	1979 Precipitation (inches)	Long-term annual precipitation (inches)
Buchanan	TVA	435	40	69.63	48.81
Springville	TVA	380	65	73.41	48.55
Paris	TVA	475	43	74.40	48.85
Wildersville	TVA	480	64	79.00	52.90
Cavvia	TVA	602	26	86.30	47.85
Cuba Landing	TVA	425	44	77.41	46.80
Center Ridge Church	TVA	545	27	77.70	51.75
Lexington	NWS	540	17	73.70	51.76
Chesterfield	TVA	455	27	72.60	51.49
Natchez Trace	TVA	490	27	81.99	51.78
Corinth Church	TVA	470	27	73.83	50.99
Scotts Hill	TVA	510	27	76.26	53.56
Perryville	TVA	390	84	70.91	50.65
Reagan	TVA	570	58	76.30	48.98
Olivehill	TVA	545	19	70.45	55.96
Pollards Mill	TVA	615	12	74.96	59.52
Pickwick Landing Dam	TVA	479	45	67.69	48.55

the year, average rainfall ranges from 4.05 to 5.72 inches with March having the greatest rainfall. More specifically, in the Tennessee River Western Valley basin, analysis of long-term precipitation records for the period 1941 to 1970 for selected rainfall stations at Springville, Perryville, and Pickwick Landing Dam indicates that the driest months of the year normally are August, September, and October with precipitation ranging from 2.42 to 3.61 inches. During the rest of the year, precipitation ranges from 3.73 to 5.60 inches. January, February, and March are the wettest months.

Average annual runoff in this basin usually ranges from 19 to 24 inches as one moves from north to south. Average discharge data for selected hydrologic data stations in the Tennessee River Western Valley River basin are contained in table 51. Most of this runoff occurs during the winter and spring months.

Major Reservoirs

Major reservoirs located in the Tennessee River Western Valley basin and their storage in acre-feet at normal minimum pool are Kentucky Reservoir (2,121,000) and Pickwick Reservoir (688,000). Note, major parts of both of these reservoirs are located in the States of Kentucky and Alabama, respectively. Wilson Reservoir (587,000) which is located on the Tennessee River in north Alabama also has a significant impact on streamflow in the Tennessee River above Pickwick Landing Dam. Detailed information describing the location and operation pattern of Pickwick Landing and Wilson Reservoirs follows:

Pickwick Reservoir

Location and drainage area.--Pickwick Reservoir is formed by Pickwick Landing Dam which is located on the Tennessee River at river mile 206.7 in Hardin County. Pickwick Landing Dam controls 32,820 mi^2 of drainage area.

Reference period.--1960-81.

Reservoir discharge (minimum daily average flow).--Through the reference period, the minimum daily average discharge from Pickwick Landing Dam ranged from a low of about 5,200 ft^3/s (3,360 Mgal/d) in 1976 to a high of about 26,900 ft^3/s (17,386 Mgal/d) in 1979. The average, 1-day minimum discharge during the reference period was about 13,186 ft^3/s (8,522 Mgal/d).

Average number of days of zero flow.--None.

Existing agreements regarding reservoir releases.--Pickwick Landing Dam is operated to provide adequate releases to maintain a minimum tailwater elevation of 355 feet above sea level for navigation purposes. This requires substantial releases, particularly when Kentucky Reservoir is drawn down to its winter pool level elevation of 354 feet above sea level.

Wilson Reservoir

Location and drainage area.--Wilson Reservoir is formed by Wilson Dam which is located on the Tennessee River at river mile 259.4 in Colbert and Lauderdale Counties in North Alabama. Wilson Dam controls 30,750 mi^2 of drainage area.