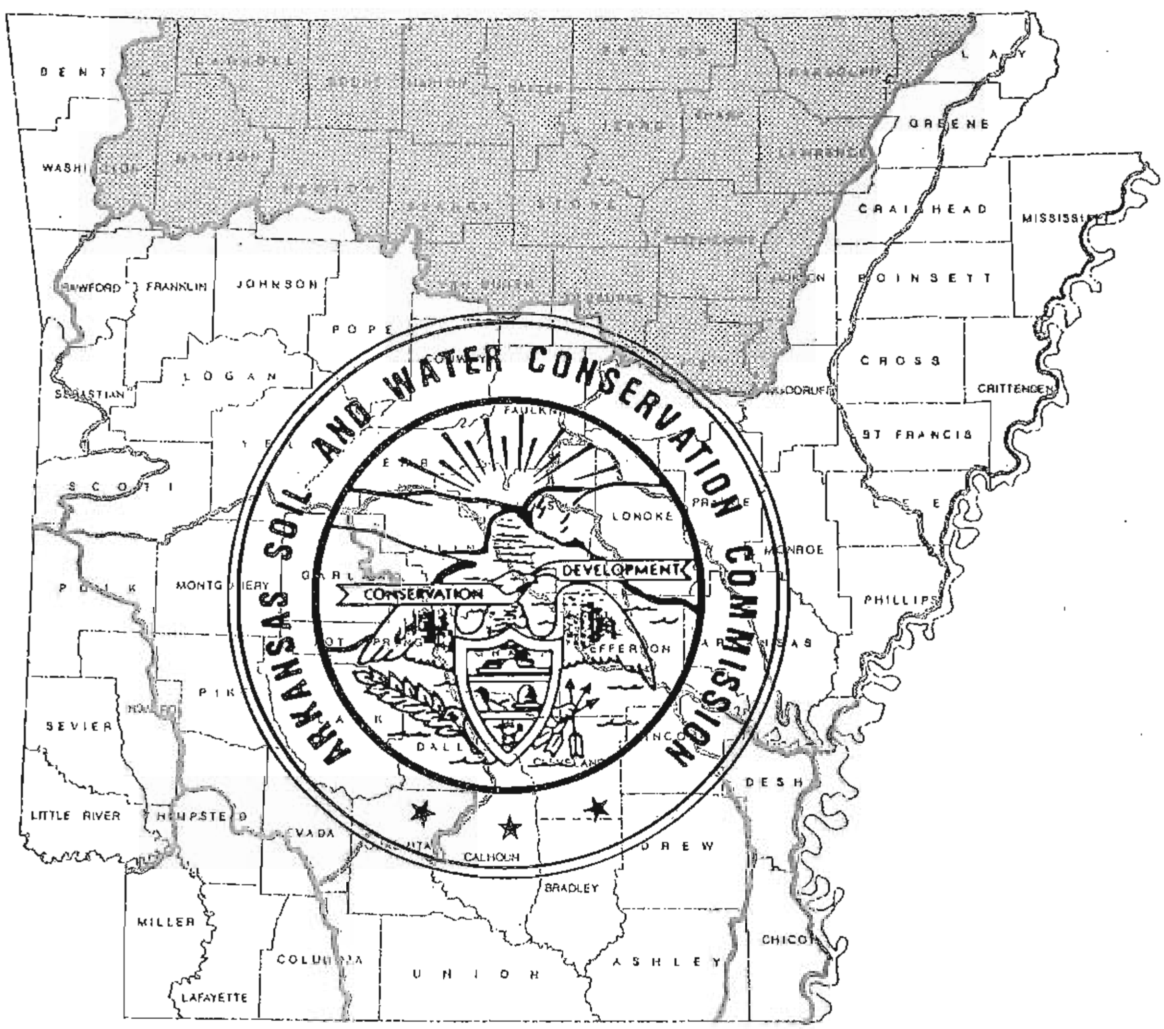
ARKANSAS STATE WATER PLAN

UPPER WHITE RIVER BASIN



Prepared for
Arkansas Soil and Water Conservation Commission
by

U.S. Army Corps
of Engineers
Little Rock District

PREFACE

The Arkansas Soil and Water Conservation Commission received statutory authority to begin work on the first Arkansas State Water Plan in 1969. Act 217 gave specific authority to the Commission to be the designated agency responsible for water resources planning at the state level. The act mandated the preparation of a comprehensive state water plan of sufficient detail to serve as the basic document for defining water policy for the development of land and water resources in the State of Arkansas.

The first State Water Plan was published in 1975 with five appendices that addressed specific problems and needs in the state. As more data have become available, it is apparent that the ever-changing nature and severity of water-resource problems and potential solutions require the planning process to be dynamic. Therefore, periodic revisions to the State Water Plan are necessary for the document to remain valid.

This report is the sixth of eight River Basin Reports to be published as a component of the 1986 Arkansas State Water Plan. The objectives of this plan are to incorporate new data available from recent research, re-evaluate new and existing problems, present specific solutions and recommendations, and satisfy the requirements of Act 1051 of 1985 for the Upper White River Basin.

ACKNOWLEDGEMENTS

The information and assistance provided by representatives of State and Federal agencies, organizations, and associations are gratefully acknowledged. Personnel form several agencies (Arkansas Department of Health, Arkansas Soil and Water Conservation Commission, U.S. Geological Survey, and Arkansas Natural Heritage Commission) were especially helpful.

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ABSTRACT

The Upper White River Basin comprises 7.5 million acres of the northern part of the state. The land use of the basin is composed of 58 percent forest land, 29 percent grassland, 9 percent cropland and 4 percent urban, builtup and other. The topography is predominately hills and mountains with level alluvial land at the eastern boundary.

Water use in the study area totaled 4,282.7 million gallons per day (mgd) in 1980.

The major streams within the Upper White River Basin are the White River and the Black River. The streams of the basin have steep gradients in their upper reaches, but at the downstream alluvial segments, the slope of the gradients become flatter.

The average annual yield of the streams of the Upper White River Basin is approximately 18.3 million acre-feet. Streamflow is adequate on an annual basis to meet existing water demands. The streamflow pattern is for high flows during the winter months and lower flows in the summer months when the greatest period of water use occurs. A majority of streams in the basin have high base flows which is due to basin geology. Of the 18.3 million acre-feet available annually, 1.7 million acre-feet is excess stream flow which is available on an average annual basis for other uses.

In the Upper White River Basin, the quality of surface water is generally good due to the less intensive land uses. Concentrations of most constituents are within acceptable limits. Streams and reservoirs support most beneficial uses. Water quality problems which exist are water quality violations from municipal waste water treatment plants and high numbers of fecal coliforms from free-grazing livestock and land application of animal waste.

There are no critical surface water areas in the Upper White River Basin based on quantity or quality problems. Shortages of water may exist, at times, caused by droughts or variation in reservoir releases.

Solutions to surface water problems in the Arkansas River Basin are water conservation, alternate source development, land use change, and implementation of best management practices.

Ground water use in the Upper White River basin amounted to 304 million gallons per day in 1985. Approximately 89 percent of the ground water used in the study area was used for irrigation. In the period 1965 to 1985, ground water use increased approximately 700 percent. Water withdrawal from the Rocks of Paleozoic Age have decreased 16 percent after peaking in 1980.

Rocks of Paleozoic age and Quaternary deposits are the sources of ground water in the Upper White River Basin. There are isolated wells withdrawing water from deeper subsurface formations such as the Eminence-Potosi, Gasconade-Van Buren, and Roubidoux Formations.

Yields from Rocks of Paleozoic age are usually less than 10 gallons per minute due to the limited storage in the consolidated units. The primary use of the Rocks of Paleozoic age is rural domestic.

Quaternary deposits are used as a source of ground water in the Mississippi Alluvial Plain. Wells into the Quaternary deposits generally yield 1,000 gallons per minute, but yields as high as 2,280 gallons per minute have been reported. Irrigation and rural domestic uses are the major users of the Quaternary deposits.

The ground water quality of the Rocks of Paleozoic age is representative of the mineral content of the formations. This ground water does not need treatment for domestic and some industrial users. Quaternary aquifers contain hard to very hard water with high iron content.

There have been no critical ground water areas designated in the Upper White River Basin. There are isolated cases where there are water quality problems such as two areas of saline intrusion near Bald Knob and Cord.

The major ground water problem in the study area is the lack of yield of the Rocks of Paleozoic age.

Potential exists for the contamination of ground water in the Upper White River Basin. Landfills, surface impoundments, hazardous waste operations, storage tanks, septic tanks and saline water intrusion are the potential hazards in the study area. Legislation is already in place for controlling or denying construction of liquid waste holding impoundments. Proper administration of the Resource Conservation and Recovery Act program should contribute to the control of groundwater contamination from hazardous wastes.

CHAPTER 1

GENERAL DESCRIPTION

GENERAL DESCRIPTION

Location and Size

The White River originates in the Boston Mountains in the western part of the Basin and flows in a generally northerly direction to the Missouri-Arkansas State line (river mile 591.9), thence in a generally easterly direction for about 115 miles in southern Missouri and for about 30 miles along either side of the state line until it crosses back into Arkansas at about mile 447.5. Downstream from that point, it flows in a generally southeasterly direction to the mouth of the Black River (mile 264.9) near Newport, Arkansas, and then, in a southerly direction to join the Mississippi River in the northeast corner of Desha County.

The White River Basin includes the Black River and comprises about 22,377 square miles, of which 10,693 are in the southern part of Missouri and 11,684 are in northern and eastern parts of Arkansas. The Upper White River Basin discussed in this report lies entirely in the State of Arkansas and consists of the upper portion of the White River Basin which extends down to just below the confluence with the Little Red River at river mile 182.6. The Upper White River Basin comprises about 11,684 square miles and encompasses a significant portion of the extreme northern section of the State of Arkansas.

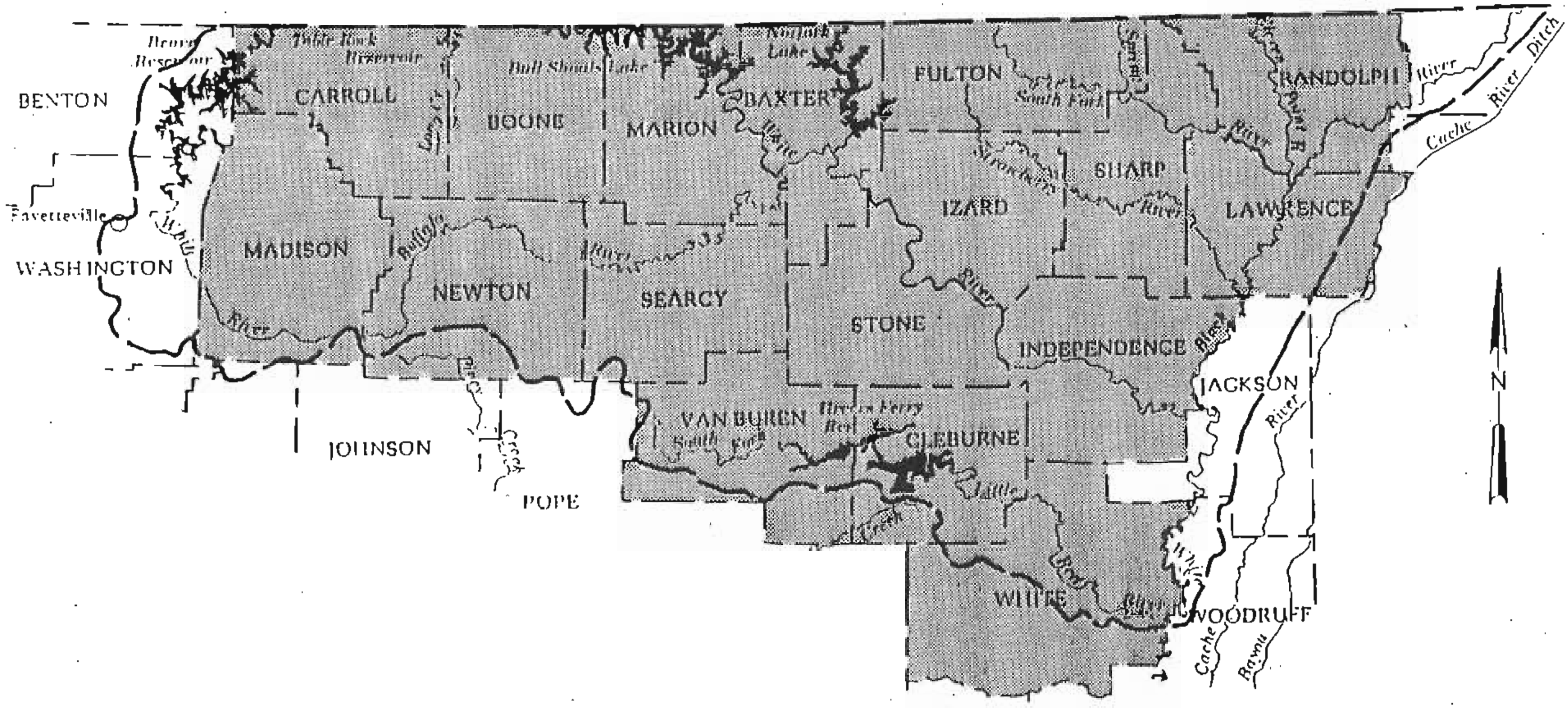
The basin is bounded by the Arkansas-Missouri State line on the north and is bounded by the natural hydrologic boundaries on the remaining sides. Major tributaries to this portion of the White River Basin include the North Fork River, Buffalo River, Black River, and the Little Red River in Arkansas. The basin streamflow is also affected by tributaries such as the Kings River, James River, and the Little North Fork River which have a part of their drainage areas in Missouri. The area of the Upper White River Basin is shown in Figure 1-1.

There are six major impoundments located in the basin including Lakes Beaver, Taneycomo, Table Rock, and Bull Shoals, all on the White River; Lake Norfork on the North Fork of the White River; and Greers Ferry Lake on the Little Red River. Portions of Table Rock, Bull Shoals, and Norfork Lakes are located within the State of Missouri. Lake Taneycomo is located entirely in Missouri. All of these impoundments are Corps of Engineers projects except Lake Taneycomo which is owned by Empire Electric Company.

Topography and Physiography

The northernmost portion of the study area is comprised of the Ozark Highlands, which range in elevation from 500 to 1,400 feet NGVD. The topography of the Ozark Highlands ranges from moderately sloping plateaus to mountainous areas with slopes that range from moderately sloping to very steep. The southern and southwestern portion of the study area is comprised of the Boston Mountains which range in elevation from 500 to 2,300 feet NGVD. The Boston Mountains are characterized by moderately sloping hilltops and rolling hills and moderately sloping to steep hillsides and mountain sides.

The Arkansas Valley and Ridges comprises a small area in the south-central portion of the study area. Elevations of the valley floor range from 300 to 500 feet, with mountains protruding from 1,200 feet to 2,000 feet NGVD. Slopes in the valleys and on ridge tops are level to gently sloping and



LEGEND

BASIN BOUNDARY

COUNTY IN STUDY

UPPER WHITE RIVER BASIN

VICINITY AND STUDY AREA MAP

FEBRUARY 1988

Figure 1-

hillsides and mountain sides are moderately sloping to steep. The southern Mississippi Valley Alluvium lies at the eastern edge of the study area. Elevations range from 170 to 400 feet NGVD and slopes range from nearly level to undulating. The physiographic regions are illustrated in Figure 1-2.

Climate

The Upper White River Basin lies in a semihumid region characterized by long summers, relatively short winters, and a wide range of temperatures. Extremes in air temperatures may vary from winter lows around 0 degrees Fahrenheit usually caused by Canadian air masses to summer highs above 100 degrees Fahrenheit. Extreme temperatures may occur for short periods of time at any location within the basin. The mean temperature during January is 40 degrees Fahrenheit and the mean temperature during July is 81 degrees Fahrenheit (Ag. Yearbook, 1941). The length of the growing season averages 200 days. Mean annual precipitation in the study area varies from 42 inches to 50 inches per year as shown in Figure 1-3 (Freiwald, 1985).

Population and Economy

Population and economic data are available by county. The county boundaries do not coincide with the hydrologic boundaries of the study. The study area includes 28 counties, but only 17 counties make up the majority of the land in the study area. The remaining 11 counties will be omitted from this discussion of population and economic data because of the relatively small area that they contribute to the Upper White River Basin and their relatively small impact on population and economic data.

The total 1980 population of the 17 counties in the study area is 299,890. This figure represents an increase from the 1970 census of about 39 percent, or 83,453 people. All of the counties in the study area showed an increase for that period of time. Table 1-1 shows the population trend in the study area since 1900. Figure 1-4 graphically displays this population trend.

The generally accepted measure of individual welfare in an area is its per capita personal income. It is determined by dividing the total personal income in an area by its total population. The 1981 per capita personal income for this area ranged from a low of $4,147 in Newton County to a high of $8,353 in Baxter Bounty. The weighted average per capita income is $6,597 for the 17 county area (Figure 1-5). This compares to $8,041 for the State and $10,495 nationally.

Income and poverty characteristics in the study area are shown in Table 1-2. Poverty level is based on income, age of householder, and number of children under 18 in a household. The poverty level for families ranges from $3,858 for 2 adults with no children to $14,024 for a family of 9 or more persons with 8 or more children.

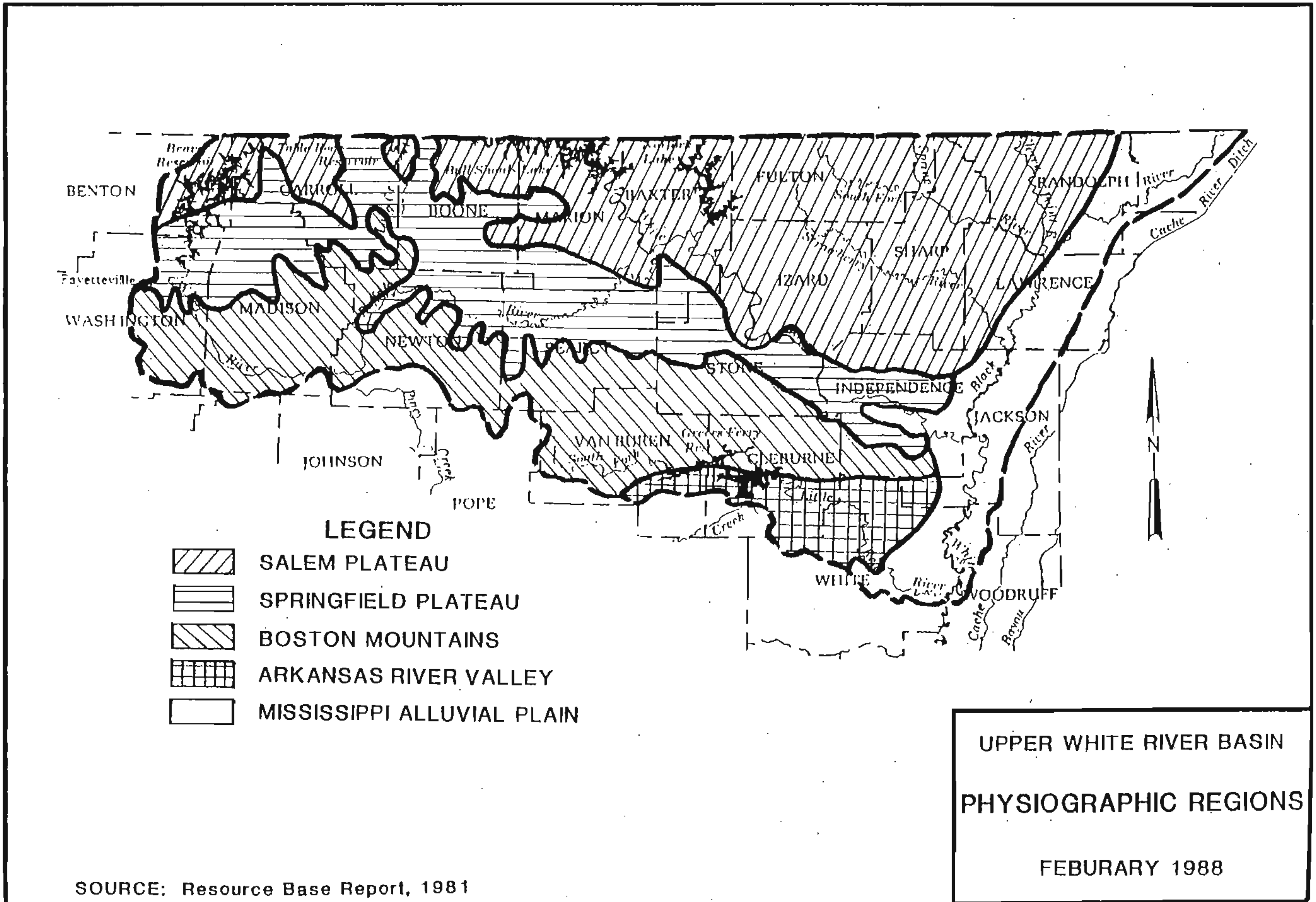
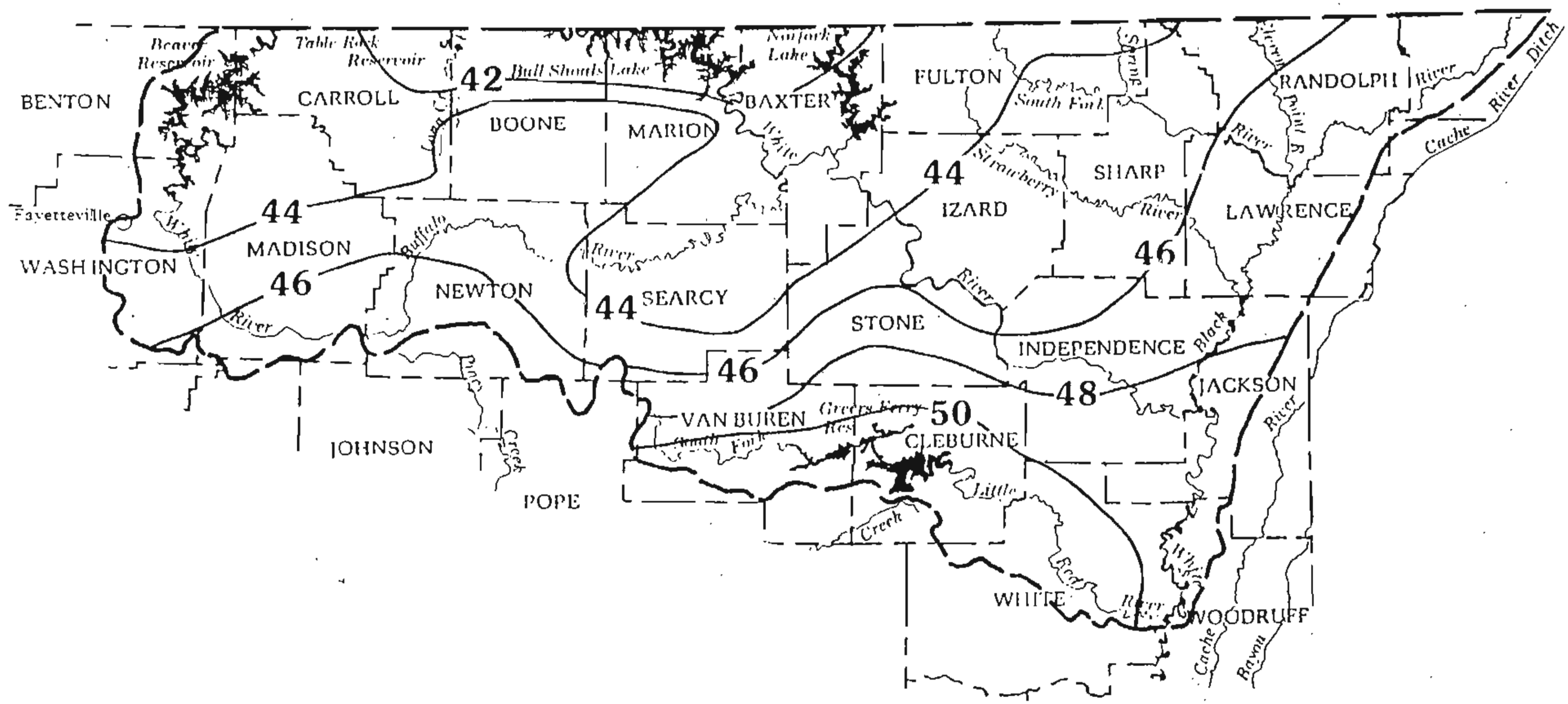

BENTON
CARROLL
BOONE
MARION
BAXTER
FULTON
RANDOLPH
SHARP
IZARD
LAWRENCE
Fayetteville
WASHINGTON
MADISON
NEWTON
SEARCY
STONE
INDEPENDENCE
JACKSON
JOHNSON
POPE
VAN BUREN
CLEBURNE
WHITE
WOODRUFF
Cache River Ditch
Black
N
LEGEND
SALEM PLATEAU
SPRINGFIELD PLATEAU
BOSTON MOUNTAINS
ARKANSAS RIVER VALLEY
MISSISSIPPI ALLUVIAL PLAIN
UPPER WHITE RIVER BASIN
PHYSIOGRAPHIC REGIONS
FEBURARY 1988
SOURCE: Resource Base Report, 1981

Figure 1-2



UPPER WHITE RIVER BASIN

MEAN ANNUAL PRECIPITATION

FEBRUARY 1988

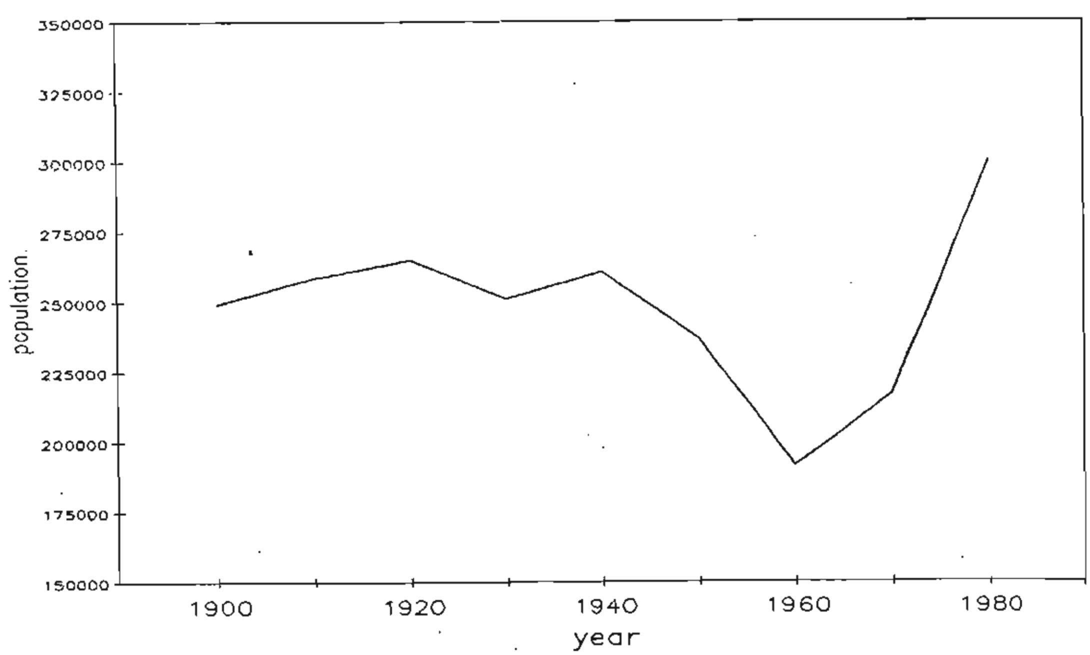
SOURCE: FREIWALD, 1985

TABLE 1-1 POPULATIONS BY COUNTY (1900 to 1980) IN THE UPPER WHITE RIVER BASIN

County	Year								
	1900	1910	1920	1930	1940	1950	1960	1970	1980
Baxter	9,298	10,389	10,216	9,519	10,281	11,683	9,943	15,319	27,409
Boone	16,396	14,318	16,098	14,937	15,860	16,260	16,116	19,073	26,067
Carroll	18,848	16,829	17,786	15,820	14,737	13,244	11,284	12,301	16,203
Cleburne	9,628	11,903	12,696	11,373	13,134	11,487	9,059	10,349	16,909
Fulton	12,917	12,193	11,182	10,834	10,253	9,187	6,657	7,699	9,975
Independence	22,557	24,776	23,976	24,225	25,643	23,488	20,048	22,723	30,147
Izard	13,506	14,561	13,871	12,872	12,834	9,953	6,766	7,381	10,768
Lawrence	16,491	20,001	22,098	21,663	22,651	21,303	17,267	16,320	18,447
Madison	19,864	16,056	14,918	13,334	14,531	11,734	9,068	9,453	11,373
Marion	11,377	10,203	10,154	8,876	9,464	8,609	6,041	7,000	11,334
Newton	12,538	10,612	11,199	10,564	10,881	8,685	5,963	5,844	7,756
Randolph	17,156	18,987	17,713	16,871	18,319	15,982	12,520	12,645	16,834
Searcy	11,988	14,825	14,590	11,056	11,942	10,424	8,124	7,731	8,847
Sharp	12,199	11,688	11,132	10,715	11,497	8,999	6,319	8,233	14,607
Stone	8,100	8,946	8,779	7,993	8,603	7,662	6,294	6,838	9,022
Van Buren	11,220	13,509	13,666	11,962	12,518	9,687	7,228	8,275	13,357
White	24,864	28,574	34,603	38,269	37,176	38,040	32,745	39,253	50,835
Total	248,947	258,370	264,677	250,883	260,324	236,427	191,442	216,437	299,890

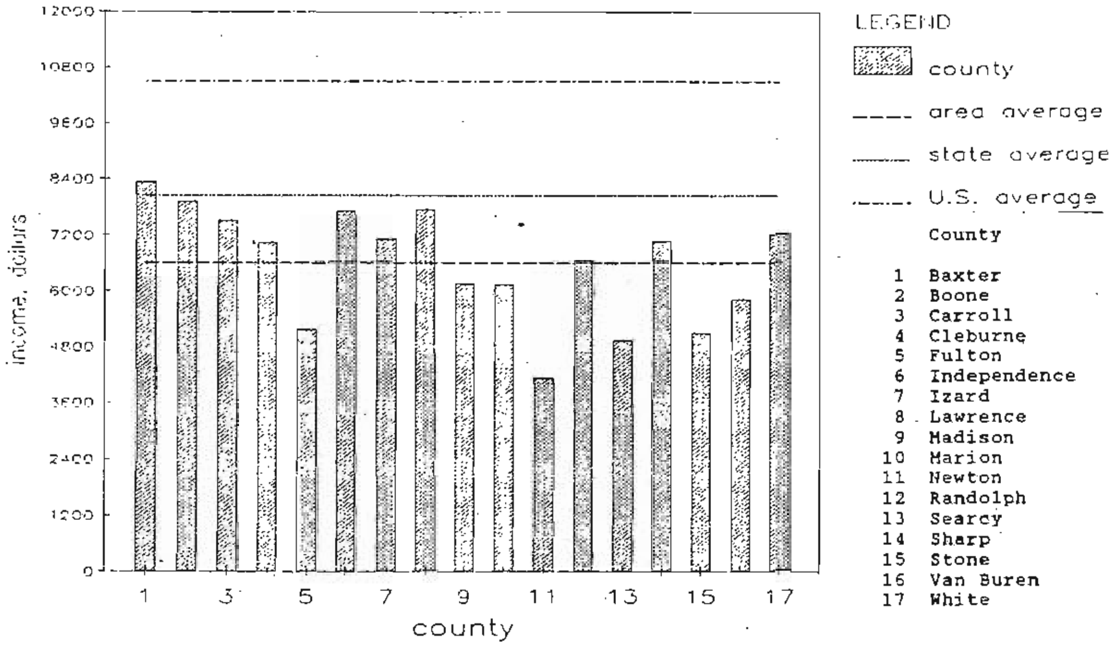
SOURCE: U.S. Department of Commerce, Bureau of Census.

FIGURE 1-4 UPPER WHITE RIVER BASIN
STUDY AREA POPULATION TREND
1900 to 1980



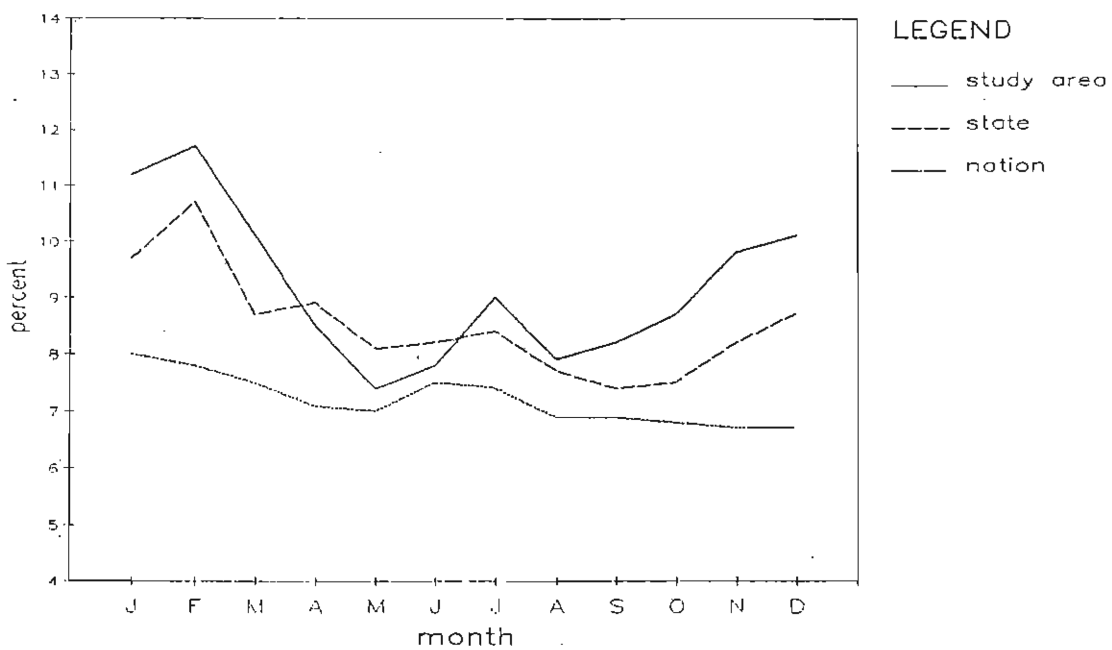
SOURCE: U.S. Dept. of Commerce, Bureau of Census

FIGURE 1-5 UPPER WHITE RIVER BASIN STUDY AREA PER CAPITA INCOME FOR 1979



SOURCE: U.S. Dept. of Commerce, Bureau of Census

FIGURE 1-6 UPPER WHITE RIVER BASIN UNEMPLOYMENT RATES FOR 1985



SOURCE: Arkansas Employment Security Division

TABLE 1-2

INCOME AND POVERTY CHARACTERISTICS1/

IN THE UPPER WHITE RIVER BASIN

	Above Poverty Level	Below Poverty Level	All Income Levels
Total Persons	241,790	58,100	299,890
Percent of Persons	80.6%	19.4%	100.0%
Total Families	73,832	14,546	88,378
Percent of Families	83.5%	16.5%	100.0%

1/ U. S. Department of Commerce Bureau of the Census 1983 (1980 census data based on 1979 income).

Unemployment rates in the study area are shown in Figure 1-6.

CHAPTER 2

LAND RESOURCES INVENTORY

LAND RESOURCES INVENTORY

Current Land Use

Most of the area in the Upper White River Basin is forest land. Of the total 7,477,441 acres in this basin, forest land accounts for 4,372,783 acres or 58.5 percent. Grassland makes up 2,132,545 acres or 28.5 percent of the basin and cropland covers 697,700 acres or 9.3 percent. Urban and built-up land accounts for 122,754 acres (1.7 percent) and water and other lands make up the remaining 151,659 acres or 2.0 percent (See Table 2-1).

a. Cropland. Of the 697,700 acres which are cropland, 75 percent (520,096 acres) is in soybeans; 13 percent (94,272 acres) is in rice; 7 percent (46,702 acres) is in grain sorghum; 3 percent (18,621 acres) is in cotton; and the remaining 2 percent (18,009 acres) is in a variety of other crops.

b. Forest Land. Most of the land in the Upper White River basin is forest land. Of the total 7,477,441 acres in this basin, forest land accounts for 4,372,783 acres or 58.5 percent. In the following tables, it can be seen that the oak-hickory forest is the dominant forest type, followed by the oak-pine association, with cedar glades a distant third (Table 2-2). Table 2-3 depicts forest land acreage by ownership while Table 2-4 compares the commercial and noncommercial forest land acreage.

TABLE 2-2

FOREST LAND BY FOREST TYPE 1/

FOREST TYPE	ACRES	PERCENT
Loblolly - Shortleaf Pine	83,083	1.9
Oak - Pine	896,420	20.5
Oak - Hickory	2,990,984	68.4
Oak - Gum - Cypress	122,438	2.8
Elm - Ash - Cottonwood	21,864	0.5
Cedar	257,994	5.9
TOTAL	4,372,783	100.0

Source: U.S.D.A., Soil Conservation Service, R.I.D.S.

TABLE 2-3

FOREST LAND BY OWNERSHIP 1/

OWNERSHIP	ACRES	PERCENT
Federal	393,551	9.0
State	83,082	1.9
City	0	0

Table 2-1 Present Landuse in the Upper White River Basin

County	Cropland	Grassland	Forest Land	Urban & Builtup	Other	Total Acres In Basin	Total Acres In County	Percent of County in Basin
Baxter	-	93,037	251,317	-	25,566	369,920	369,920	100
Benton	-	26,421	92,101	-	6,112	124,634	567,040	22.0
Boone	-	181,022	183,074	11,965	10,499	386,560	386,560	100
Carroll	-	181,908	189,460	17,584	16,808	405,760	405,760	100
Clay	88,911	11,884	26,042	-	3,623	130,460	409,600	31.9
Cleburne	5,308	65,492	218,847	2,349	28,187	320,183	380,800	84.1
Conway	-	-	28	-	-	28	358,400	.0
Craighead	62	-	-	-	-	62	458,880	.0
Crawford	-	-	82	-	-	82	388,480	.0
Franklin	-	2,483	9,929	-	-	12,412	398,720	3.1
Fulton	-	185,576	205,464	-	-	391,040	391,040	100
Greene	1,965	-	2,039	-	-	4,004	370,560	1.1
Independence	65,044	165,119	241,651	5,502	9,084	486,400	486,400	100
Izard	-	155,451	203,427	10,402	-	369,280	369,280	100
Jackson	171,507	16,408	29,738	15,829	-	233,482	407,680	57.3
Lawrence	157,031	50,903	110,589	4,990	3,061	326,574	378,880	86.2
Madison	-	158,295	348,249	-	-	506,544	532,480	95.1
Marion	-	105,880	271,513	5,578	24,709	407,680	407,680	100
Newton	-	50,093	383,820	-	-	433,913	526,080	82.5
Pope	-	4,028	12,823	-	-	16,851	529,920	3.2
Randolph	71,088	140,670	196,729	2,345	-	410,832	414,080	99.2
Searcy	-	131,170	286,712	-	2,664	420,546	424,960	99.0
Sharp	-	106,621	259,232	16,867	-	382,720	382,720	100
Stone	-	59,290	327,873	-	4,517	391,680	391,680	100
Van Buren	-	75,043	247,892	9,948	-	332,883	456,960	72.8
Washington	2,310	79,455	128,655	12,042	2,354	224,816	616,320	36.5
White	89,039	86,296	138,323	7,353	7,301	328,312	665,600	49.3
Woodruff	45,435	-	7,174	-	7,174	59,783	379,520	15.8
Total	697,700	2,132,545	4,372,783	122,754	151,659	7,477,441		

Source: U.S.D.A., Soil Conservation Service, RIDS.

TABLE 2-3

FOREST LAND BY OWNERSHIP (cont.)1/

OWNERSHIP	ACRES	PERCENT
Forest Industry	69,965	1.6
Private	3,826,185	87.5
TOTAL	4,372,783	100.0

1/ U. S. D. A. - Soil Conservation Service, 1977 RIDS.

TABLE 2-4

COMMERCIAL AND NONCOMMERCIAL FOREST LAND 1/

ITEM	COMMERCIAL	NONCOMMERCIAL	TOTAL
Percent in Basin	96.9	3.1	100.0
Acres	4,237,227	135,556	4,372,783

1/ U. S. D. A. - Soil Conservation Service, 1977 RIDS.

Wetlands

Wetlands, as used in this report, refers to low land areas which remain saturated with water for extended periods of time. Wetlands found in the Upper White River Basin are wet meadows, freshwater marshes, and bottomland hardwood wetlands. These wetlands have populations of plants and animals which are unique to these areas. Not only do these areas have unique species of plants and animals, these wetland areas have large numbers of plants and animals which are of great value to man.

Major functions of wetlands are food and cover for fish and wildlife, water quality improvement, soil enrichment, erosion control and downstream fishery benefits.

Natural wetland acreage in Arkansas has been reduced by modern farming, urban development, and other uses such as highways, airports, etc., to approximately 317,051 acres. In the Upper White River Basin, there are approximately 40,000 acres of wetlands, of which about 20,500 acres are forested wetlands (Arkansas Resource Base Report).

Wetlands are waters of the United States and are subject to regulation by the U.S. Army Corps of Engineers as promulgated by Section 404 of the Clean Water Act (CWA) of 1977, as amended. Any discharge of dredge or fill material in a wetland that is adjacent to a Phase I, II, or III stream (as described in Section 404 of the CWA, 1977) will require a permit from the Corps of Engineers (in this case the Little Rock District Corps of Engineers).

Projected Land Use

Land use in the Upper White River Basin is not anticipated to change significantly. The land use expected to show the largest gain is urban. Real estate speculators are investing in areas and developing them for retirement resorts. Forest land and grassland are expected to be converted by small amounts to urban.

Changes are predicted to occur within cropland. One major change is more acres of crops are expected to be irrigated to increase production. In Table 2-5, the projected acres of irrigated crops for the year 2030 are shown.

TABLE 2-5 IRRIGATED CROPLAND PROJECTIONS

FOR THE YEAR 2030 IN THE UPPER WHITE RIVER BASIN

CROP	ACREAGE
Rice	83,900
Cotton	43,700
Soybeans	267,800
Corn	700
Grain Sorghum	1,000
Total	397,100

Source: Agricultural Water Use Study, 1983

The projections in Table 2-5 predict a 183 percent increase in the acres of irrigated crops. Rice acreage is shown to decrease 20 percent. The crop with the largest increase in irrigated acreage is cotton with a 7,817 percent increase. Acres of irrigated soybeans is also projected to increase significantly; 894 percent.

The potential exists for these projections to occur. There is adequate land for this change to occur; prime farmland - 1,050,000 acres and current cropland - 697,700 acres. Additional water, both ground water and surface water, is available in the alluvial areas of the Upper White River Basin.

The main factor influencing the development of farm operations is economics. Currently with the depressed prices farmers are receiving for their crops, farmers are not expanding or upgrading their operations.

Urban and Built-up Areas

Urban and built-up areas involve high density urban functions, small acreage of land and large numbers of people. The greatest use of these lands is residential, with transportation, communications, and utilities accounting for a majority of the remaining uses. Other uses are industrial sites, cemeteries, golf courses, shooting ranges, and institutional sites. Urban and built-up land accounts for 122,754 acres (1.7 percent).

SOIL RESOURCES

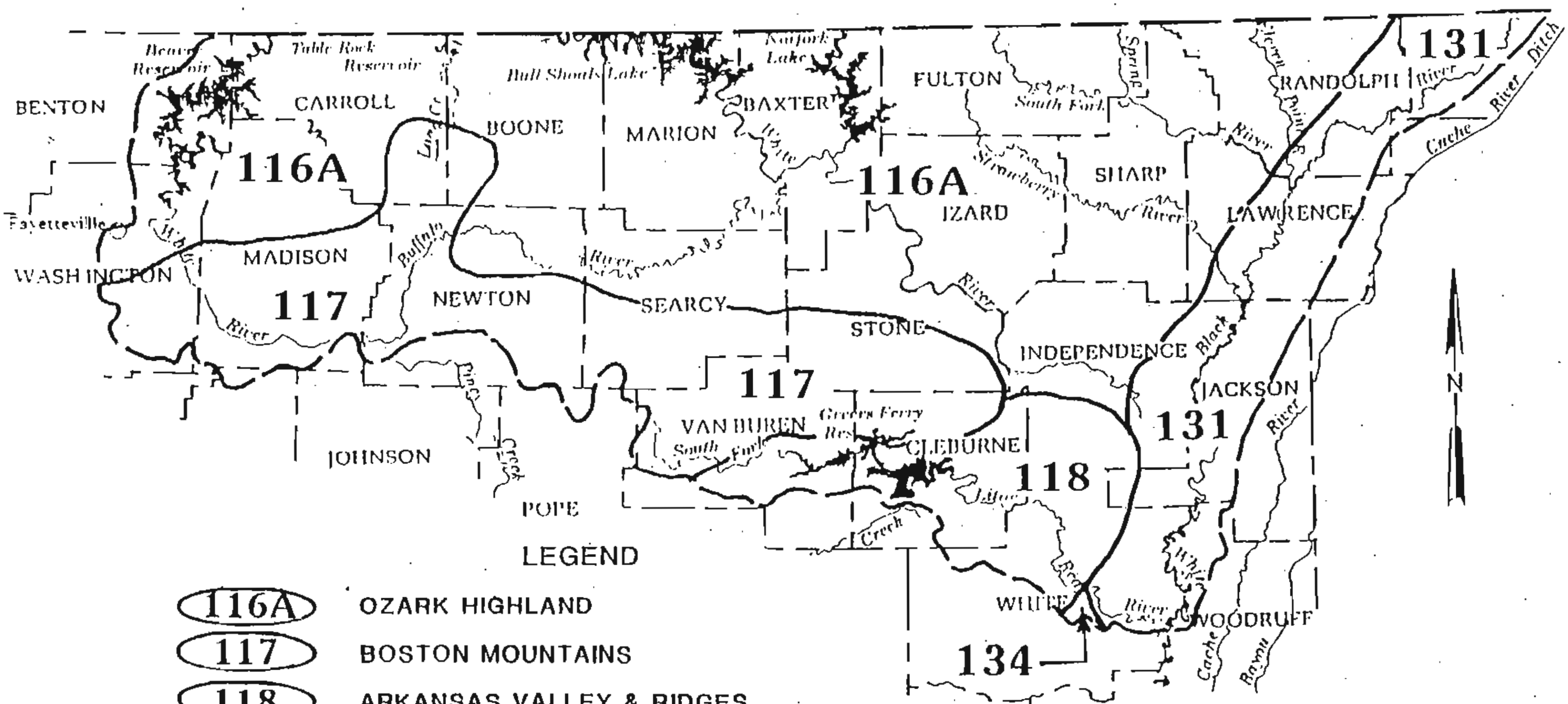
Major Land Resource Areas

There are four Major Land Resource Areas (MLRA'a) in the Upper White River Basin (see Figure 2-1). Their names and a general description of their soils are found in the following paragraphs. More specific soils descriptions can be found in county soil surveys published by the Soil Conservation Service.

a. Ozark Highlands are comprised chiefly of limestone and dolomite hills and valleys in the northern part of the state along the Arkansas-Missouri state line. Elevations range from about 500 to 1,400 feet above sea level. The soil developed mainly from limestone and dolomite from deep to shallow and is rapidly to very slowly permeable. Surface textures are mainly silt loam and very cherty silt loam. The most productive soils occur on nearly level to moderately sloping plateaus and narrow stream valleys and are used for orchards, pasture, and row crops. The more mountainous areas have slopes that range from moderately sloping to very steep. Some of the less sloping areas are used for pasture production with steeper areas remaining in hardwood timber.

b. The Boston Mountains are remnants of an old plateau in the northern part of the state bordering the Ozark Highlands area. The mountains are capped by sandstone. Soils were formed from interbedded sandstone and shale on the steep mountainsides. Elevations range from about 500 to 2,300 feet above sea level. Soils formed from sandstone and shale are deep to shallow and rapidly permeable to very slowly permeable. Surface textures are mainly sandy loam, gravelly sandy loam, or stony sandy loam. Most of this area remains in woodland. Narrow valleys and ridgetops have been cleared and are used mainly for pasture. This association consists of moderately sloping hilltops and rolling hills and moderately sloping to steep hillsides and mountainsides.

c. Arkansas Valley and Ridges are comprised of broad valleys, narrow ridges, and high flat topped mountains in the central portion of the state. Elevations of the valley floor range from 300 to 500 feet, with mountains protruding from 1,200 feet to 2,800 feet above sea level. Soils developed from sandstone and shale. Soils are deep to shallow and are rapidly permeable to very slowly permeable. Surface textures are mainly sandy loam, gravelly sandy loam, or stony sandy loam. Slopes in the valleys and on ridgetops are level to gently sloping and hillsides and mountainsides are moderately sloping to steep. The valleys are mainly used for pasture production. The steeper areas remain in woodland.



LEGEND

- 116A — OZARK HIGHLAND
- 117 — BOSTON MOUNTAINS
- 118 — ARKANSAS VALLEY & RIDGES
- 131 — SOUTHERN MISSISSIPPI VALLY ALLUVIUM
- 134 — SOUTHERN MISSISSIPPI VALLEY SILTY UPLANDS

UPPER WHITE RIVER BASIN

MAJOR LAND RESOURCE AREAS

FEBRUARY 1988

SOURCE: RESOURCE BASE REPORT, 1981

Figure 2-1

d. Mississippi Valley Alluvium consists of broad alluvial plains. Elevations range from about 100 to 400 feet above sea level. Soils developed from deep sediments. The soils are deep and rapidly permeable to very slowly permeable. Surface textures are mainly sandy loam, silt loam, or clay. Slopes are dominantly level to nearly level and some areas are undulation. This area is used extensively for production of cultivated crops.

General Soil Units

Below are listed the general soil units for the different Major Land Resource Area.

a. Ozark Highlands, Limestone and Dolomite

Clarksville - Nixa - Noark

Gepp - Doniphan - Gassville - Agnos

Arkana - Moko

Captina - Nixa - Tonti

Eden - Newnata - Moko

b. Ozark Highlands, Sandstone and Limestone

Estate - Portia - Moko

Brockwell - Boden - Portia

c. Boston Mountains

Linker - Mountainburg - Sidon

Enders - Nella - Mountainburg - Steprock

d. Arkansas Valley and Ridges

Leadvale - Taft

Enders - Mountainburg - Nella - Steprock

Linker - Mountainburg

e. Bottomlands and Terraces

Foley - Jackport - Crowley

Kobel

Dundee - Bosket - Dubbs

Amagon - Dundee

f. Loessial Plains

Calloway - Henry - Grenada - Calhoun

g. Loessial Hills

Loring

Prime Farmland

Prime farmlands are those lands well suited to the production of food and fiber and have qualities needed to produce sustained yields of crops economically. The U.S.D.A., Soil Conservation Service estimates that there are 1,050,000 acres of prime farmland in the Upper White River Basin. The prime farmland map (Figure 2-2) shows the distribution of the prime farmland in Upper White River Basin.

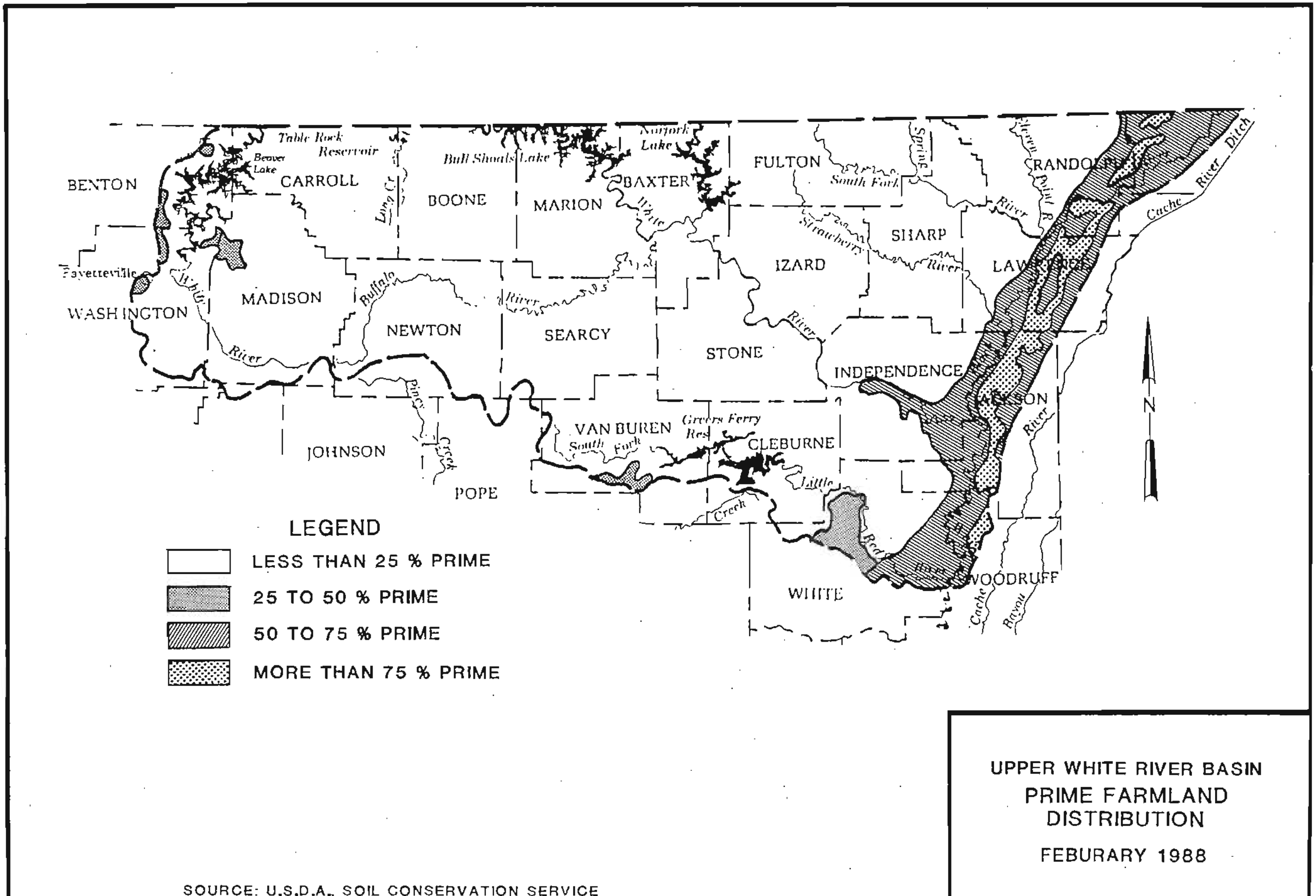
Total agricultural land lost to other uses in this basin from November 1978 to November 1979 was 13,880 acres, of which 2,211 acres were prime farmland.

Soil Surveys

The Soil Conservation Service (SCS) is responsible for all soil survey activities of the U. S. Department of Agriculture. The soil surveys and interpretations are made cooperatively with the University of Arkansas Agricultural Experiment Station, Agricultural Extension Service, U. S. Forest Service, Arkansas Highway Department, the 76 Soil and Water Conservation Districts and other state and Federal agencies.

The surveys are prepared for many different uses. Farmers, ranchers, foresters, and agronomists can use them to determine the potential of the soil and the management practices required for food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use them to plan land use, select sites for construction, develop soil resources, or identify any special practices that may be needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use them to help understand, protect, and enhance the environment.

Twenty-six of the 28 counties in the study area have a published soil survey. The two counties which do not have a published soil survey are Newton and Carroll. The published soil survey is available from the respective local conservation district office or from the SCS State Office located in Little Rock, Arkansas.



UPPER WHITE RIVER BASIN
PRIME FARMLAND DISTRIBUTION
FEBURARY 1988

CHAPTER 3

SURFACE WATER

INTRODUCTION

The surface water of the Upper White River Basin is enjoyed by millions of people every year. The major lakes in the Basin attract a large percentage of the visitors with their well developed recreation areas and large areas of beautiful clean blue water. Also, many of the larger streams attract large numbers of canoeists and fishermen.

The surface water within the Upper White River Basin is generated by rainfall which varies from 42 to 50 inches during a year (Freiwald, 1985). The large quantities of rainfall yield approximately 14 inches of runoff per year from the basin (Lamb, et. al., 1986). A large part of the streamflow is due to surface runoff which is responsible for high peak discharges and flooding in certain instances.

The major streams within the Upper White River Basin are the White River and the Black River. Other significant streams in the basin include the Kings River, James River (Mo.), North Fork River, Crooked Creek, Buffalo River, Current River, Eleven Point River, Spring River, Strawberry River and Little Red River.

This chapter presents an inventory of the surface water resources of the Upper White River Basin. Water use, past, present, and future is quantified. Problems are identified and solutions recommended for the water resource concerns.

SURFACE WATER DATA COLLECTION NETWORK

Streamflow Data

Streamflow data are collected in the Upper White River Basin primarily by the U.S. Geological Survey and the U.S. Army Corps of Engineers. Location of 18 streamflow data collection sites used in this report are shown in Figure 3-1. Six of the 18 data collection sites are located in Missouri. Table 3-1 lists pertinent data for the gaging stations.

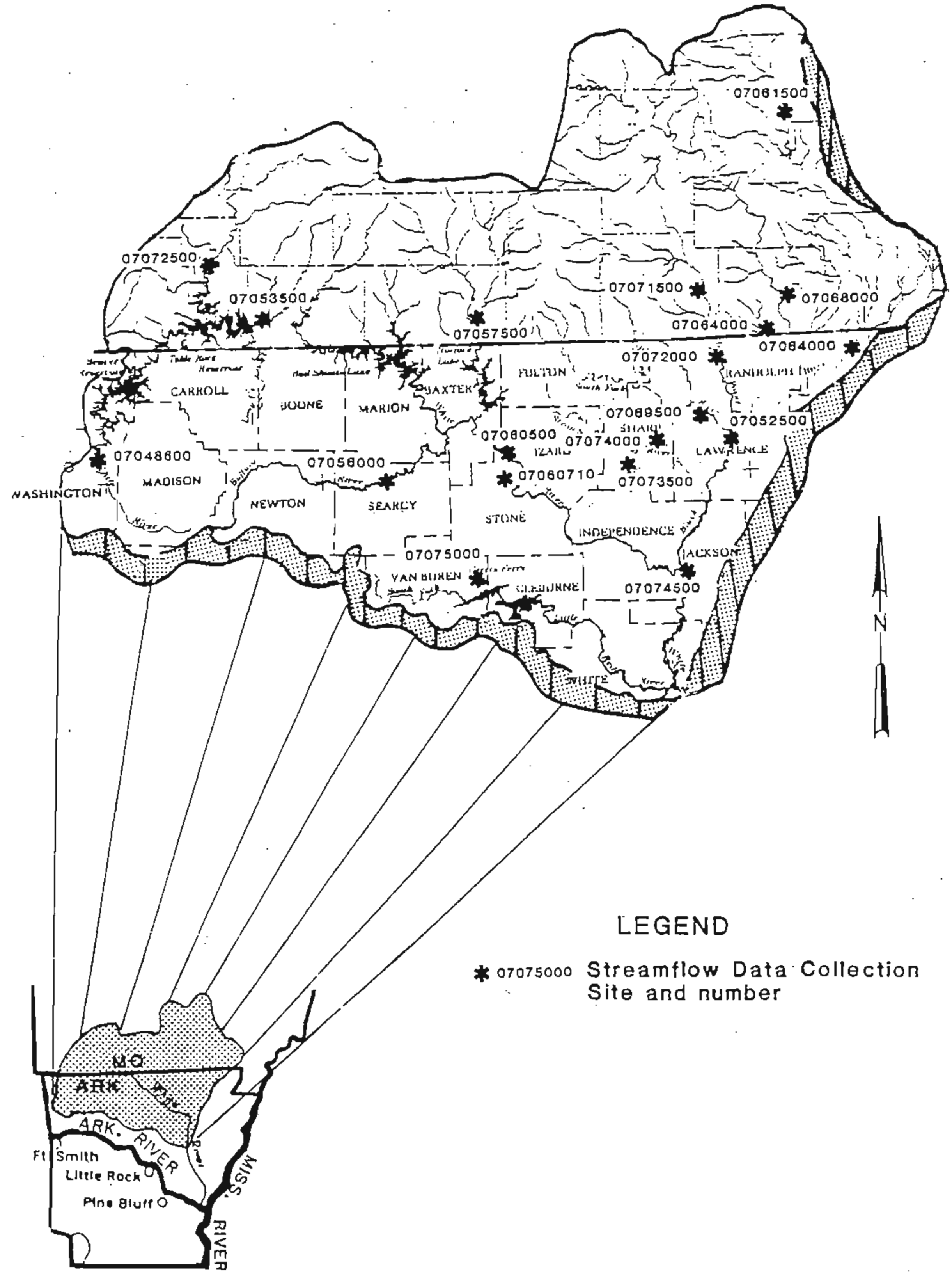
Six stations in Missouri were selected to show the influence of flow from Missouri on the mainstem flow of the White River.

All of the available streamflow data for the Upper White River Basin was not used in this report. Stream gaging stations were selected based on distribution and existing stream modifications. Distribution of stations was such that all areas of the basin were represented in the data. Periods of record for the various stations were selected to account for watershed modifications such as construction of major dams.

STREAMFLOW CHARACTERISTICS

General Characteristics

In the Upper White River Basin, streamflow is generally highest during November through June because of the large amount of precipitation during this period and lack of water use. Streamflow is generally lowest during July



UPPER WHITE RIVER
BASIN STUDY AREA

STREAMFLOW DATA
COLLECTION SITES

Figure 3-1

TABLE 3-1 STREAMFLOW GAGING STATION DATA

STATION NUMBER AND NAME	DRAINAGE AREA SQ. MI	STREAMFLOW PERIOD OF RECORD FROM	TO	DISCHARGES FOR PERIOD OF RECORD MAXIMUM	MINIMUM	AVERAGE
				---------CFS AND (DATE)----------		
07048600 White River near Fayetteville, Ar.	400	10/63	9/84	46,400 (11/73)	0.1 (10/82)	508
07052500 James River at Galena, Mo.	987	10/21	9/84	52,700 (5/43)	10 (9/54)	944
07053500 White River near Branson, Mo.	4,022	10/51	9/84	89,100 (5/56)	24 (9/54)	3514
07056000 Buffalo River near St. Joe, Ar.	829	10/39	9/84	158,000 (12/82)	6.6 (9/54)	1,023
07057500 N. Fork of White River near Tecumseh, Mo.	4,022	10/44	9/84	37,900 (4/74)	187 (9/54)	710
07060500 White River at Calico Rock, Ar.	9,978	10/39	9/84	310,000 (4/45)	305 (9/54)	9,825
07060710 North Sylamore Creek near Fifty Six, Ar.	58	12/65	9/84	25,200 (12/82)	1.6 (11/78)	47
07061500 Black River near Annapolis, Mo.	484	4/39	9/84	49,700 (11/72)	65 (8/65)	571
07064000 Black River near Corning, Ar.	1,749	10/38	9/84	48,600 (6/45)	224 (9/41)	1,806
07068000 Current River at Doniphan, Mo.	2,038	10/21	9/84	49,800 (12/82)	152 (1/56)	754
07069500 Spring River at Imboden, Ar.	1,183	2/36	9/84	244.000 (12/82)	215 (8/36)	1,357
07071500 Eleven Point River near Bardley, Mo.	793	10/21	9/84	49,800 (12/82)	152 (1/56)	152
07072000 Eleven Point River near Ravenden Springs, Ar.	1,134	10/29	9/84	162,000 (12/82)	226 (9/36)	1,118
07072500 Black River at Black Rock, Ar.	7,369	6/29	9/84	190,000 (12/82)	1,730 (9/56)	8,418
07073500 Piney Fork at Evening Shade, Ar.	99	2/39	9/84	50,400 (12/82)	0	99
07074000 Strawberry River near Poughkeepsie, Ar.	473	2/39	9/84	158,000 (12/82)	31 (10/38)	499
07074500 White River at Newport, Ar.	19,860	9/27	9/84	343,000 (4/45)	2870 (9/54)	22,430
07075000 Middle Fork of Little Red R. at Shirley, Ar.	302	2/39	9/84	241,000 (12/82)	0	465

through October due to a decrease in precipitation and an increase in water use that occurs during the growing season. Monthly mean discharges at selected gaging stations are shown in Table 3-2.

Annual flow variability is shown in more detail by the streamflow distribution graphs in Figures 3-2a through 3-2d. The graphs show that annual mean flows are less than average more times than the annual mean flows are greater than average. This also indicates periodic high annual flows have a significant effect on the mean annual flow value.

General streamflow characteristics which are more predictable are the seasonal fluctuations that occur annually. Annual fluctuations are not as readily predicted.

Table 3-3 is a tabulation of the different duration flows for the various streams in the Upper White River Basin. Only a few of the streams with larger drainage areas have no flow 99.9 percent of the time.

Figure 3-3 is a comparison plot of the flow of the Strawberry River near Poughkeepsie to the flow of the Middle Fork of the Little Red River at Shirley. The curves are similar during the 0.5 percent to 40 percent range of exceedances. The curves are different during the 40 to 99.9 percent range of exceedances. The reason for the divergance of the curves is that the Strawberry River drains a geological area where the aquifers do not readily accept recharge. The unaccepted recharge enters the surface streams and is measured as streamflow. The Middle Fork of the Little Red River drains a geologic area where the aquifers accept recharge. Therefore, after surface runoff has left the area, the streams do not have flow at the higher percentages of exceedance.

Low Flow Characteristics

Minimum streamflows generally occur during July through October of each year in the Upper White River Basin. Management and development of surface water supplies depend on the rate of sustained streamflow during these dry periods.

Subsurface flow, another form of rainfall runoff, is responsible for prolonged flows in streams. Subsurface flow is rainfall which has infiltrated into the soil and has flowed downward until the water has reached an impervious layer of soil or rock. Upon reaching the impervious material, the water flows in a lateral direction. A part of the subsurface flow emerges at points sometimes known as springs and enters the surface drainage system. The subsurface flow proceeds at a slower rate than surface flow, therefore subsurface flow is primarily responsible for the base flow in unregulated streams. Table 3-4 shows that many streams in the Upper White River Basin have substantial base flows.

Friewald (1987) did a study which included part of the Upper White River Basin on stream gains and losses in 1985. Several streams were selected for study including Kings, Strawberry, and Spring Rivers and Crooked Creek. A streamflow gaging team took measurements along the stream at varing intervals, especially, above and below tributaries and faults. The results of the study showed that geology had a significant effect on the quantity of base streamflow. When dolomite geologic formations were exposed in the stream bottom, gains in streamflow were recorded. Faults caused streams to gain or lose flow depending on the site (Freiwald, 1987).

TABLE 3-2 MEAN MONTHLY DISCHARGES AT SELECTED GAGING STATIONS

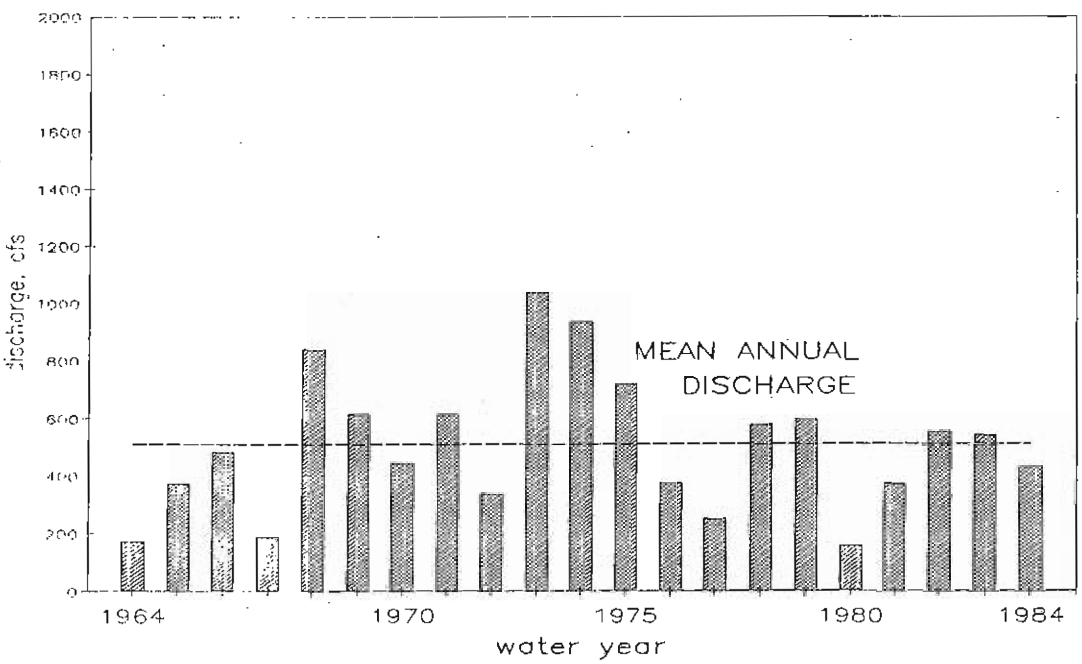
STATION NUMBER AND NAME	DRAINAGE AREA SQ. MI	PERIOD OF RECORD (WTR YRS)	MEAN MONTHLY DISCHARGE (CUBIC FEET PER SECOND)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
07048600 White River near Fayetteville, Ar.	400	1964-84	236	500	583	457	685	1073	1042	844	438	77	39	147
07052500 James River at Galena, Mo.	987	1965-84	488	1128	1187	922	1176	1685	1818	1377	884	547	284	459
07053500 White River near Branson, Mo.	4,022	1965-84	1760	3303	4285	3717	4081	4764	5425	4987	3514	3665	2959	2051
07056000 Buffalo River near St. Joe, Ar.	829	1941-84	299	823	1126	1100	1528	1994	2160	1997	830	260	194	165
07057500 N. Fork of White River near Tecumseh, Mo.	4,022	1945-84	387	557	645	691	783	1032	1218	1103	743	555	415	395
07060500 White River at Calico Rock, Ar.	9,978	1965-84	5703	7134	10240	10880	11760	12380	13920	12670	8453	8948	8204	6321
07060710 North Sylamore Creek near Fifty Six, Ar.	58	1967-84	19	42	89	39	54	97	98	71	26	11	6.80	12
07061500 Black River near Annapolis, Mo.	484	1950-83	237	492	681	546	695	998	1137	841	397	297	216	238
07064000 Black River near Corning, Ar.	1,749	1950-84	712	1210	1939	2265	2436	3170	3210	2852	1537	1004	749	695
07068000 Current River at Doniphan, Mo.	2,038	1922-84	1578	2154	2556	2785	2984	3782	4515	4119	2942	1958	1677	1524
07069500 Spring River at Imboden, Ar.	1,183	1937-84	568	1019	1392	1630	1781	2270	2399	2131	1201	778	574	572
07071500 Eleven Point River near Bardley, Mo.	793	1923-84	404	531	664	758	810	1033	1271	1160	901	606	481	421

TABLE 3-2 MEAN MONTHLY DISCHARGES AT SELECTED GAGING STATIONS (cont.)

STATION NUMBER AND NAME	DRAINAGE AREA SQ. MI	PERIOD OF RECORD (WTR YRS)	MEAN MONTHLY DISCHARGE (CUBIC FEET PER SECOND)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
07072000 Eleven Point River near Ravenden Springs, Ar.	1,134	1930-84	570	805	1013	1250	1311	1634	1870	1716	1178	826	561	601
07072500 Black River at Black Rock, Ar.	7,369	1949-84	3780	5834	8823	10180	11130	13780	15290	13890	7609	5239	4062	3844
07073500 Piney Fork at Evening Shade, Ar.	99	1960-84	22	66	106	119	126	183	176	140	64	29	20	30
07074000 Strawberry River near Poughkeepsie, Ar.	473	1937-84	176	378	535	700	762	965	911	730	366	191	126	168
07074500 White River at Newport, Ar.	19,860	1965-84	10500	14790	26100	25630	28440	31180	37620	33390	18090	14830	13180	11790
07075000 Middle Fork of Little Red R. at Shirley, Ar.	302	1940-84	165	427	606	588	713	953	883	721	287	70	88	96

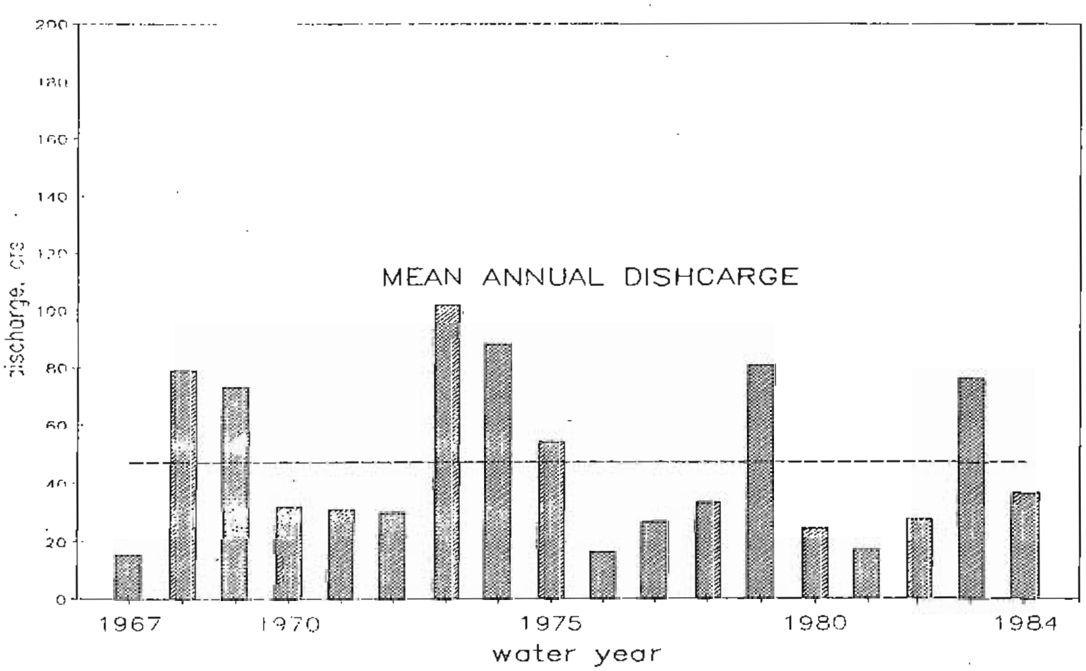
SOURCE: U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS

FIGURE 3-2a ANNUAL STREAMFLOW DISTRIBUTION
White River near Fayetteville
1964 to 1984



SOURCE: U.S.G.S. DATA

FIGURE 3-2b ANNUAL STREAMFLOW DISTRIBUTION
North Sylamore Creek near Fifty Six
1967 to 1984



SOURCE: U.S.G.S. DATA

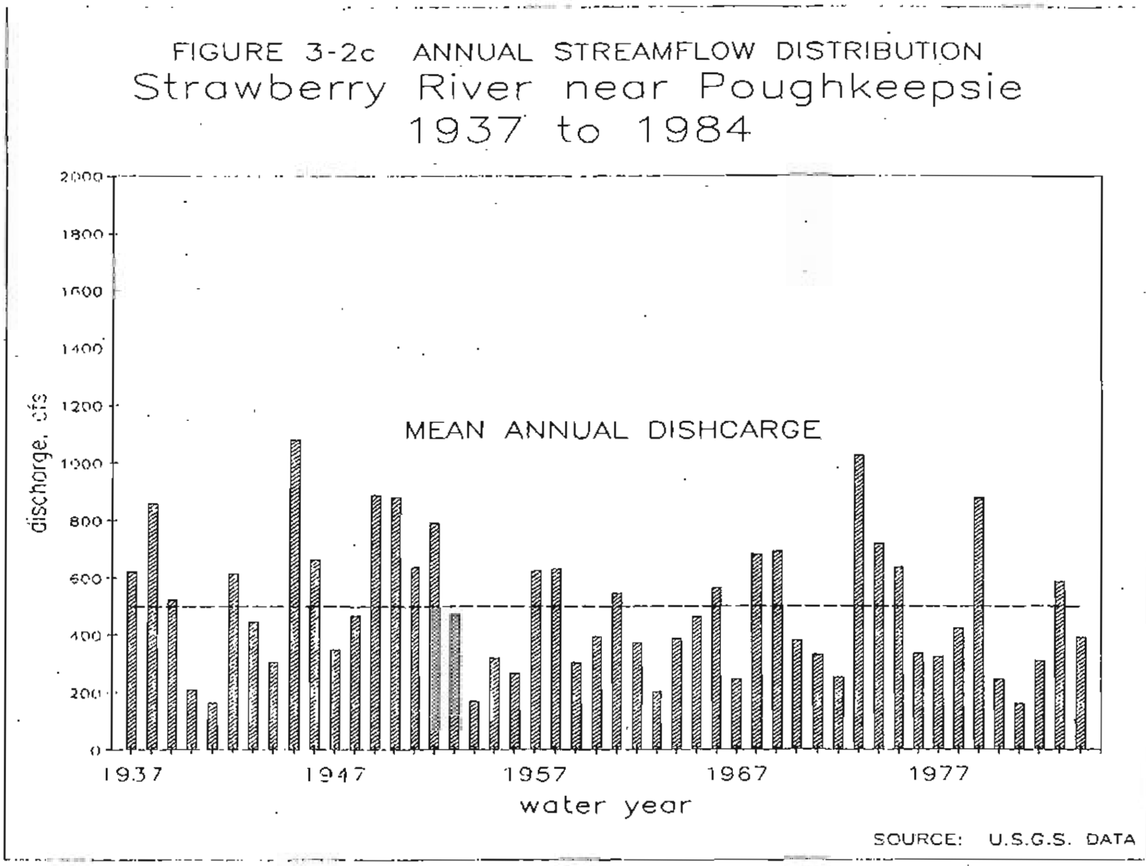


FIGURE 3-2c ANNUAL STREAMFLOW DISTRIBUTION
Strawberry River near Poughkeepsie
1937 to 1984
MEAN ANNUAL DISHCARGE
discharge, cfs
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1937
1947
1957
1967
1977
water year
SOURCE: U.S.G.S. DATA

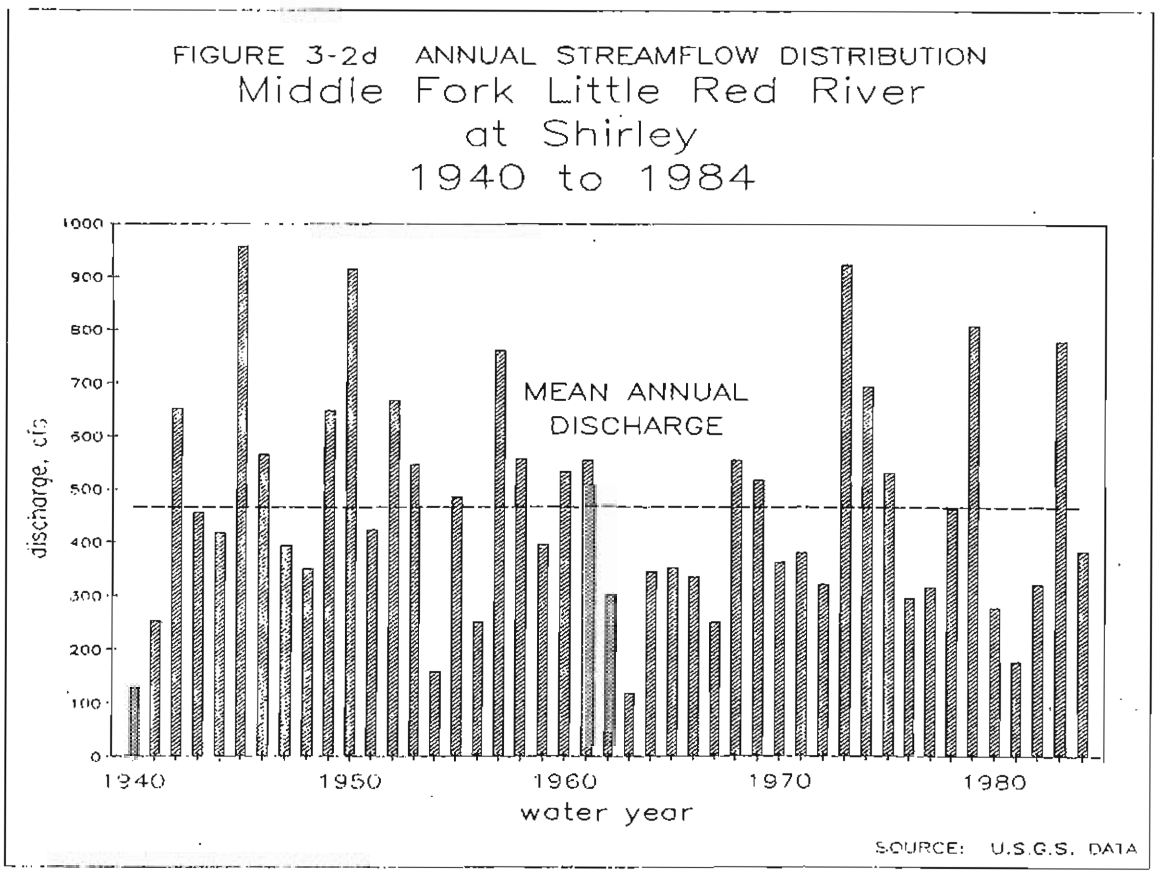


FIGURE 3-2d ANNUAL STREAMFLOW DISTRIBUTION
Middle Fork Little Red River
at Shirley
1940 to 1984
MEAN ANNUAL
DISCHARGE
discharge, cfs
1000
900
800
700
600
500
400
300
200
100
0
1940
1950
1960
1970
1980
water year
SOURCE: U.S.G.S. DATA

TABLE 3-3 FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS-RECORD GAGING STATIONS

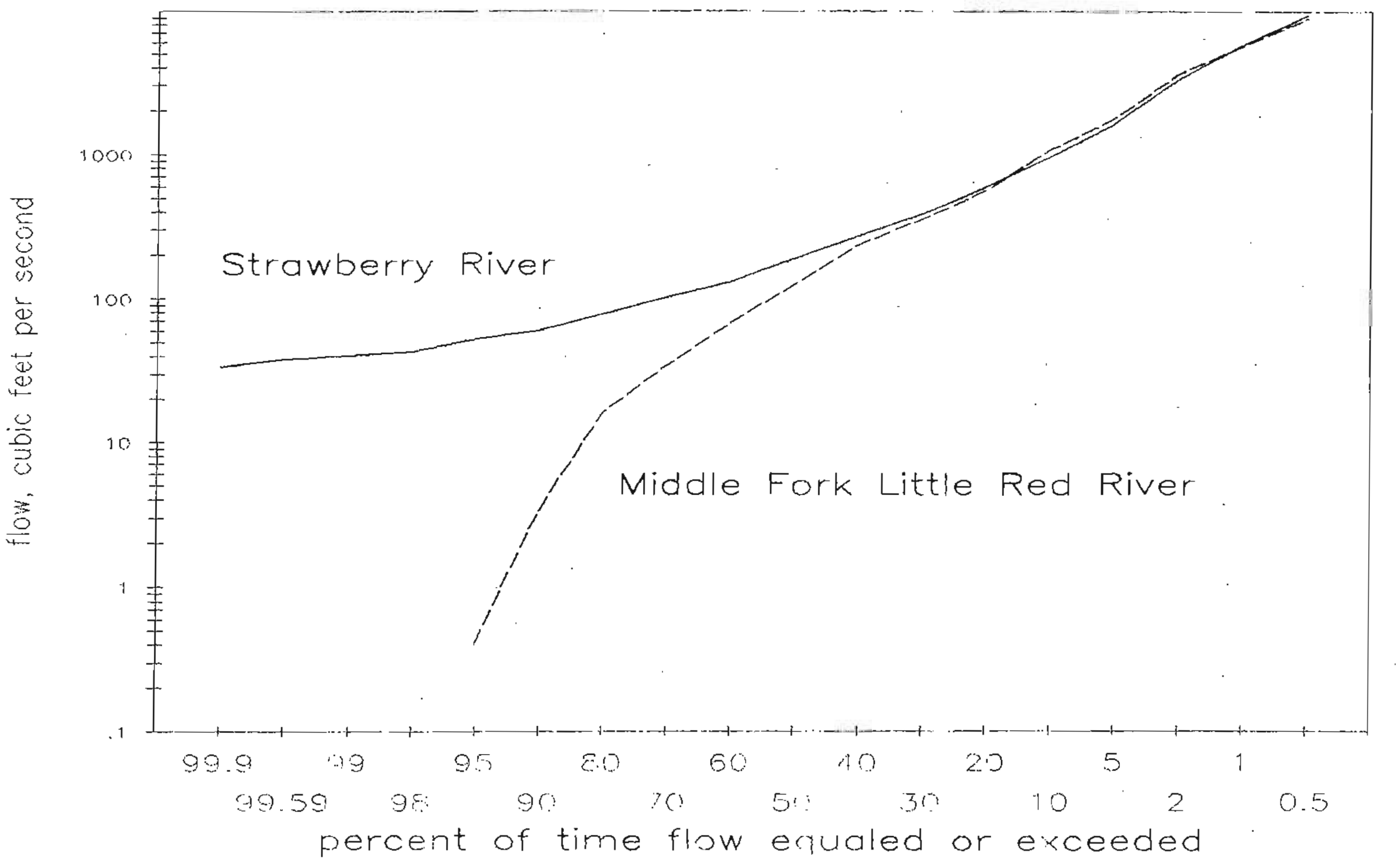
STATION NUMBER AND NAME	DRAINAGE AREA (SQ MI)	RECORDS USED (WTR YRS)	FLOW IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF TIME INDICATED IN COLUMN SUBHEADS																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
07048600 White River near Fayetteville, Ar.	400	1963-83	.25	1.33	1.77	2.40	3.80	6.40	10.50	28	68	135	238	370	650	1250	2100	4150	5600	8000
07052500 James River at Galena, Mo.	987	1922-83	63	73	82	95	115	140	190	268	335	485	640	860	1250	2130	3400	6200	8950	13500
07053500 White River near Branson, Mo.	4,022	1964-84	41	43	44	45	49	115	405	1050	1675	2500	3550	4675	6500	9200	13200	15000	16000	17000
07056000 Buffalo River near St. Joe, Ar.	829	1940-84	10	14	17	22	32	46	72	118	192	315	540	780	1330	2310	3600	7300	11800	17600
07057500 N. Fork of White River near Tecumseh, Mo.	4,022	1952-84	190	203	212	223	250	273	328	368	410	468	545	650	840	1270	1830	3000	4000	5600
07060500 White River at Calico Rock, Ar.	9,978	1940-84	660	780	900	1130	1575	2150	3210	4290	5400	7100	9400	11900	15500	21300	24900	29500	33900	39500
07060710 North Sylamore Creek near Fifty Six, Ar.	58	1966-84	2	2.3	2.5	2.8	3.4	4.1	5.3	6.9	9.2	12	16	25	36	84	140	300	560	1100
07061500 Black River near Annapolis, Mo.	484	1922-84	78	85	90	93	100	111	133	167	203	258	336	440	630	1110	1920	3600	5450	7900
07064000 Black River near Corning, Ar.	1,749	1939-84	249	260	272	282	333	389	465	604	760	993	1270	1700	2630	3990	5400	8100	11000	14500

TABLE 3-3 FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS-RECORD GAGING STATIONS (cont.)

STATION NUMBER AND NAME	DRAINAGE AREA (SQ MI)	RECORDS USED (WTR YRS)	FLOW IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF TIME INDICATED IN COLUMN SUBHEADS																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
07068000 Current River at Doniphan, Mo.	2,038	1919-84	860	900	930	980	1080	1160	1300	1400	1630	1870	2150	2600	3330	4900	6500	10000	15000	20000
07069500 Spring River at Imboden, Ar.	1,183	1936-84	238	252	262	279	326	362	425	540	620	753	950	1200	1580	2560	3700	6800	10800	15800
07071500 Eleven Point River near Bardley, Mo.	793	1922-84	162	175	185	195	222	255	305	365	425	526	625	780	1000	1400	1970	2750	3975	5600
07072000 Eleven Point River Near Ravenden Springs, Ar.	1,134	1930-84	245	265	280	305	340	392	470	550	650	784	910	1100	1380	2020	2800	4100	6800	10000
07072500 Black River at Black Rock, Ar.	7,369	1929-84	1750	1850	1940	2075	2310	2610	3120	3710	4490	5510	6800	8800	11800	18800	24700	35000	45000	57000
07073500 Piney Fork at Evening Shade, Ar.	99	1939-84	0	.2	.5	.9	2.2	3.6	7.3	12	19	29	43	62	95	176	287	640	1130	1910
07074000 Strawberry River near Poughkeepsie, Ar.	473	1936-84	33	38	40	43	52	60	77	102	130	187	270	385	585	954	1620	3320	5750	9300
07074500 White River at Newport, Ar.	19,860	1927-84	3700	4050	4350	4800	5800	7150	8900	11200	13300	15700	18700	23900	32600	46000	57000	75000	90000	180000
07075000 Middle Fork of Little Red R. at Shirley, Ar.	302	1939-84	0	0	0	0	.4	3.4	16	34	67	124	235	355	555	1070	1750	3600	5600	8800

SOURCE: U.S.G.S.

FIGURE 3-3 COMPARISON OF FLOW DURATION OF THE STRAWBERRY RIVER AND THE MIDDLE FORK OF THE LITTLE RED RIVER



SOURCE: USGS data

TABLE 3-4 LOW FLOW CHARACTERISTICS

STATION NUMBER AND NAME	PERIOD OF RECORD (WTR YRS)	7Q2 (cfs)	7Q2/sq. mi. (cfsm)	7Q10 (cfs)	7Q10/sq. mi. (cfsm)
07048600 White River near Fayetteville, Ar.	1965-84	3.20	.008	.90	.002
07052500 James River at Galena, Mo.	1966-84	126	.128	78	.079
07053500 White River 1/ near Branson, Mo.	1966-84	174	.043	78	.079
07056000 Buffalo River near St. Joe, Ar.	1942-84	38	.046	16	.019
07057500 N. Fork of White River near Tecumseh, Mo.	1946-84	297	.529	225	.401
07060500 White River 1/ at Calico Rock, Ar.	1966-84	1950	.195	1020	.102
07060710 North Sylamore Creek near Fifty Six, Ar.	1968-84	3.30	.057	2.50	.043
07061500 Black River near Annapolis, Mo.	1951-83	96	.198	73	.151
07064000 Black River 1/ near Corning, Ar.	1951-84	363	.208	273	.139
07068000 Current River at Doniphan, Mo.	1923-84	1190	.584	959	.470
07069500 Spring River at Imboden, Ar.	1938-84	366	.309	281	.238
07071500 Eleven Point River near Bardley, Mo.	1924-84	276	.348	189	.238

TABLE 3-4 LOW FLOW CHARACTERISTICS

STATION NUMBER AND NAME	RECORDS USED (WTR YRS)	7Q2 (cfs)	7Q2/sq. mi. (cfsm)	7Q10 (cfs)	7Q10/sq. mi. (cfsm)
07072000 Eleven Point River Near Ravenden Springs, Ar.	1930-84	416	.367	292	.257
07072500 Black River 1/ at Black Rock, Ar.	1949-84	2640	.358	2000	.271
07073500 Piney Fork at Evening Shade, Ar.	1940-84	2.60	.026	.10	.001
07074000 Strawberry River near Poughkeepsie, Ar.	1937-84	54	.114	41	.087
07074500 White River 1/ at Newport, Ar.	1965-84	6200	.312	4270	.215
07075000 Middle Fork of Little Red R. at Shirley, Ar.	1940-84	1	.003	0	0

Source: U.S.G.S. Streamflow Data

1/ Low-flow characteristics are applicable only as long as the existing pattern of regulation and/or diversion exists.

The dolomite formations were the surface geologic units which have ground water levels higher than adjoining streams and provide flow to streams. Mississippian, Upper Ordvician, and Middle Ordvician formations especially the Boone Formation, Powell Dolomite, and Jefferson City Dolomite were found to contribute ground water to stream flow in the Upper White River Basin (Freiwald, 1987).

The Cotter Dolomite found in the Lower Crooked Creek basin has developed porosity adequate to divert the lower stream flows entirely underground. In other basins such as the Spring River drainage area, the Cotter Dolomite contributed to the flow of streams (Freiwald, 1987).

Indices generally used to define low flow characteristics of streams are the lowest mean discharges for seven consecutive days having recurrence intervals of 2 and 10 years. For simplicity, these indices are referred to as the 7-day Q2 (7Q2) and 7-day Q10 (7Q10) discharges, respectively. These discharges are taken from a frequency curve of annual values of the lowest mean discharge for seven consecutive days. Low flow characteristics of selected streams are shown in Table 3-4. The 7Q2 and 7Q10 discharges per square mile are also shown in Table 3-4 for comparison purposes.

The 7Q2 and 7Q10 values were determined using U. S. Geological Survey streamflow data and the log Pearson Type III probability distribution program (Riggs, 1972). This program mathematically fits a frequency curve to the discharge data, and the 7Q2 and 7Q10 values are then taken from the curve generated by the program. If a stream is dry during any part of the year, however, this procedure is not directly applicable and a graphical solution for determining the low flow characteristics must be used.

It should be noted that extrapolation of the 7Q2 and 7Q10 indices in Table 3-4 to other reaches on the streams or to other streams in the basin should not be attempted, if made without knowledge of the basin characteristics and without knowledge of the effects of man-made practices. For example, the diversion of water at many locations along a stream affects the low-flow characteristics throughout much of the stream reach. Also, the effects could be different if there are several large industrial and muncipal effluent discharges along a stream.

In a report prepared by Hunrichs (1983), there were numerous streams in the Upper White River Basin identified as having perennial flow (Hunrichs, 1983). Perennial flow is a condition where the 7Q10 flow is greater than zero. Perennial flows occur naturally, for example, in the Buffalo and Strawberry Rivers. Perennial flows in some streams are aided by releases from water impoundments such as are the White River and the Black River.

The minimum release from Clearwater Dam on the Black River is 150 cfs. The 7Q10 at Corning, 105 miles downstream, is 273 cfs.

Low-flow releases from dams on the White and North Fork River are dictated by hydropower releases requested by the Southwest Power Administration when lake levels are within power pool limits. Table 3-5 shows the ranges of hydropower releases from the Corps of Engineers White River Lakes.

Table 3-5 Range of Hydropower Releases

Project	Releases (cfs) Minimum	Maximum
Beaver Lake	1,800	7,900
Table Rock Lake	1,300	13,400
Bull Shoals Lake	1,200	22,400
Norfork Lake	900	5,400
Greers Ferry Lake	1,400	6,900

SOURCE: Corps of Engineers, file data

During three-day weekends when the daytime temperatures are 85 degrees Fahrenheit or hotter, special releases are required from Bull Shoals and Norfork Lakes to maintain the cold-water fisheries below these dams. An interagency agreement between the U.S. Army Corps of Engineers and the Southwestern Power Administration is the means for making these water temperature related emergency releases to minimize trout kills on the White River below Bull Shoals Dam and Norfork Dam (Corps of Engineers, file data). These releases are shown in Table 3-6.

Table 3-6 Water Temperature Related Emergency Releases from Bull Shoals and Norfork Lakes

Project	Temperature, degrees Fahrenheit 90	91 - 95	96 - 104	105 and above
	----- cfs -----			
Bull Shoals	250	375	500	750
Norfork	145	218	290	360

The minimum combined operation at Bull Shoals and Norfork shall not be less than a 3-day summation of 6,000 day second feet (dsf) or 12,000 acre-feet. Any 3-day average shall not be less than 2,000 dsf. This applies for all air temperature conditions above 85 degrees Fahrenheit.

INSTREAM FLOW REQUIREMENTS

Instream flow requirements are generally defined as "the quantity of water needed to maintain the existing and planned in-place uses of water in or along a stream channel or other water body and to maintain the natural character of the aquatic system and its dependent systems" (U.S. Bureau of Land Management, 1979). Instream flow requirements are established at a level at which the flow regime best meets the individual and collective instream uses and off-stream withdrawals of water. Instream uses of water include uses of water in the stream channel for navigation, recreation, fisheries, riparian vegetation, aesthetics, and hydropower. Off-stream water withdrawals include uses such as irrigation, municipal and industrial water supplies, and cooling water.

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to determine instream flow requirements for: (1) water quality, (2) fish and wildlife, (3) navigation, (4) interstate compacts, (5) aquifer recharge, and (6) needs of all other users in the basin such as industry, agriculture, and public water supply. Determination of the amount of water required to satisfy instream needs in the Upper White River Basin is necessary so that streamflow available for use within the basin as well as the amount of excess water available for interbasin transfer can be quantified.

To determine instream flow requirements for the categories mentioned above, information was obtained from other agencies such as the Arkansas Department of Pollution Control and Ecology, the Arkansas Game and Fish Commission, and the Corps of Engineers. The flows recommended for the different categories (as provided by the appropriate agencies) were evaluated with respect to all other instream needs in order to determine the flow regime which best meets the collective instream uses and off-stream withdrawals. This resulted in a two-part solution for the process of determining instream flow requirements. The first approach was to determine the amount of water necessary to satisfy instream needs in the basin based on the flows recommended by other agencies before interbasin transfer of water could take place. The information compiled in the following instream flow requirements sections pertains to this first approach. The second approach was to quantify the amount of water necessary to satisfy minimum instream flow requirements in order to determine the streamflow available for use within the basin. This second approach is described in more detail in the minimum streamflow section of this report.

Water Quality Requirements

The 7Q10 low-flow characteristic is a common criterion used by state and Federal agencies to determine the permissible rate of effluent discharge into a given stream since one of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The Arkansas Department of Pollution Control and Ecology (ADPC & E) is responsible for the management of water quality conditions in the Upper White River Basin. The ADPC & E has selected the 7Q10 discharges for streams and rivers in the basin as the minimum flow at which the Department is responsible for maintaining streamflow contaminant concentrations at acceptable levels. The ADPC & E continues to monitor point-source discharges below the 7Q10 discharge and requires concentrations of certain pollutants to be maintained below critical levels. However, since sufficient water is not available at times during the year to dilute the effluent discharges, streamflow water quality may not meet the quality standards during all times of the year. Streams that are regulated are addressed on a case by case basis to determine instream flow requirements for water quality.

The 7Q10 discharges are listed in Table 3-4. Since the White River is regulated, the 7Q10 discharge criteria for water quality standards may not be applicable.

Fish and Wildlife Requirements

The fishery of the Upper White River Basin is one of national importance. The trout fishery below Bull Shoals and Norfork Dams have produced many record-class fish. The current Arkansas record brown trout, which was caught in the White River, weighs 2 ounces less than the national record. During the period October 1982 to September 1983, recreation benefits attributed to the Bull Shoals-Norfork area was estimated to be $18 million (Summary of Findings, 1985). The Arkansas Department of Parks and Tourism estimates that trout fishing permit holders spend $41 million dollars annually in an eight county area of the Upper White River area.

Instream flow requirements for maintenance of fish and wildlife populations in the Upper White River Basin are based on an unpublished Arkansas Game and Fish report by Filipek and others (Filipek et al, 1985). According to this report, several methods are presently available for determining instream flow requirements for fisheries. Some of these methods require considerable field work to characterize fish habitats in the basin. However, Tennant (1975) developed a method (sometimes referred to as the "Montana Method") which utilizes historic hydrologic records to estimate instream flow requirements for fish and other aquatic life. Results of Tennants comprehensive study showed that: (1) 10% of the average annual streamflow is the minimum flow recommended for short-term survival of most aquatic life forms, (2) 30% of the average annual streamflow is recommended to sustain a good survival habitat, and (3) 60% of the average annual streamflow should provide excellent to outstanding habitat for most aquatic life forms. Tennant, also, suggested that the flow regimens should be altered to fit different hydrologic cycles or to coincide with vital periods of the life cycle of fishes.

Filipek and others (1985) have developed a new method (termed the "Arkansas Method") which utilizes some of Tennants basic principles. This new method was developed due to limitations in the application of the Montana method to Arkansas streams. The Arkansas method divides the water year into three seasons based on the physical and biological processes that occur in the stream. The three physical/biological seasons are described in Table 3-7, as well as, the flow recommended for maintenance of fisheries during each season. The instream flow requirements, as determined by the Arkansas Method, are those that apply to fish populations only. The method assumes that when instream flows meet the needs for fisheries, instream requirements for other wildlife forms are probably satisfied.

The Arkansas method was applied to streamflow data from the U. S. Geological Survey gaging stations in the Upper White River Basin. The results of the Arkansas Method are shown in Table 3-8.

If instream flow requirements are needed at other ungaged locations on the stream and additional information about the basin is unavailable, the following procedure may be used. Mean monthly flows from the gaging station closest to, or most representative of the point of interest can be adjusted based on a ratio of the drainage areas. Factors to be examined when comparing stream points are similar drainage area size, similar surficial geology, similar rainfall-runoff characteristics, topography and low-flow characteristics. The Arkansas Method then may be applied to these mean monthly flows to determine the instream flow requirements at the point in question. Because there are relatively few gaging stations with historic

Table 3-7 Description of Physical/Biological Seasons in the Arkansas Method of Instream Flow Quantification

Time of Year	November thru March	April thru June	July Thru October
Flow Required	60% of the Mean Monthly Flow	70% of the Mean Monthly Flow	50% of the Mean Monthly Flow or the Median Monthly Flow, Whichever is Greater
Physical/Biological Processes involved	Clean and Recharge	Spawning	Production
Normal Conditions	High average Monthly Flows. Low water temperatures. High dissolved oxygen content. Flushing of accumulated sediment and cleaning out of septic wastes. Spawning areas cleaned and rebuilt by gravel and other substrate brought downriver by high flows. Recharge of groundwater aquifers.	High average monthly flows. Increasing (preferred) temperatures. High dissolved oxygen content. High flows and increasing water temperatures spur spawning response in fish to spawn: 1) in channel 2) in overbank area or 3) upriver after migration. Feeding activated by high spring flows.	Low average monthly flows. High water temperatures. Low dissolved oxygen content common. High water temperatures increase primary, secondary and tertiary production. Low flows concentrate predators (fish) with prey (invertebrates, forage fish).
Limiting Factors	Reduced flows at this time of year cause: decrease in benthic production due to accumulated sediment on substrate. Decrease in fish spawning habitat due to reduced flushing. Decrease in aquifer recharge.	Reduced flows at this time of year cause: decrease in spawning egg and fry survival and overall reproductive success of important sport and non-game fish. Weak year classes of important sport, commercial, non-game and threatened fish species.	Reduced flows at this time of year cause: water temperatures to increase, decreasing survival of certain fish species. Decrease in wetted substrate and therefore decrease in algae, macroinvertebrates. Decrease in dissolved oxygen due to higher water temperatures; fish kills. Increase concentration of pollutant and sediment in water. Additional decrease in groundwater table.

SOURCE: Filipek, et al, 1985

TABLE 3-2 MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR SELECTED GAGING STATIONS

STATION NUMBER AND NAME	DRAINAGE AREA (SQ MI)	RECORDS USED (WTR YRS)	FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS (CUBIC FEET PER SECOND)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
07048600 White River near Fayetteville, Ar.	400	1964-84	118	300	350	274	411	644	729	591	307	38	20	74
07052500 James River at Galena, Mo.	987	1965-84	244	677	712	553	706	1011	1273	964	619	273	142	230
07053500 White River near Branson, Mo.	4,022	1965-84	880	1982	2571	2230	2449	2858	3798	3491	2460	1838	1480	1026
07056000 Buffalo River near St. Joe, Ar.	829	1941-84	150	494	676	660	917	1196	1512	1398	581	130	97	52
07057500 N. Fork of White River near Tecumseh, Mo.	4,022	1945-84	194	334	387	415	470	619	853	772	520	178	208	198
07060500 White River at Calico Rock, Ar.	9,978	1965-84	2852	4280	6144	6528	7056	7428	9744	8869	5917	2474	4102	3160
07060710 North Sylamore Creek near Fifty Six, Ar.	58	1967-84	10	25	53	23	32	58	69	50	18	6	3.40	5
07061500 Black River near Annapolis, Mo.	484	1950-83	118	295	409	328	417	599	796	589	278	148	108	119
07064000 Black River near Corning, Ar.	1,749	1950-84	356	726	1163	1359	1462	1902	2247	1996	1076	502	374	348
07068000 Current River at Doniphan, Mo.	2,038	1922-84	789	1292	1534	1671	1790	2269	3160	2883	2059	979	338	762
07069500 Spring River at Imboden, Ar.	1,183	1937-84	284	611	835	978	1069	1362	1679	1492	841	389	287	286
07071500 Eleven Point River near Bardley, Mo.	793	1923-84	202	319	398	455	486	620	890	812	631	303	240	210

TABLE 3-8 MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR SELECTED GAGING STATIONS (cont.)

STATION NUMBER AND NAME	DRAINAGE AREA SQ. MI	RECORDS USED (WTR YRS)	FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS (CUBIC FEET PER SECOND)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
07072000 Eleven Point River Near Ravenden Springs, Ar.	1,134	1930-84	285	483	608	750	787	980	1309	1201	825	413	330	300
07072500 Black River at Black Rock, Ar.	7,369	1949-84	1890	3500	5294	6108	6678	8268	10703	9723	5326	2670	2031	1922
07073500 Piney Fork at Evening Shade, Ar.	99	1940-84	11	40	64	71	76	110	123	98	45	14	10	15
07074000 Strawberry River near Poughkeepsie, Ar.	473	1937-84	88	227	321	420	457	579	638	511	256	96	63	84
07074500 White River at Newport, Ar.	19,860	1965-84	5250	8874	15660	15378	17064	18708	26334	23373	12663	7415	6590	5895
07075000 Middle Fork of Little Red at Shirley, Ar.	302	1940-84	82	256	364	353	428	572	619	505	166	35	44	48

records in the Upper White River Basin, this method does enable estimation of mean monthly discharges and instream flow requirements at other points of interest.

The method of adjusting mean monthly flow based on the ratio of drainage areas is not always applicable, especially, when the surficial geology is not similar. In cases such as this, it is necessary to examine the basin by smaller drainage areas and add the flows estimated by the method described above.

According to the report submitted to the Arkansas Soil and Water Conservation Commisssion by Filipek and others (1985), the recommended instream requirements as determined by the Arkansas method are "absolute minimum values to maintain and protect stream fisheries". Therefore, to protect stream fisheries and to satisfy water needs for fish and wildlife in the Upper White River Basin, the instream flow requirement as previously described for streams in the basin represent an amount of water that is unavailable for interbasin transfer.

To compute the volume of water to satisfy the instream flow requirement for fish and wildlife the procedure in Table 3-9 was used.

TABLE 3-9 COMPUTATION OF VOLUME OF WATER NEEDED TO SATISFY THE FISH AND WILDLIFE REQUIREMENT ON AN AVERAGE ANNUAL BASIS OF THE WHITE RIVER AT NEWPORT

Month	Fish and Wildlife (percent)	Mean Monthly Flow (cfs)	Product (% x cfs/100)
January	60	10,500	5,250
February	60	14,790	8,874
March	60	26,100	15,660
April	70	25,630	15,378
May	70	28,440	17,064
June	70	31,180	18,708
July	50	37,620	26,334
August	50	33,390	23,373
September	50	18,090	12,663
October	50	14,830	7,415
November	60	13,180	6,590
December	60	11,790	5,895
Total		265,540	163,204

weighted average = 163,204 / 265,540 x 100 = 61.5%

Since the flows vary by month and the fish and wildlife percentages vary, a weighted average procedure was used to compute the annual volume flow needed to satisfy the fish and wildlife requirement. In this particular case, 61.5 percent of the average annual yield is needed to satisfy the fish and wildlife requirement.

Navigation Requirements

Currently, the only Federally maintained channel for navigation is a section of the White River. A minimum 5 foot deep by 125 foot wide channel is maintained from the mouth to Augusta on the White River. From Augusta to Newport, a 4.5 foot deep by 100 foot channel is maintained. This maintenance is performed by the U. S. Army Corps of Engineers. The required flow at Newport to maintain adequate navigation depths is 7,700 cfs.

Navigation above Newport is not possible even on the White River or Black River due to channel obstructions. A combination of stream slope and lack of drainage area are the factors which make navigation unreliable above Newport for today's navigation equipment (White River Navigation, 1979). No other streams in the Upper White River Basin have instream flow requirements for navigation.

Interstate Compact

At the present time, an interstate compact does not exist between Missouri and Arkansas. The lack of a compact presents a problem in that it does not guarantee either state a share of water even though 47% of the Upper White River's drainage area is in Missouri. A compact would help ensure a certain quantity of water for Arkansas.

Aquifer Recharge Requirements

Recharge to the major aquifers in the Upper White River Basin is primarily from precipitation and percolation in the outcrop areas. Since, most of the streams in the basin have a sustained baseflow during dry-weather conditions, the aquifers are not accepting recharge, but rather discharging water to the streams.

Riparian Use Requirements

The Arkansas Soil and Water Conservation Commission is required by Section 2 of Act 1051 of 1985 to determine surface water needs of public water supplies, industry, and agriculture. In 1984, reported surface water use for irrigation, industry, and public water supply totaled approximately 289,000 acre-feet of water in the Upper White River Basin as determined from Arkansas Soil and Water Conservation Commission's records of registered diversions. Table 3-10 shows the amount of water diverted for the different uses representing the current riparian needs in the Upper White River Basin.

TABLE 3-10
1984 UPPER WHITE RIVER RIPARIAN WATER USE

USE	AMOUNT (acre-feet)
Irrigation	31,975
Industrial	193,685
Power	14,536
Municipal	47,680
Fish Farming	920
Total	288,796

Source: Arkansas Soil and Water Conservation Commission

In this report, the amount of water diverted from the major streams was not determined for the Upper White River Basin. The purpose of defining and quantifying instream flow requirements for streams in the basin was to determine the amount of water available for other uses such as interbasin transfer. Since the water diverted for the uses mentioned above has already been removed from the streams and is not available, it was not included in the computations for total surface water yield and excess streamflow of the basin.

Riparian water use requirements may vary considerably from year to year based on changing needs. Projected riparian water needs are accounted for in the water use projections for irrigation, industry, and public water supplies.

Recreation Requirements

Water based recreation is an important use of surface water in the Upper White River Basin. Even though recreation is not an authorized purpose for the six Corps of Engineers lakes, swimming, boating, fishing and camping attract a large number of people each year. Many of the freeflowing streams are highly utilized by canoeists. At times, the Buffalo River is filled to capacity by canoeists. The peak-use time for canoeists is March through July. Canoeists will continue to use the streams until the water depth is too shallow to float a canoe.

Other requirements have indirectly quantified the water needs for recreation, especially fish and wildlife requirements.

Aesthetic Requirements

There are many aesthetically pleasing streams in the Upper White River Basin. One stream within the Basin has received national recognition by being designated a National Scenic River. Six streams have received state recognition for their natural beauty by being placed on the Arkansas Natural and Scenic River Commission System or the Arkansas Natural Scenic Rivers Registry.

The Buffalo River was designated a National Scenic River by Public Law 92-237 in 1972. The river is administered by the National Park Service. Public Law 92-237 protects the Buffalo River from alteration from its natural state so that present and future generations may enjoy its scenic beauty. The law prohibits any development which will alter the flow of the river.

The Upper Strawberry River was included in the Natural and Scenic Rivers Commission System by Arkansas Act 689 of 1985. Act 689 states that there shall be no dams or impounding structures except low water bridges and water gap fencing built across the stream; also, no channelization is allowed except as required to remove flood caused debris accumulation.

There are several streams of the Upper White River Basin on the Arkansas Natural Scenic Rivers Registry. The streams on the registry are not protected by any specific regulation with the exception of the Kings River in the Upper White River Basin. Arkansas Act 319 of 1971 states that the Kings River is afforded protection in Madison County. It is unlawful to construct any permanent dam or other structure on the river. Also, it is unlawful to degrade the quality of water of a Registry stream. Construction of buildings or platting of subdivision is prohibited within 50 feet of the stream. Other streams on the Registry are the Eleven Point River, Spring River, South Fork of Spring River, and Strawberry River.

Also, fish and wildlife add to the aesthetics of an area. It is important to note that, according to the Arkansas National Heritage Commission, there are no less than 29 aquatic species of federal and/or state concern in the Upper White River Basin. These are listed below:

Lampsilis orbiculata	pink mucket	Endangered
Epioblasma florentina curtisi	Curtis' pearly mussel	Endangered
Epioblasma turgidula	turgid-blossum " "	endangered
Cambarus zophonastes	Hell Creek Cave crayfish	Proposed Endangered
Simpsonaias ambigua	salamander mussel	Federal candidate
Ammocrypta asprella	crystal darter	Federal candidate
Cryptobranchus alleganiensis	Ozark hellbender	Federal candidate
Percina nasuta	longnose darter	Federal candidate
Lampsilis streckeri (possibly extinct)	speckled pocketbook	Federal candidate
Notropis camurus	bluntface shiner	
Lampetra appendix	American brook lamprey	
Lampetra aepytera	least brook lamprey	
Etheostoma spectabile fragi	Strawberry River darter	
Notropis sabinae	Sabine shiner	
Somatogyrus crassilabris	thicklipped pebblesnail	
Anodonta suborbiculata	flat floater	
Caecidotea ancyla	isopod	
Caecidotea Steevesi	isopod	
Caecidotea stiladactyla	isopod	
Caecidotea dimorpha	isopod	
Lirceus bicuspidatus	isopod	
Moxostoma anisurum	silver redhorse	
Moxostoma macrolepidotum	shorthead redhorse	

Hiodon alosoides	goldeye
Epioblasma triquetra	snuffbox
Notropis spilopterus	spotfin shiner
Notropis maculatus	taillight shiner
Etheostoma moorei	yellowcheek darter
Typhlichthys subterraneus	southern cavefish
Ammocrypta clara	western sand darter

In addition, the Arkansas Game and Fish Commission has recommended adding the paddlefish (polydon spatula) to the list. The Commission is initiating work to evaluate abundance, life history information, and spawning site locations for this fish which they claim is presently being exploited.

These species depend on surface water for their exsistence and would most likely be adversely affected if stream flows were reduced to where their natural biological and physical processes are disrupted. All uses of surface water should be managed so that the negative affects on the biota are minimized.

MINIMUM STREAMFLOW

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to establish minimum streamflows. Minimum streamflow is defined as the lowest daily mean discharge that will satisfy minimum instream flow requirements. Minimum streamflows were established for the purpose of protecting all instream flow needs during low-flow conditions which may occur naturally or during periods of significant water use from the streams. The minimum streamflow represents the point below which some instream flow need will not be met. This could be the instream flow requirements for water quality, fish and wildlife, navigation or interstate compacts. The minimum flow is not a target level or a flow that can be maintained for an extended period of time without serious environmental consequences. The minimum streamflow also represents the discharge at which all withdrawals from the stream will cease. Because of the critical low-flow conditions which may exist at the minimum streamflow level, allocation of water based on the establishment of water use priorities should be in effect which should maintain streamflow above the established minimum discharge.

There is no scientific method to compute the minimum streamflow. Human judgement and common sense are the two factors that ultimately decide the magnitude of minimum streamflow.

Minimum streamflows for streams in the Upper White Basin were determined based on the instream flow requirements as previously described in this report with the exception of fish and wildlife requirements. The instream flow requirements for fish and wildlife were re-evaluated to determine instream needs that represent minimum conditions. This was necessary because, as previously stated in the Instream Flow Requirements section of this report, recommended instream flow requirements for fish and wildlife using the Arkansas Method would provide excellent to outstanding habitat for most aquatic life forms. The recommendations of the Arkansas Method require that all flows remain instream for fish and wildlife use. These recommended flows are viewed as representing desirable conditions and not minimum instream flow needs.

Recommended instream flow requirements for fish and wildlife as determined by the Arkansas Method were compared with daily median discharge hydrographs for selected streams in the Upper White Basin. Hydrographs for the White River near Fayetteville, Black River near Corning, Strawberry River near Poughkeepsie, and White River at Newport were plotted for illustrative purposes and are shown in Figures 3-4a through Figures 3-4d, respectively.

To determine minimum instream flow requirements for fish and wildlife, the following procedure was used. As previously stated in the Instream Flow Requirements section, Tennant concluded from his study that 10 percent of the average annual streamflow is the minimum flow required for short-term survival of most aquatic life forms. Three of the four hydrographs (Figures 3-4b through 3-4d) had flows which exceeded the 10-percent flow for the entire water year. The hydrograph for the White River near Fayetteville showed flows which were less than the 10-percent level during July to November. The flows less than the 10-percent level are caused by low precipitation and geologic formations which recharge the underlying aquifer.

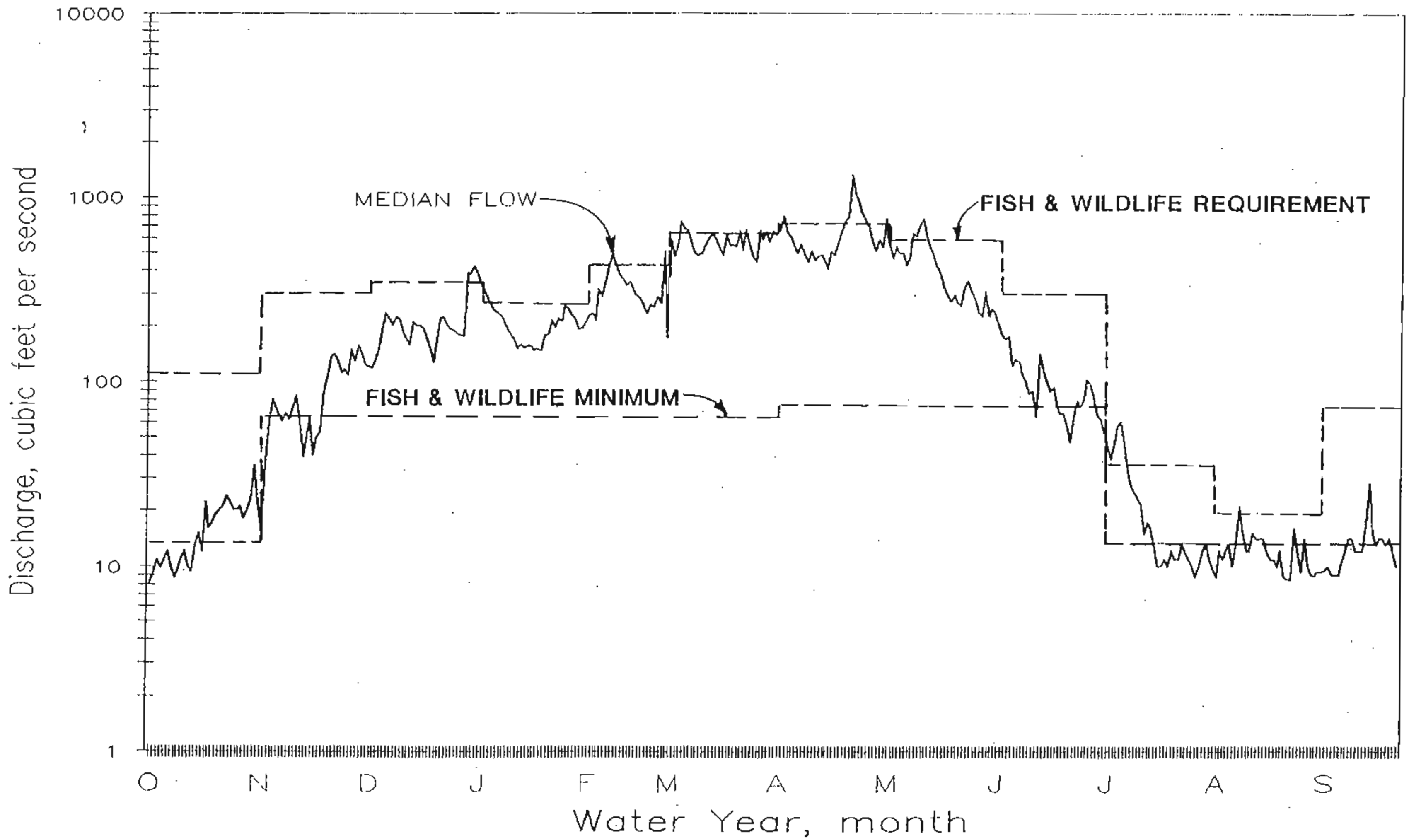
To account for the seasonal variability of stream flow in the basin, the year was divided into three seasons as identified in the Arkansas Method (Filipek et al, 1985). The seasons are based on physical processes that occur in the stream and the critical life stages of the fish and other aquatic organisms. The minimum instream flow requirements for fish and wildlife were established by taking 10 percent of the average seasonal flows.

In addition to fish and wildlife requirements, instream flow requirements for water quality, riparian use, navigation, and aesthetics were also considered in the determination of minimum streamflows. Since the instream flow requirements are not additive, the highest instream requirement for each season was used to establish the minimum streamflow for each season. Minimum streamflows were established at gaging station locations and other selected sites and are presented in Table 3-11. Fish and wildlife minimum flow is the governing instream flow requirement at a majority of the selected locations in the White River Basin. Water quality is the governing instream requirement at sections of the Black River, Spring River, and Eleven Point River. The navigation requirement is the governing flow requirement of the White River at Newport.

Establishment of minimum streamflows will have varying effects on different water users in the basin. Riparian users will be affected by the establishment of minimum streamflows. Industrial and agricultural riparian users must either conserve water or construct storage reservoirs in the anticipation of the times when the streamflow falls below the minimum levels. Instream water users will also be affected by the establishment of minimum streamflows. Although some level of flow protection will be beneficial to fish and wildlife, minimum streamflows are definitely not desirable conditions.

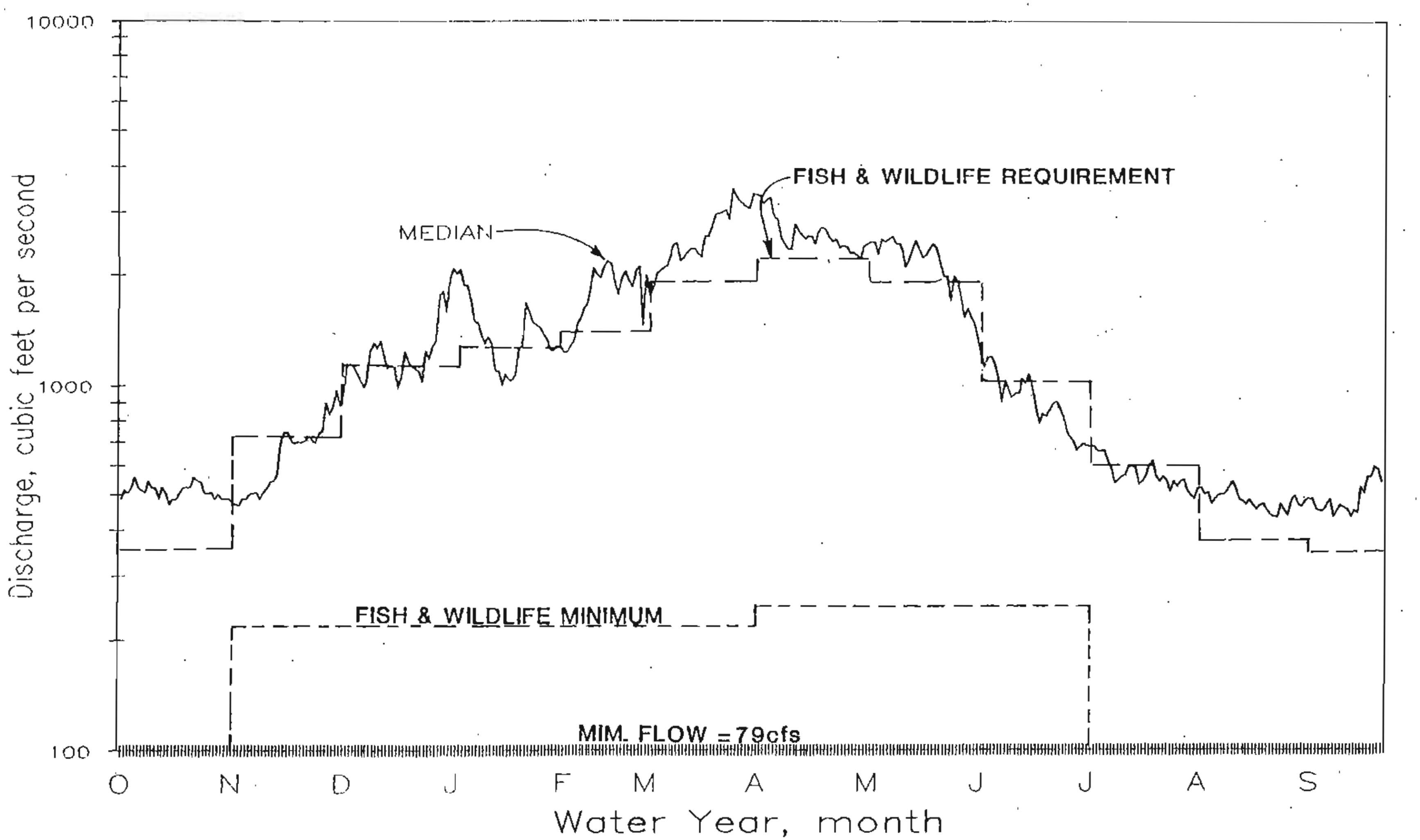
Low-flow conditions impact fish and wildlife. The Arkansas Game and Fish Commission has stated that at the minimum streamflow level extreme degradation to the fish and wildlife resource in a stream has already occurred. Water temperatures have significantly increased, mirrored by a substantial decrease in dissolved oxygen content in the water. Shoal or riffle areas are dewatered or essentially out of production. Spawning and survival of desirable fish types is greatly reduced. A shift to more tolerant and less diverse fish and invertebrate population is occurring. Riparian vegetation and associated wildlife is greatly reduced. Flushing of sediment and septic wastes in the stream is essentially nonexistant, magnifying the dissolved oxygen depletion, fish kills, pollution, and groundwater contamination. Waterfowl habitat is

FIGURE 3-4a COMPARISON OF MEDIAN DAILY DISCHARGE FOR THE PERIOD 1964 TO 1984 TO SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE WHITE RIVER NEAR FAYETTEVILLE, ARK.



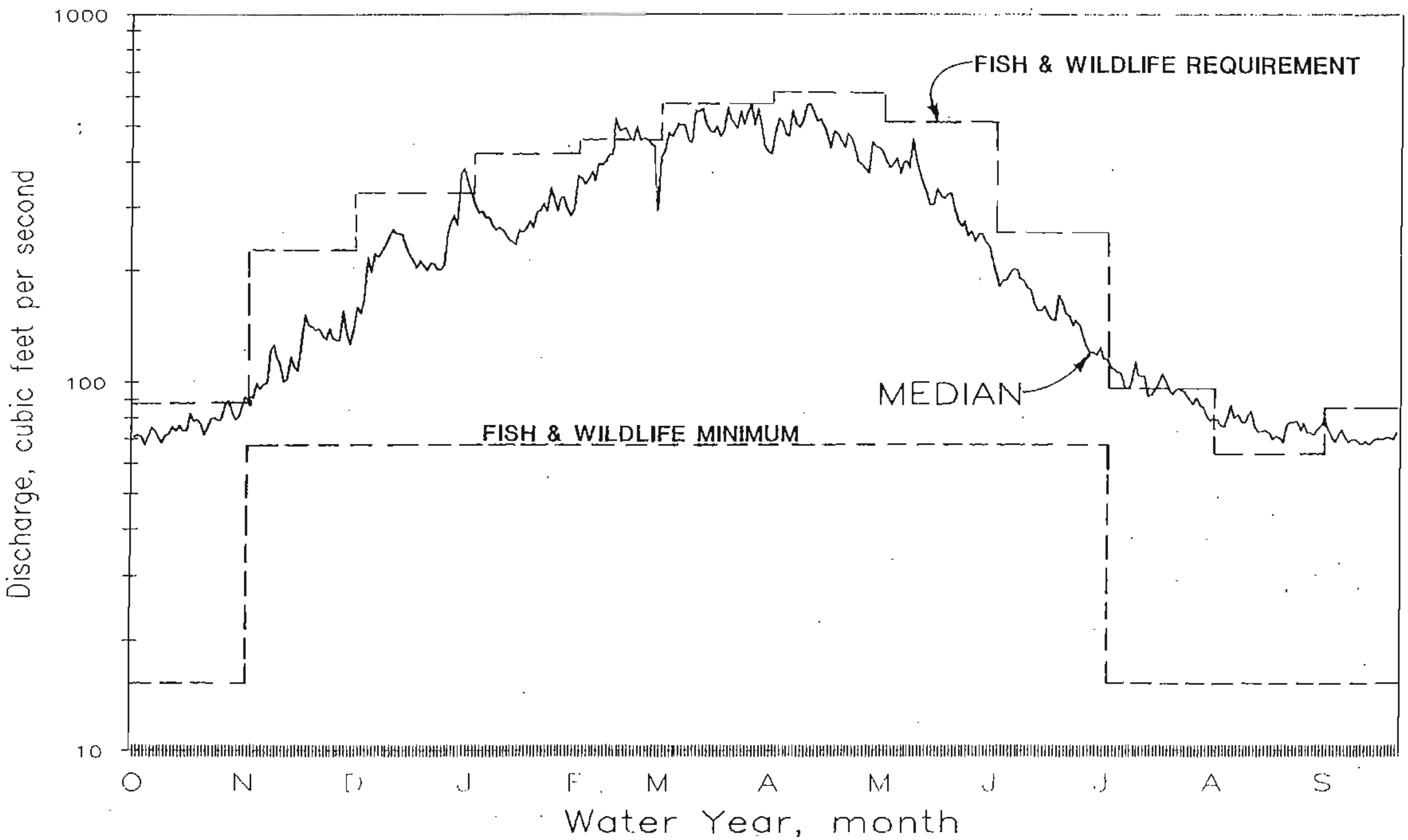
SOURCE: U.S. Geological Survey

FIGURE 3-4b COMPARISON OF MEDIAN DAILY DISCHARGE FOR THE PERIOD 1950 TO 1984 TO SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE BLACK RIVER NEAR CORNING, ARK.



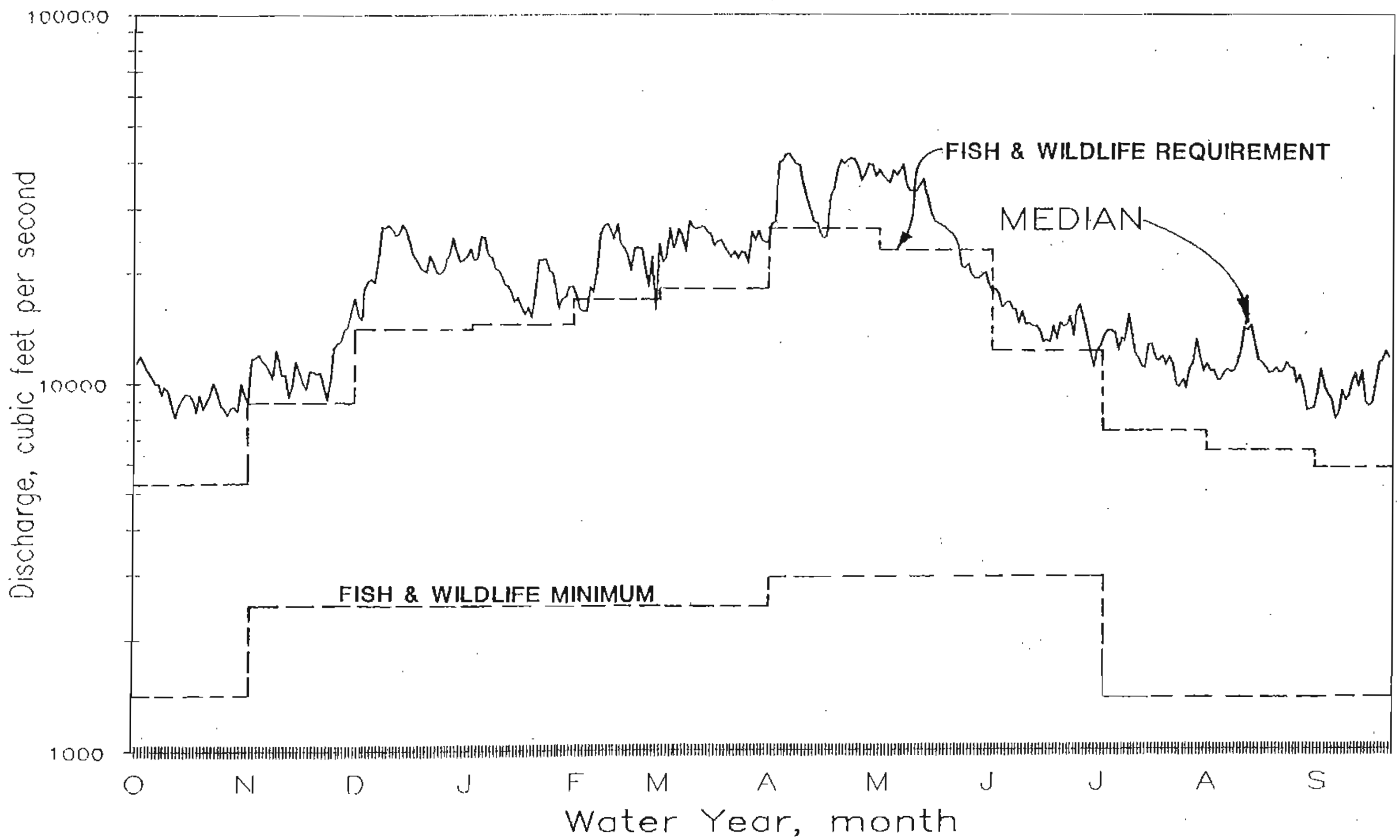
SOURCE: U.S. Geological Survey

FIGURE 3-4c COMPARISON OF MEDIAN DAILY DISCHARGE FOR THE PERIOD 1937 TO 1984 TO SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE STRAWBERRY RIVER NEAR POUGHKEEPSIE, ARK.



SOURCE: U.S. Geological Survey

FIGURE 3-4d COMPARISON OF MEDIAN DAILY DISCHARGE FOR THE PERIOD 1965 TO 1984 TO SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE WHITE RIVER AT NEWPORT, ARK.



SOURCE: U.S. Geological Survey

TABLE 3-11 MINIMUM STREAMFLOWS IN THE UPPER WHITE RIVER BASIN BY SEASON

STATION NAME AND LOCATION	NOVEMBER - MARCH MINIMUM FLOW, cfs	NOVEMBER - MARCH GOVERNING INSTREAM REQUIREMENT	APRIL - JUNE MINIMUM FLOW, cfs	APRIL - JUNE GOVERNING INSTREAM REQUIREMENT	JULY - OCTOBER MINIMUM FLOW, cfs	JULY - OCTOBER GOVERNING INSTREAM REQUIREMENT
White River near Fayetteville, Ar.	66	FW	78	FW	12	FW
James River at Galena, Mo.	122	FW	136	FW	178	FW
White River near Branson, Mo.	403	FW	464	FW	648	FW
Buffalo River near St. Joe, Ar.	131	FW	166	FW	23	FW
N. Fork of White River near Tecumseh, Mo.	225	WQ	225	WQ	225	FW
White River at Calico Rock, Ar.	1048	FW	1168	FW	1020	WQ
North Sylamore Creek near Fifty Six, Ar.	6.4	FW	6.5	FW	1.2	WQ
Black River near Annapolis, Mo.	73	WQ	79	FW	73	WQ
Black River near Corning, Ar.	273	WQ	273	WQ	316	FW
Current River at Doniphan, Mo.	959	WQ	959	WQ	959	WQ
Spring River at Imboden, Ar.	281	WQ	281	WQ	281	WQ
Eleven Point River near Bardley, Mo.	189	WQ	189	WQ	189	WQ
Eleven Point River Near Ravenden Springs, Ar.	292	WQ	292	WQ	292	WQ
Black River at Black Rock, Ar.	2000	WQ	2000	WQ	2000	WQ
Piney Fork at Evening Shade, Ar.	12	FW	13	FW	2.5	FW
Strawberry River naar Poughkeepsie, Ar.	67	FW	67	FW	41	WQ
White River at Newport, Ar.	7700	N	7700	N	7700	N
Middle Fork of Little Red R. at Shirley, Ar.	66	FW	61	FW	10	FW

Legend: FW - Fish and Wildlife WQ - Water Quality N - Navigation decimated and terrestrial wildlife dependent on the river become more susceptible to dependent limiting factors such as predation, disease, lack of reproductive success and starvation. The minimum streamflow is clearly not a desirable flow condition for fish and wildlife, nor one which should be maintained for any length of time.

Establishment of minimum streamflows will have an impact on waterfowl habitat. The use of surface water to flood green tree reservoirs may be restricted during the fall, especially November except on regulated streams.

Finally, an important question to be addressed is the impact of minimum streamflows on priority of other users during allocation conditions. Under current law, the Arkansas Soil and Water Conservation Commission (AS&WCC) has the authority to allocate water during periods of water shortage based on the following water-use priorities: 1) sustaining life, 2) maintaining health, and 3) increasing wealth. Additionally, in "Rules for Surface Water Diversion Registration and Allocation in the State of Arkansas" by AS&WCC, the following are to be reserved prior to allocation:

1. Domestic and municipal-domestic use;
2. Instream flow required to maintain stream ecosystems;
3. All water requirements for support of those purposes previously authorized; and,
4. All other lawful uses of water.

It would appear that the minimum streamflow for fish and wildlife would define the number 2 reservation according to the rules. However, since the minimum streamflow is defined as a critical low-flow condition, allocation should begin above this point. Two questions arise: 1) What is the point at which allocation should begin and should this be a fixed point? (i.e. what defines a shortage); and 2) What is the priority of competing uses in a shortage which has not reached the minimum flow conditions? Simply stated, where does fish and wildlife priority fall in relation to agriculture, industry, hydropower and other uses in allocation above the defined minimum flow? It would appear under current case law and rules and regulations; all of these uses have equal priority.

The point at which allocation should begin is a decision which should be made on a case by case basis taking into account the historical uses and values of each stream resource. This is envisioned as a judgement which will vary not only within the state but also vary in different reaches of individual streams.

SAFE YIELD

Section 2 of Act of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to define the safe yield of streams and rivers in Arkansas. The safe yield of a stream or river is defined as the amount of water that is available, or potentially available, on a dependable basis which could be used as a surface water supply.

Existing Streamflow Conditions

Seasonal and annual variability of streamflow affect the dependability of water available for development. To analyze the variability of streamflow in the Upper White River Basin, flow-duration curves were developed for streams at gaging station locations. The flow-duration curve is a cumulative frequency curve of daily mean flows that shows the percent of time which specified discharges were equaled or exceeded. The method outlined by Searcy (1959) was used to develop the flow-duration curves and selected points from the curves are summarized in Table 3-3. It should be noted that the flow-duration curve applies only to the period for which data were used to develop the curve or to the period to which the curve is adjusted (Searcy, 1959). However, these data may be used to estimate the probability of occurrence of future streamflow if the period of record is representative of the long-term flow of the stream.

Figure 3-3 shows a commparison of two streams with different low-flow characteristics. The Strawberry River plot is a curve with a high base flow. The Middle Fork of the Little Red River plot is a curve which represents a stream without base flow (7Q10 = 0). The Middle Fork of the Little Red River plot illustrates that when surface runoff is complete there is no base flow.

Safe Yield

To quantify the safe yield of streams in the Upper White River Basin, the amount of water available on a dependable basis was designated as the discharge which has been equaled or exceeded 95 percent of the time for the available period of record. This flow represents the discharge which can be expected at selected stream locations on a dependable basis, however, not all of this flow is actually available for use. Minimum streamflows which have been established for streams and rivers in the Upper White River Basin and were previously defined in this report represent discharge that is not available for use. The minimum flow was selected as discussed previously in the Minimum Streamflow Section. This selection process considered all instream flow requirements.

Therefore, the safe yield of a stream or river is the discharge which can be expected 95 percent of the time minus the discharge necessary to maintain the minimum flow in the stream during the normal dry period of the year.

Table 3-12 shows the safe yield at several selected continuous gaging stations in the Upper White River Basin. The safe yield was computed using mean daily flows throughout the entire period of record. In Table 3-12, there are values of safe yield which are zero. The zero values indicate that there is no safe yield.

Potential for Development

Safe yield has been addressed by considering existing streamflow conditions, but the potential for development must be considered to get an accurate portrayal of the water supplying capabilities of the basin. Water

TABLE 3-12 SAFE YIELD OF STREAMS AT SELECTED GAGING STATIONS

NUMBER, STREAM, AND LOCATION	July through October		
	FLOW WHICH WAS EQUALED OR EXCEEDED 95 % OF THE TIME (cfs)	MINIMUM STREAMFLOW (cfs)	SAFE YIELD (cfs)
07048600 White River near Fayetteville, Ar.	2.3	12	0
07052500 James River at Galena, Mo.	102	261	0
07053500 White River near Branson, Mo.	45	261	0
07056000 Buffalo River near St. Joe, Ar.	21	23	0
07057500 N. Fork of White River near Tecumseh, Mo.	236	225	11
07060500 White River at Calico Rock, Ar.	1490	1020	470
07060710 North Sylamore Creek near Fifty Six, Ar.	3	1.2	2
07061500 Black River near Annapolis, Mo.	82	73	9
07064000 Black River near Corning, Ar.	288	273	15
07068000 Current River at Doniphan, Mo.	1000	959	41
07069500 Spring River at Imboden, Ar.	296	281	15

TABLE 3-12 SAFE YIELD OF STREAMS AT SELECTED GAGING STATIONS (cont.)

NUMBER, STREAM, AND LOCATION	July through October FLOW IN CFS WHICH WAS EQUALED OR EXCEEDED 95 % OF THE TIME	MINIMUM STREAMFLOW (cfs)	SAFE YIELD (cfs)
07071500 Eleven Point River near Bardley, Mo.	207	189	18
07072000 Eleven Point River Near Ravenden Springs, Ar.	318	292	26
07072500 Black River at Black Rock, Ar.	2100	2000	100
07073500 Piney Fork at Evening Shade, Ar.	.9	2.5	0
07074000 Strawberry River near Poughkeepsie, Ar.	45	41	4
07074500 White River at Newport, Ar.	5090	7700	0
07075000 Middle Fork of Little Red R. at Shirley, Ar.	.02	10	0

supply development, within a given basin, is the construction of features that permit the withdrawal of water when it is needed usually a reservoir. The reservoir stores runoff from rainfall so that water may be available for later use.

Studies have been made by the Soil Conservation Service (SCS) and the Corps of Engineers (Corps) which located flood control impoundments in the Upper White River Basin. SCS has identified 383 flood water retarding sites with a combined beneficial storage of 1.79 million acre-feet and an estimated yield of 1,500 million gallons per day. The Corps has identified 7 multi-purpose reservoirs with conservation storage of 910,000 acre-feet. The SCS sites are located throughout the basin while the Corps sites are located on the river mainstems and major tributaries (Comprehensive Basin Study, 1968). No attempt was made to assign a release rate to the various structures since the release rate will depend on the situation.

Many of the sites have little potential to be constructed as floodwater retarding structures due to lack of interest or cost effectiveness, but these sites are potential surface water storage sites.

WATER USE

Current Water Use

In 1980, the 17 county study area used 143.1 mgd, along with 3713.0 mgd for the production of electricity (Use of Water in Arkansas, 1980). The 3713 mgd of water used for hydroelectric production is not considered part of the water use because it essentially is returned to the stream in the same area as it was withdrawn (nonconsumptive use). The water is available for reuse downstream of the power plant and can be used in computations of excess streamflow. The study area water use by category and source is listed in Table 3-13.

TABLE 3-13 1980 USE OF WATER IN THE 17 COUNTY STUDY AREA
(million gallons per day)

USE CATEGORY	SURFACE WATER
Public Supply	22.5
Self Supplied Industry	1.4
Rural Use:	
Domestic	0
Livestock	13.8
Subtotal	13.8
Irrigation	105.4
Electric Energy	3,713.0
TOTAL	3,856.1

SOURCE: Use of Water in Arkansas, 1980

A portion of the 143.1 mgd water used was consumed. The consumed portion was either evaporated, transpired, ingested, or incorporated into a product. Consumptive water use in the study area amounted to 100 mgd of the 143.1 mgd withdrawn (Use of Water in Arkansas, 1980).

Water Use Trend

Water use data from 1960, 1965, 1970, 1975 and 1980 for the various uses are plotted in Figures 3-5a through Figure 3-5g. Most categories showed an overall increase in the use of surface water except self-supplied industry which has shown a 39 percent decline in use since 1970. The range of increases were 71 percent for rural use to 1,028 percent for irrigation.

Potential Water Use

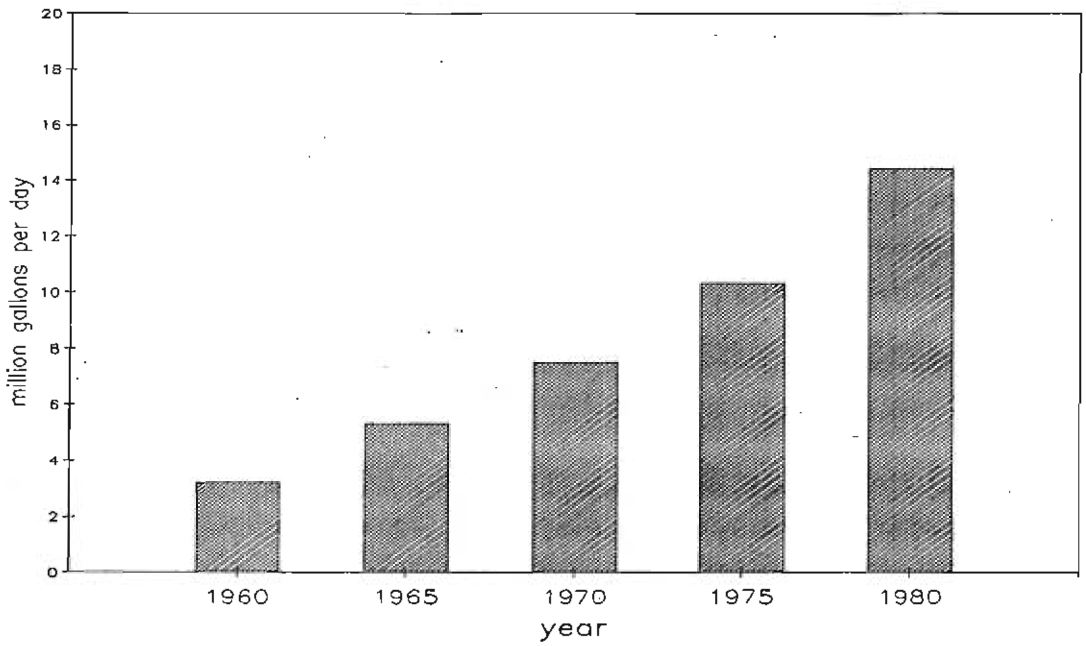
The Arkansas Soil and Water Conservation Commission projections indicate that the use of water in the Upper White River Basin will gradually increase during the period 1980 through 2030. Table 3-14 shows the projected changes in surface water use.

Overall use of surface water in the Upper White River Basin will increase 3.6 percent from 1980 to 2030. The reason for such a low percentage of increase in surface water is that electric energy production is expected to remain constant through the year 2030. The facilities which produce the electric energy will not have exceeded their expected life by the year 2030. Electric energy production used 96 percent of the surface water in 1980.

The public supply category is projected to have the greatest increase of water use or an increase of 240 percent by 2030. Major residential developments are occurring around the large lakes in the basin. High quality surface water sources are available or potentially available in the Upper White River Basin.

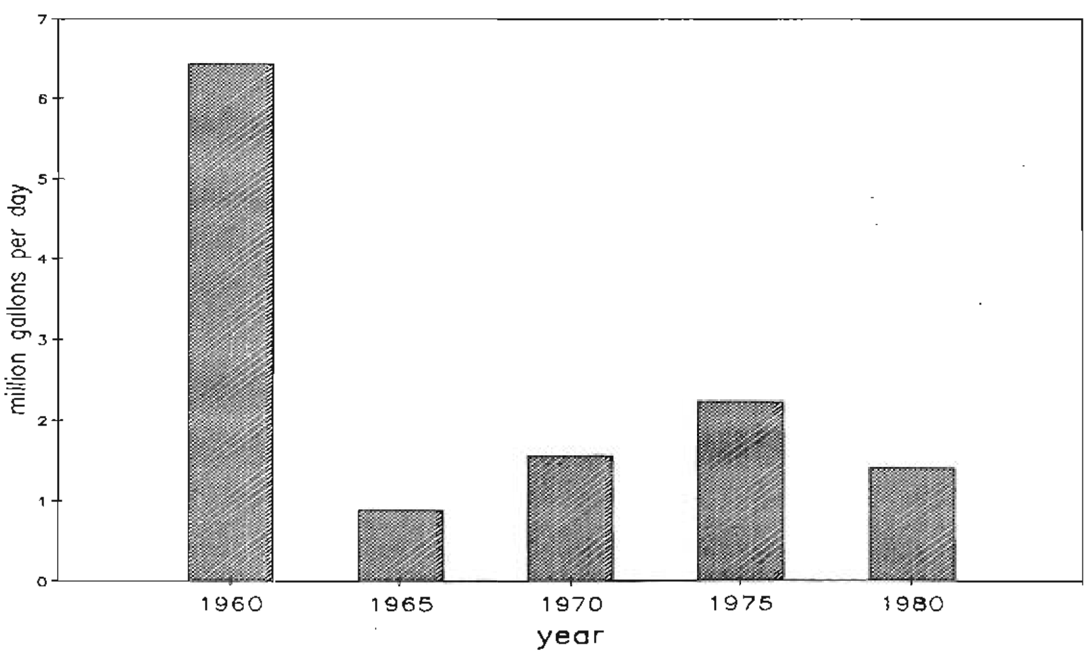
Irrigation water use is projected to have a 78 percent increase. One reason for the increased use of surface water is the greater number of acres irrigated which is expected to increase from 140,122 acres in 1980 to 397,100 acres in 2030. Farming technology will advance to the level which will promote increased use of irrigation. The acres of land are available to support the irrigation of 397,100 acres of cropland since there are estimated to be 1.05 million acres of prime farmland in the Upper White River Basin and currently 703,027 acres of cropland. The high investment cost of irrigation equipment will be a deterrent to the increased use of surface water for irrigation.

FIGURE 3-5a WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Public Supply



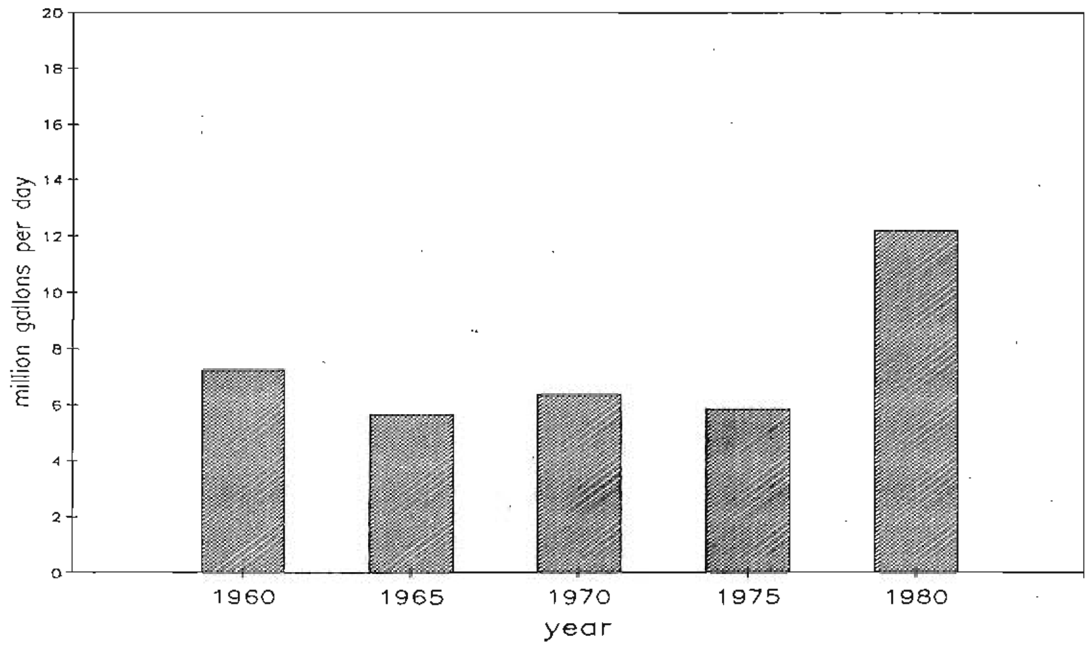
SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5b WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Self-Supplied Industry



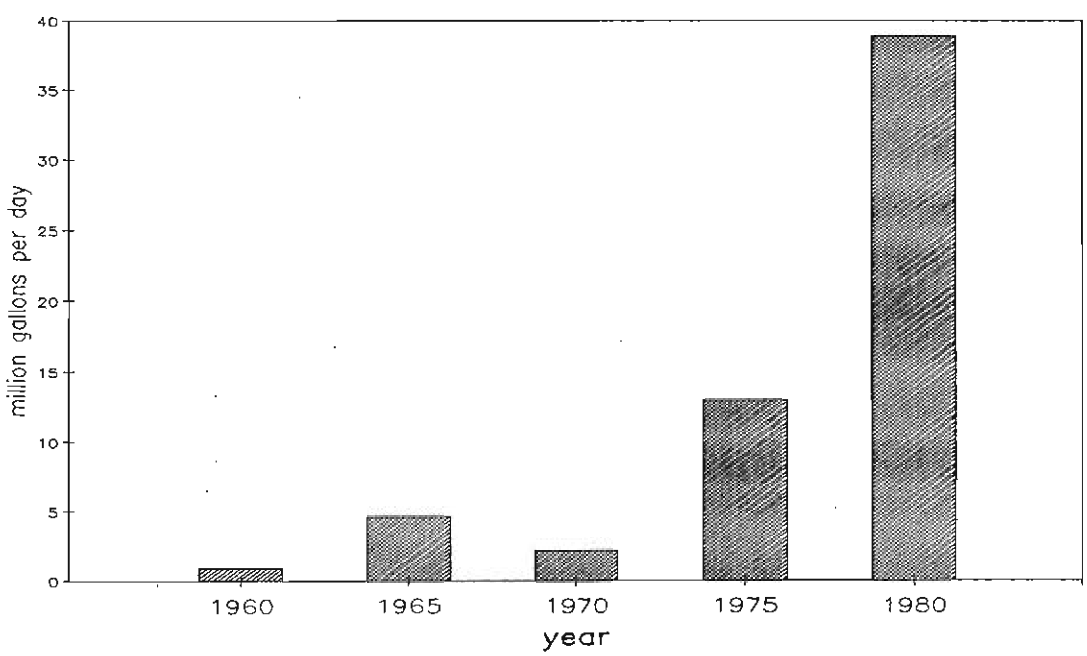
SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5c WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Rural Use - Livestock



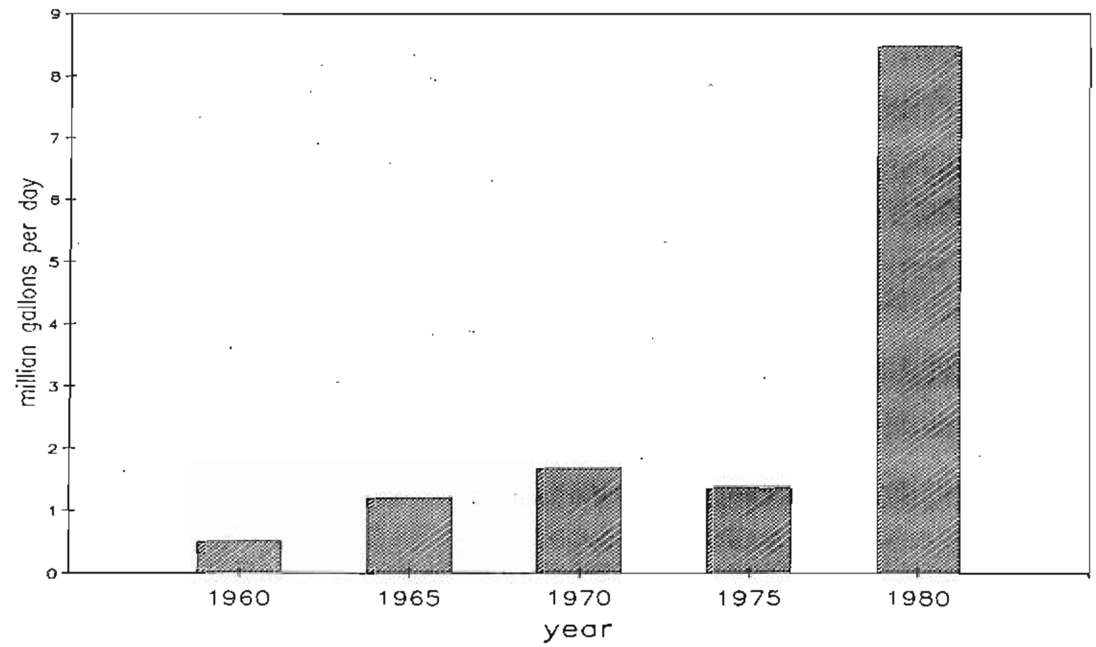
SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5d WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Irrigation - Rice



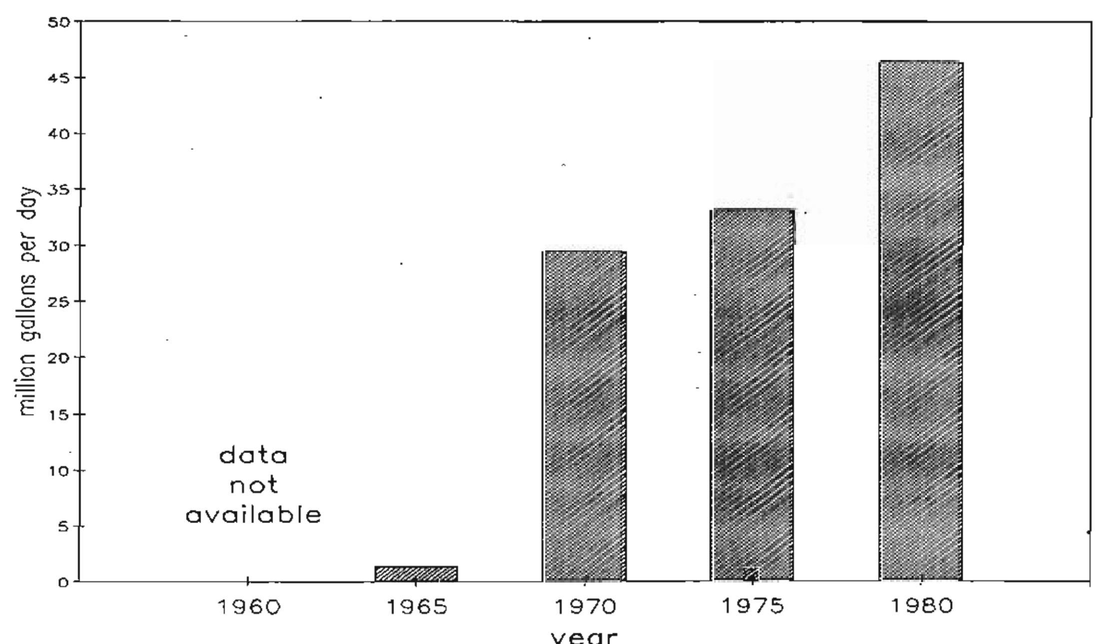
SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5e WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Irrigation - Other



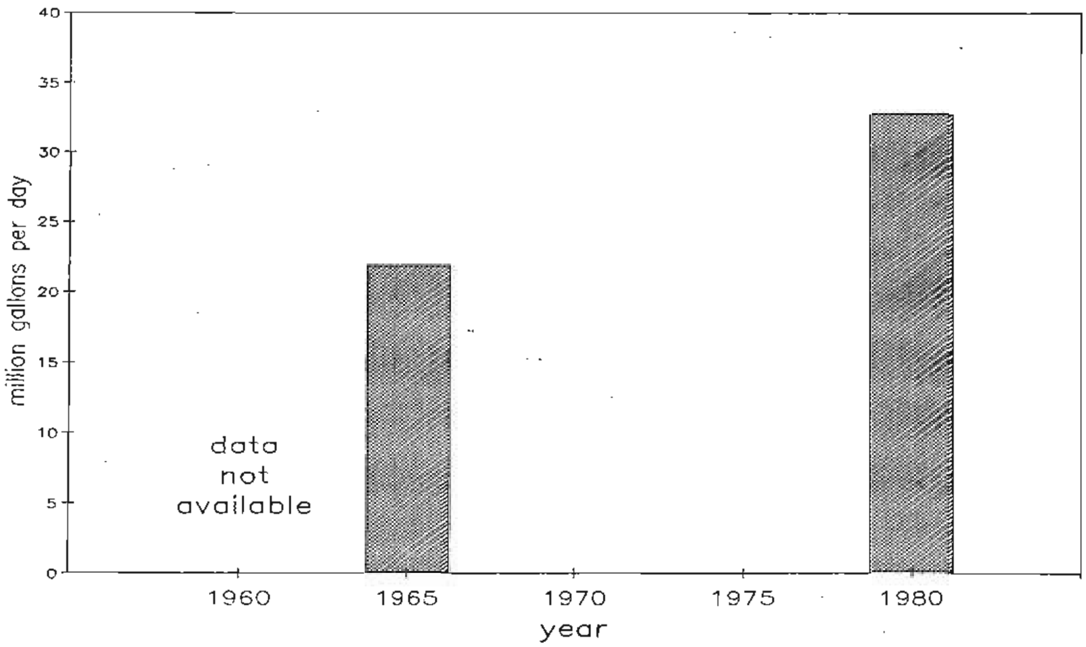
SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5f WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Fish and Minnow Farms



SOURCE: U.S.G.S., Use of Water in Arkansas

FIGURE 3-5g WATER USE TREND IN THE UPPER WHITE RIVER BASIN
Wildlife Impoundments



SOURCE: U.S.G.S., Use of Water in Arkansas

TABLE 3-14 CURRENT SURFACE WATER USE AND SURFACE WATER USE PROJECTIONS FOR 2030 BY CATEGORY (million gallons per day)

USE	1980 1/	2030 2/
Public Supply	22.5	76.4
Self-Supplied Industry	1.4	3.3
Rural Use:		
Domestic	0.0	0.0
Livestock	13.8	16.2
Subtotal (Rural Use)	13.8	16.2
Irrigation 3/	105.4	187.2
Electric Energy	3713.0	3713.0
Total	3856.1	3996.1

1/Use of Water in Arkansas, 1980
2/Arkansas Soil and Water Conservation Commission
3/Includes fish and minnow farms and wildlife impoundments

Excess Streamflow

As defined in Section 5 of Act 1051 of 1985, excess stream flow is twenty-five percent of that amount of water (available on an average annual basis) above the amount required to satisfy the existing and projected water needs of the basin. To determine the excess streamflow in the Upper White River Basin, the amount of water in the streams and rivers on an average annual basis was first calculated based on U.S. Geological Survey streamflow data. Since the lower end of the basin is entirely within Arkansas, the data for the gaging station on the White River at Newport was adjusted using a ratio of drainage areas to determine the average annual flow below the confluence of the Little Red River with the White River. The surface water yield at this point is estimated to be 18.3 million acre-feet annually.

The available surface water in the Upper White River Basin was calculated by subtracting the instream flow requirements for fish and wildlife (11.2 million acre-feet) and projected water use (0.3 million acre-feet) from the 18.3 million acre-feet of water yielded on an average annual basis from the basin resulting in 6.8 million acre-feet of available water.

As defined in Section 5 of Act 1051 of 1985, excess stream flow is twenty-five percent of that amount of water available on an average annual basis above the amount required to satisfy the existing and projected water needs of the basin. In the Upper White River Basin, the volume of excess stream flow is 1.7 million acre-feet of water which is available for other uses such as interbasin transfer.

SURFACE WATER QUALITY DATA COLLECTION NETWORK

Introduction

Surface water quality has been addressed by the Arkansas Department of Pollution Control and Ecology (ADPC&E) in its published reports "Water Quality Inventory Report, 1984", "Water Quality Inventory Report, 1986" and Arkansas Soil and Water Conservation Commission Report "Nonpoint Source Pollution Assessment Summaries for the Upper White River Basin, 1979". ADPC&E divides the White River Basin into eleven segments, 4A through 4k. Segments 4E through 4K cover the area known as the Upper White River Basin. See Figure 3-6 for a map showing the water quality segments.

Stream monitoring data are collected within the basin as part of ADPC&E's routine stream monitoring program. The water quality problems in each segment are addressed in the surface water quality problems section later in this chapter.

Segment 4E - Little Red River from the Headwaters to the Mouth

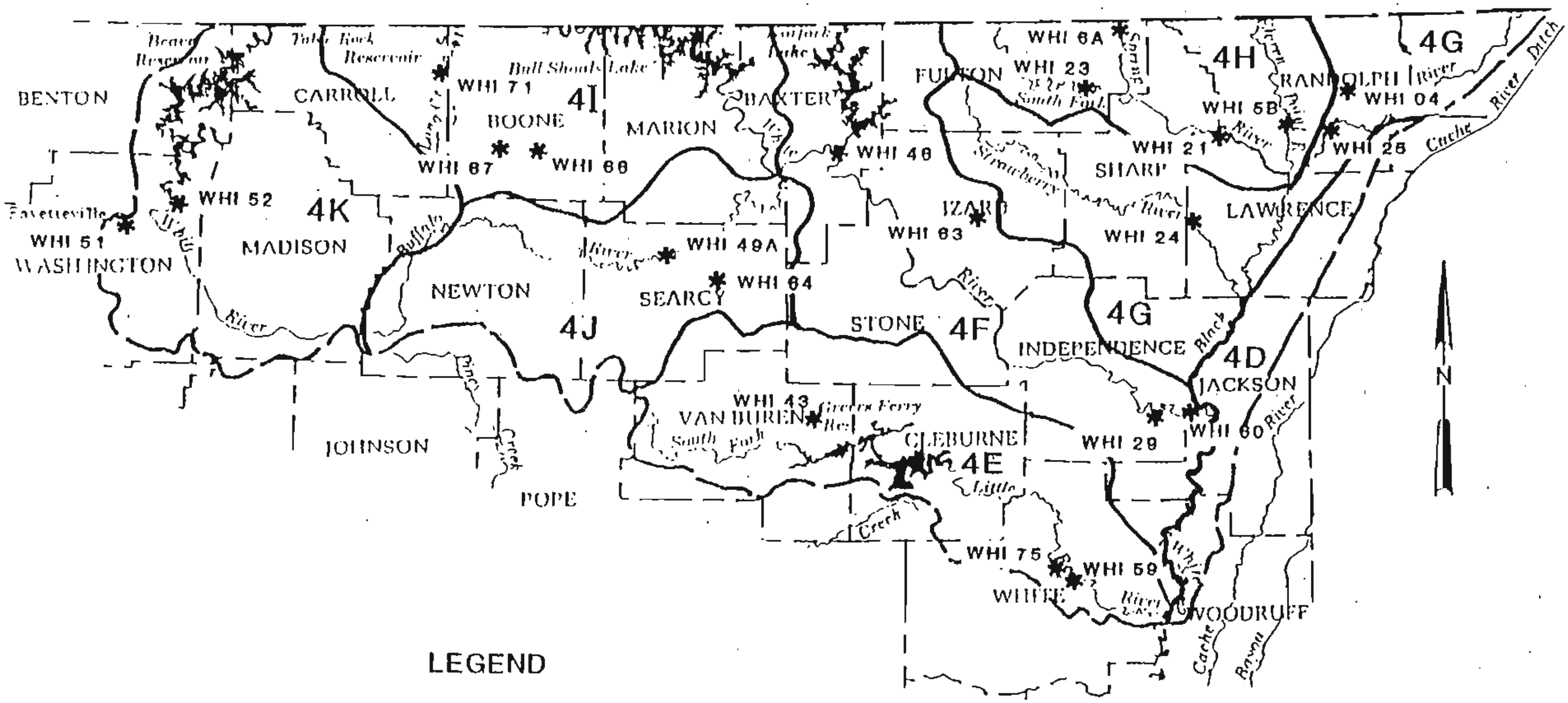
Segment 4E includes portions of Searcy, Van Buren, Stone, Cleburne, and White Counties. The segment encompasses the entire 81-mile length of the Little Red River and its major tributaries - the Middle, South, and North Forks, Big Creek, and Devil's Fork. The drainage area is 1,782 square miles.

There are three water quality monitoring stations in the segment. Two of the stations are on the Little Red River above and below Searcy. One is on the Middle Fork of the Little Red River (Water Quality, 1986).

Segment 4F - White River from the Mouth of Black River to the Mouth of the Buffalo River

Segment 4F is a 125-mile long reach of the White River which extends from the mouth of the Black River to the mouth of the Buffalo Buffalo. The drainage area of this segment is 2,199 square miles. Counties included are Baxter, Fulton, Izard, Stone, Independence, and Sharp. Major tributaries of this segment are Polk Bayou, Sylamore Creek, Salado Creek, Hicks Creek, Norfork River, and Bennett's River.

There are seven water quality monitoring stations in Segment 4F. The White River has five water quality monitoring stations in this segment which are located at Oil Trough, at Norfork, near Jacksonport, above Batesville, and below Batesville. Other stations are located on Mill Creek below Melbourne and Hicks Creek below Mountain Home.



LEGEND

✱ WATER QUALITY MONITORING STATION

4E WATER QUALITY PLANNING SEGMENT NUMBER

UPPER WHITE RIVER BASIN

WATER QUALITY PLANNING SEGMENTS AND MONITORING STATIONS

FEBRUARY 1988

SOURCE: ARKANSAS WATER QUALITY INVENTORY REPORT, 1986

Figure 3-6

Segment 4G - Black River, Strawberry River, and Tributaries

Segment 4G includes portions of Izard, Sharp, Independence, Lawrence, Randolph, and Clay counties in the northeast corner of the state. This segment encompasses a 121-mile reach of the Black River from its mouth to the Missouri state line, and its major tributaries; the Strawberry River and Current River. The drainage area of the segment is 1,708 square miles.

Two water quality monitoring stations are found in Segment 4G. The stations are on the Current River near Pocahontas and the Strawberry River near Smithville.

Segment 4H - Spring River, South Fork Spring River and Eleven Point

Segment 4H encompasses the entire 46-mile length of the Spring River and its major tributaries, the South Fork, the Eleven Point River, Myatt Creek, and Martin's Creek. Portions of Fulton, Sharp, and Randolph counties make up the 911 square mile drainage area which comprise Segment 4H.

There are five water quality monitoring stations in Segment 4H. They are located on Spring River, Black River, and Eleven Point River. Spring River has gages near Thayer, Missouri and Ravenden, Arkansas. South Fork of Spring River has a gage at Saddle. The gage on the Eleven Point River is near Pochontas.

Segment 4I - White River from the Mouth of Crooked Creek to the Mouth of Long Creek

Segment 4I is a 31-mile reach of the White River from the mouth of Crooked Creek to the mouth of Long Creek. Located in north central Arkansas, Segment 4I includes portions of Carroll, Boone, and Marion counties. The major tributaries are Crooked Creek and Long Creek. The area of Segment 4I is 1,400 square miles.

The water quality in Segment 4I is monitored at Crooked Creek below Harrison, Crooked Creek above Harrison, and Long Creek below Denver.

Segment 4J - Buffalo River and Tributaries

Segment 4J includes portions of Newton, Searcy and Marion counties in north central Arkansas. The entire drainage area of the 113-mile length of the Buffalo River is included in this segment. The area of Segment 4J is 1,362 square miles.

The quality of water is monitored at two stations within the Buffalo River Basin. There are water quality monitoring stations near St. Joe on the Buffalo River and Bear Creek below Marshall.

Segment 4K - Upper White River and Kings River

Segment 4K encompasses 1,830 square miles in portions of Washington, Benton, Madison and Carroll counties in northwest Arkansas. The segment includes a 66-mile reach of the White River with its tributaries and an 85-mile reach of the Kings River and its tributaries.

There are six water quality monitoring stations in Segment 4K. The locations of the stations are on the Kings River near Grandview, Osage Creek above Berryville, Osage Creek below Berryville, the West Fork of the White River near Fayetteville and the White River near Goshen.

Impoundments Inventory

In the Upper White River Basin, there are many surface water impoundments. The major impoundments are Beaver, Table Rock, Bull Shoals, Norfork, Greers Ferry and Clearwater Lakes with a combined surface area of 115,340 acres and 10.56 million acre-feet of storage at the top of the flood control pool. Table Rock dam is located in Missouri with a small area of water in Arkansas. Also, Clearwater Lake on the Black River is situated entirely in Missouri.

It is estimated there are 241 impoundments of 5 acres or more comprising 8,419 surface acres and storing 84,612 acre-feet of water. Impoundments of 5 acres or less are estimated to number 38,565 (Lakes of Arkansas, 1981).

The six major lakes in the Upper White River Basin were built during the period of 1940 through 1965 as part of the flood control works for the Lower Mississippi River. These lakes are owned and operated by the U. S. Army Corps of Engineers. The six major lakes are described in more detail in the following paragraphs.

Beaver Lake is formed by Beaver Dam and is located six miles west of Eureka Springs in Northwest Arkansas. Authorized purposes of Beaver Lake are flood control, water supply, hydropower, and other purposes. The drainage area above the dam is 1,186 square miles. The dam is 2,575 feet long and rises 228 feet above the river bed which includes a 1,333-foot-long concrete section. Construction of the dam started in October 1959, and the project was completed and hydropower generation began in May 1965. The conservation pool, elevation 1120 National Geodetic Vertical Datum (NGVD), covers an area of 28,200 acres with a shoreline of 450 miles. At elevation 1130 NGVD, the top of the flood control pool, the lake has a surface area of 31,700 acres surrounded by a shoreline of almost 500 miles. Beaver Lake provides a storage capacity of 1.95 million acre-feet, which includes 300,000 acre-feet for flood control and the remainder for water supply and power generation (Water Resource Development, 1981).

Hydropower generation is scheduled by the Southwest Power Administration and the power is used to meet peak demands, especially, during the summer months. The average annual power generation during the period May 1965 through December 1979 was 133 million kilowatt hours of electricity.

Beaver Lake supplies a large quantity of water to Northwest Arkansas. Beaver Water District and Carroll-Boone Water District have contracted with the U.S. Government to utilize storage in Beaver Lake. The total water supply useage from Beaver Lake for October 85 to September 86 was 26.3 million gallons per day. The estimated yield of the water supply storage is 126 million gallons per day or 81 cubic feet per second.

Flow regulation of Beaver Lake is based on pool levels of Table Rock and Bull shoals. Any pool elevations are between top of power pool and top of spillway gates, Beaver Dam's releases are restricted to that required for firm power as long as water is stored in the flood pools at Table Rock and/or Bull Shoals. When Beaver Lake's stages are between firm power rule curve and top of power pool and water is stored in the flood pools of the downstream lakes, Beaver will restrict releases to that required for firm power when needed for system peaking purposes, otherwise reduce releases to zero. When flood pools at Table Rock and Bull Shoals are empty, secondary power generation at Beaver will be based on power-load conditions at the time. The estimated dependable discharge of the hydropower storage is 925 cubic feet per second.

The water level in Beaver Lake has shown an annual pattern as shown in Figure 3-7. The water levels are highest during the period April through September. The highest recorded water elevation was 1130.4 feet NGVD on December 1984 and the lowest recorded water elevation was approximately 1096 feet NGVD during January 1977. (See Figure 3-7.)

Table Rock Lake is formed by Table Rock Dam and is located eight miles west of Branson in southwest Missouri. Authorized purposes of Table Rock Lake are flood control, hydropower, and other purposes. The drainage area above the dam is 4,020 square miles. The dam is 6,423 feet long and rises 252 feet above the river bed which includes a 1,602-foot-long concrete section. Construction of the dam started in October 1954, and the dam was completed in August 1958. The top of conservation pool, elevation 915 NGVD, covers an area of 43,100 acres with a shoreline of 745 miles. At elevation 931 NGVD, the top of the flood control pool, the lake has a surface area of 52,300 acres surrounded by a shoreline of almost 500 miles. Beaver Lake provides a storage capacity of 3.46 million acre feet, which includes 760,000 acre-feet for flood control and 2.7 million acre-feet for power generation (Water Resource Development, 1981).

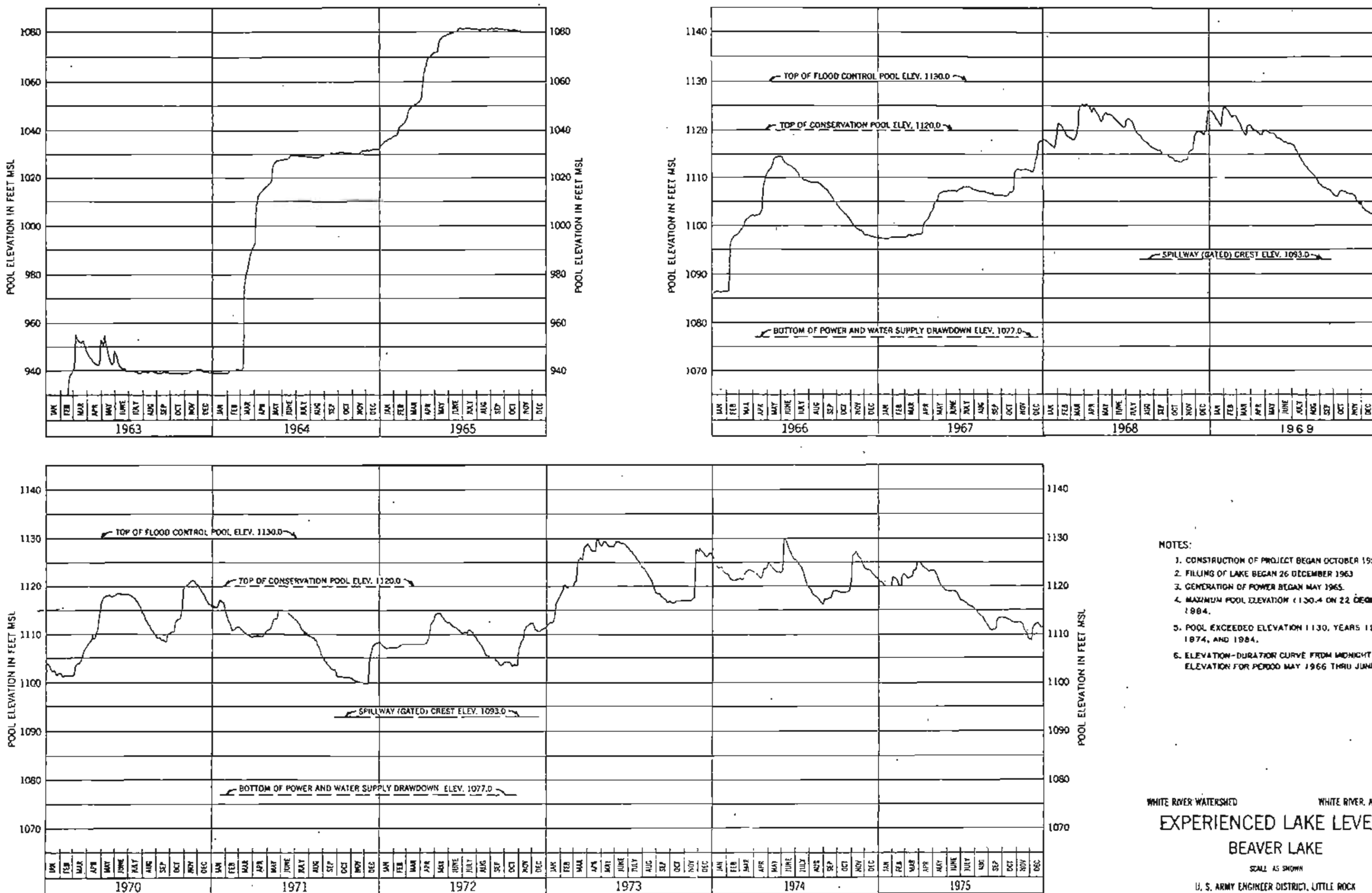
Hydropower generation began in June 1959 with the completion of two generating units and two additional generating units were added to the system in August 1961. Hydropower generation is scheduled by the Southwest Power Administration and the power is used to meet peak demands, especially, during the summer months. The power generation from June 1959 through December 1979 has totalled 9.3 billion kilowatt hours of electricity.

Table Rock releases are based on stages of Bull Shoals Lake. Firm power generation continues as scheduled by Southwest Power Administration until the water level in Bull Shoals rises into the flood pool.

The annual pattern of water level elevations for Table Rock Lake is not as definite as that for Beaver Lake. The water level elevations in Figure 3-8 are higher in the April through September period than the October through March period. The highest water level in Table Rock Lake was recorded on May 10, 1961 at elevation 932.5 NGVD (Figure 3-8) and the lowest water level was recorded during February 1965 at elevation 882 feet NGVD (Figure 3-8).

Bull Shoals Lake was formed by Bull Shoals Dam which began impounding water in July 1951. Bull Shoals Dam is on the White River, 11 miles west of Mountain Home, in north central Arkansas. The dam is 2,250 feet long and 256 feet high and is constructed entirely of concrete. Bull Shoals Dam has a drainage area of 6,000 square miles. Bull Shoals Lake has a storage capacity of 5.4 million acre-feet, which includes 2.36 million acre-feet for flood control and 3.05 million acre-feet power generating purposes. The lake has a surface area in excess of 71,200 acres and a 1,050-mile shoreline at elevation

CORPS OF ENGINEERS U. S. ARMY



NOTES:

1. CONSTRUCTION OF PROJECT BEGAN OCTOBER 1959.
2. FILLING OF LAKE BEGAN 26 DECEMBER 1963
3. GENERATION OF POWER BEGAN MAY 1965.
4. MAXIMUM POOL ELEVATION 1130.4 ON 22 DECEMBER 1984.
5. POOL EXCEEDED ELEVATION 1130, YEARS 1973, 1974, AND 1984.
6. ELEVATION-DURATION CURVE FROM MIDNIGHT POOL ELEVATION FOR PERIOD MAY 1966 THRU JUNE 1985.

WHITE RIVER WATERSHED WHITE RIVER, ARKANSAS

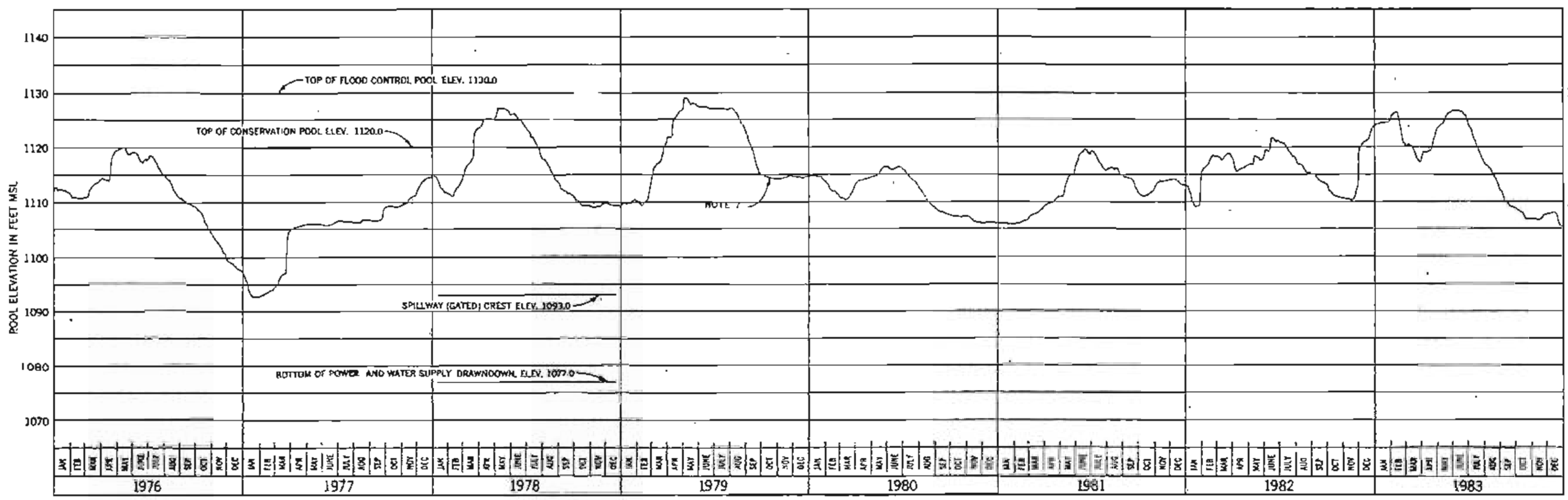
EXPERIENCED LAKE LEVELS

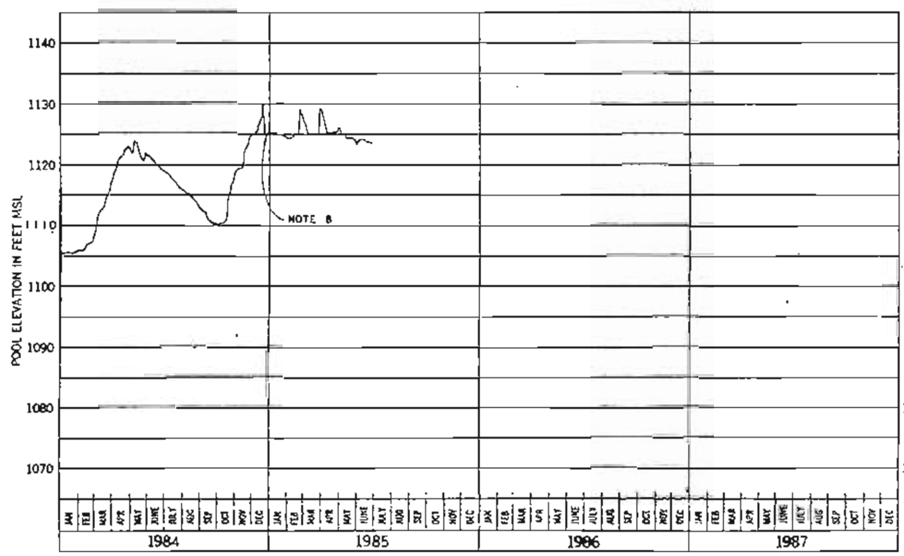
BEAVER LAKE

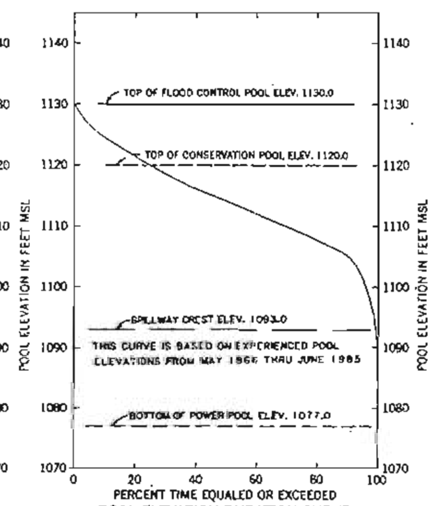
SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-7







POOL ELEVATION DURATION CURVE

NOTES:

1. CONSTRUCTION OF PROJECT BEGAN OCTOBER 1959.
2. FILLING OF LAKE BEGAN 28 DECEMBER 1963.
3. GENERATION OF POWER BEGAN MAY 1966.
4. MAXIMUM POOL ELEVATION 1130.4 ON 22 DEC 1984.
5. POOL EXCEEDED ELEVATION 1130, YEARS 1973, 1974, AND 1984.
6. ELEVATION-DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MAY 1966 THRU JUNE 1985.
7. POOL LOWERED FOR EMBANKMENT REPAIRS.
8. FLOOD POOL EVACUATED 6 FT. TO REDUCE SEEPAGE THROUGH DIKE NO. 1.

WHITE RIVER WATERSHED — WHITE RIVER, ARKANSAS

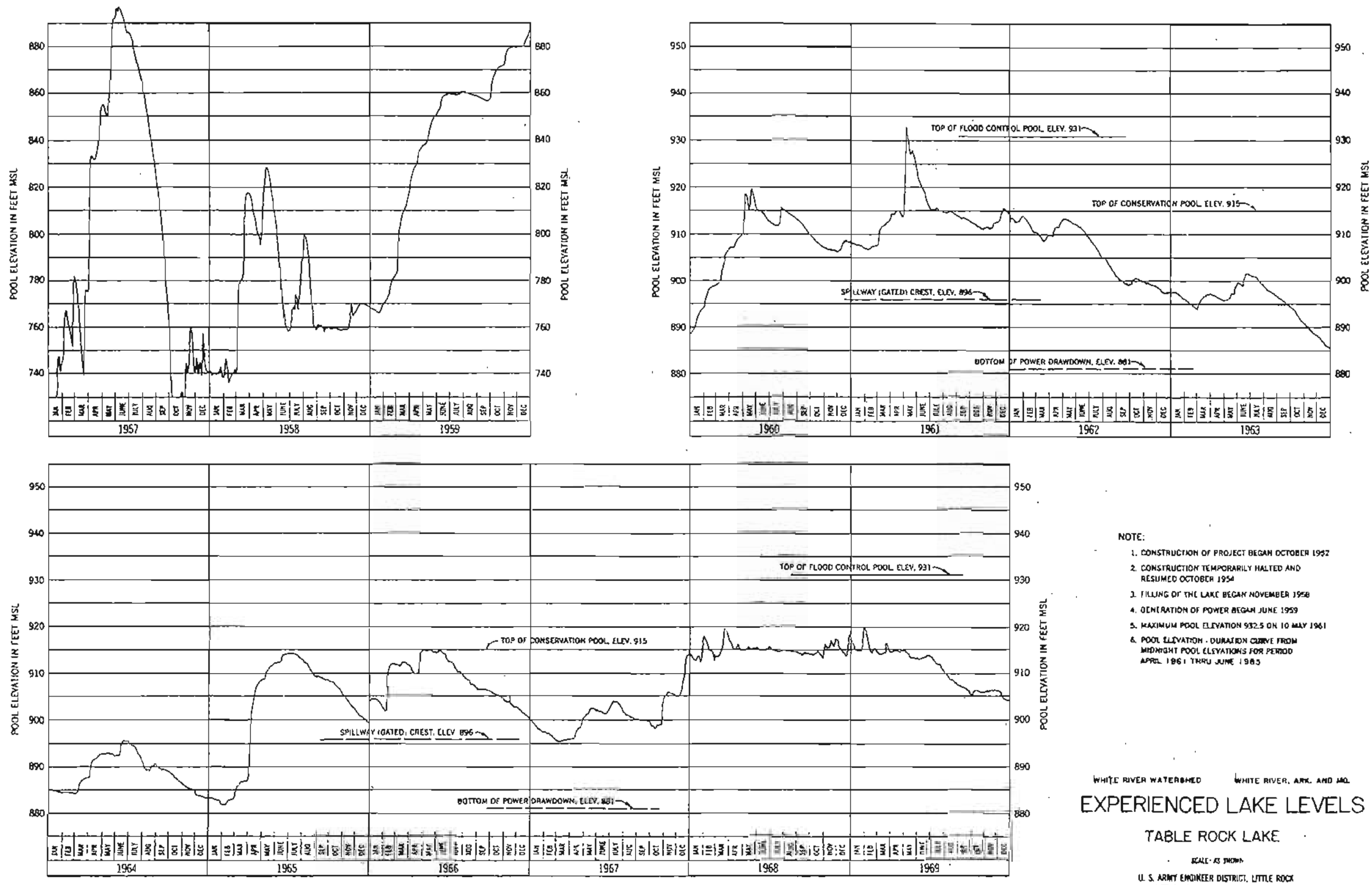
EXPERIENCED LAKE LEVELS

BEAVER LAKE

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-7



NOTE:

1. CONSTRUCTION OF PROJECT BEGAN OCTOBER 1952
2. CONSTRUCTION TEMPORARILY HALTED AND RESUMED OCTOBER 1954
3. FILLING OF THE LAKE BEGAN NOVEMBER 1958
4. GENERATION OF POWER BEGAN JUNE 1959
5. MAXIMUM POOL ELEVATION 932.5 ON 10 MAY 1961
6. POOL ELEVATION - DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD APRIL 1961 THRU JUNE 1985

WHITE RIVER WATERSHED — WHITE RIVER, ARK. AND MO.

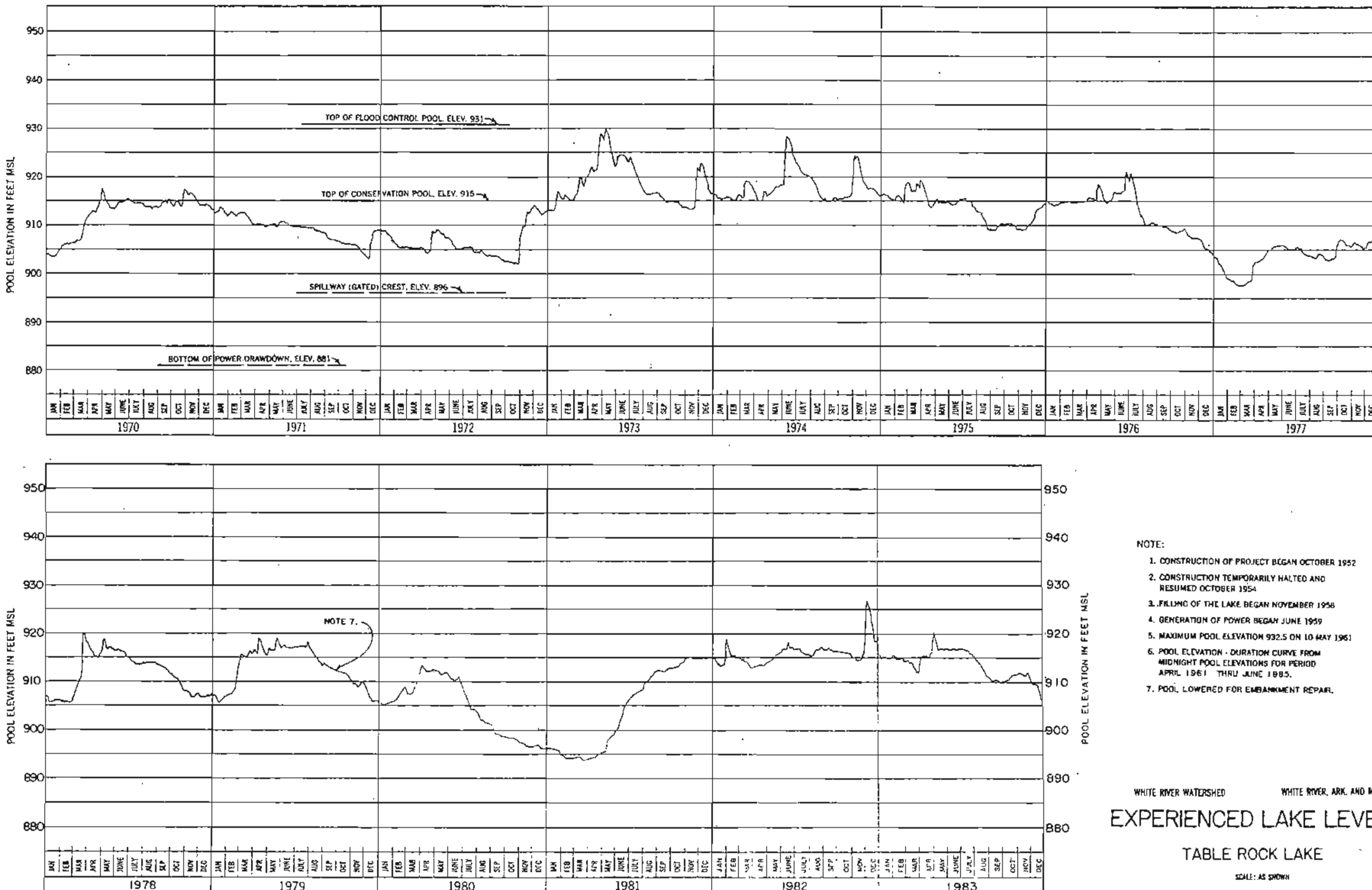
EXPERIENCED LAKE LEVELS

TABLE ROCK LAKE

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-8



NOTE:

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3. FILLING OF THE LAKE BEGAN NOVEMBER 1958
4. GENERATION OF POWER BEGAN JUNE 1959
5. MAXIMUM POOL ELEVATION 932.5 ON 10 MAY 1961
6. POOL ELEVATION - DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD APRIL 1961 THRU JUNE 1985.
7. POOL LOWERED FOR EMBANKMENT REPAIR.

WHITE RIVER WATERSHED — WHITE RIVER, ARK. AND MO.

EXPERIENCED LAKE LEVELS

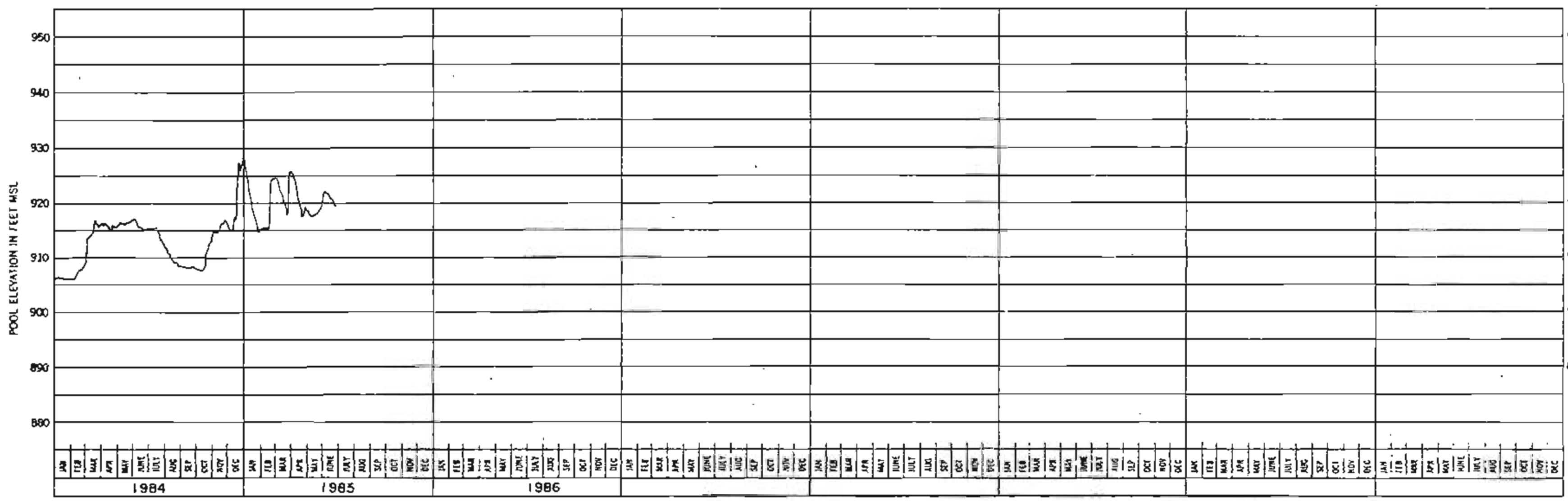
TABLE ROCK LAKE

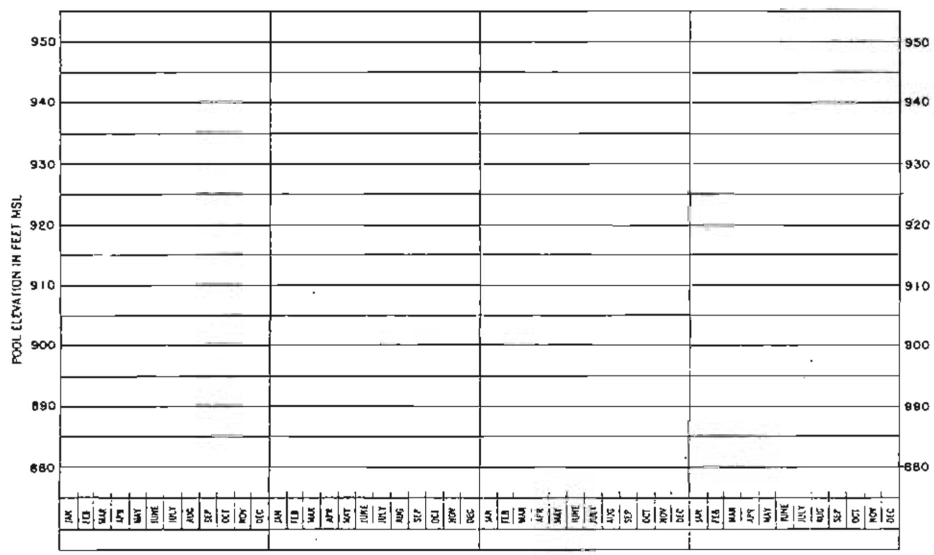
SCALE: AS SHOWN

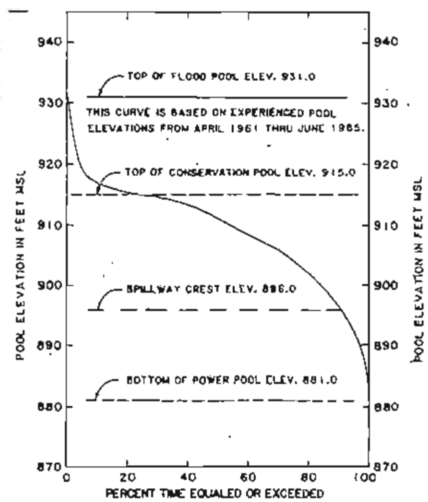
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-8

CORPS OF ENGINEERS U. S. ARMY







POOL ELEVATION DURATION CURVE

NOTES:

1. CONSTRUCTION OF PROJECT BEGAN OCTOBER 1952.
2. CONSTRUCTION TEMPORARILY HALTED AND RESUMED OCTOBER 1954.
3. FILLING OF THE LAKE BEGAN NOVEMBER 1958.
4. GENERATION OF POWER BEGAN JUNE 1959.
5. MAXIMUM POOL ELEVATION 932.5 ON 10 MAY 1961.
6. POOL ELEVATION - DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD APRIL 1961 THRU JUNE 1985

WHITE RIVER WATERSHED WHITE RIVER, ARK. AND MO

EXPERIENCED LAKE LEVELS

TABLE ROCK LAKE

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-8

695 feet NGVD, the top of flood control pool. The top of conservation pool, elevation 654 feet NGVD, covers an area of more than 45,400 acres with a shoreline of 740 miles.

Hydropower generation began in September 1952 and through December 1979 more than 17.3 billion kilowatt hours of electric energy has been produced. The power plant consists of 8 generators with a combined capacity of 340,000 kilowatts. The production and marketing of the energy is controlled by the Southwest Power Administration.

Bull Shoals Lake is regulated in conjunction with Norfork Lake. The releases from the two lakes are prorated to achieve the desired stage at the regulating gage and to maintain an equal percent of available flood control storage in Norfork and the Beaver-Table Rock-Bull Shoals system in so far as practicable. The regulating gage for the White River Lakes is located at Newport. With the lake water level into the flood pool during the December to April timeframe, releases do not normally exceed a 21 foot stage at the Newport gage which corresponds to a discharge of 50,000 cfs; during May to April releases do not normally exceed an 18 foot stage which is a discharge of 40,000 cfs; and, during June to November releases do not normally exceed a 14 foot stage which is a discharge of 30,000 cfs.

The water level elevation of Bull Shoals has exhibited an erratic pattern since the pool was filled in 1952. (See Figure 3-9) The maximum water surface elevation without Beaver and Table Rock Lakes was recorded on June 20, 1957 at 694.4 feet NGVD and a maximum water surface elevation of 691.0 feet NGVD as regulated by Beaver and Table Rock Lakes on June 14, 1973. The lowest water surface elevation was recorded in March 1981 at 837 feet NGVD. Bull Shoals Lake water level has been at the top of conservation pool approximately 30 percent of the time (Corps of Engineers file data).

Norfork Lake is on the North Fork River approximately 11 miles southeast of Mountain Home in north central Arkansas. The drainage area behind the dam is 1,808 square miles. Norfork Dam is a concrete structure extending more than 2,600 feet and has a height of 216 feet. Construction of Norfork Dam was started in October 1940 and completed in June 1944.

At the top of the flood control pool, elevation 580 feet NGVD, Norfork Lake contains almost 2.0 million acre-feet of storage and covers 30,700 acres. The conservation pool contains 1.2 million acre-feet of storage and has a surface area of 21,900 acres when at elevation 552 feet NGVD.

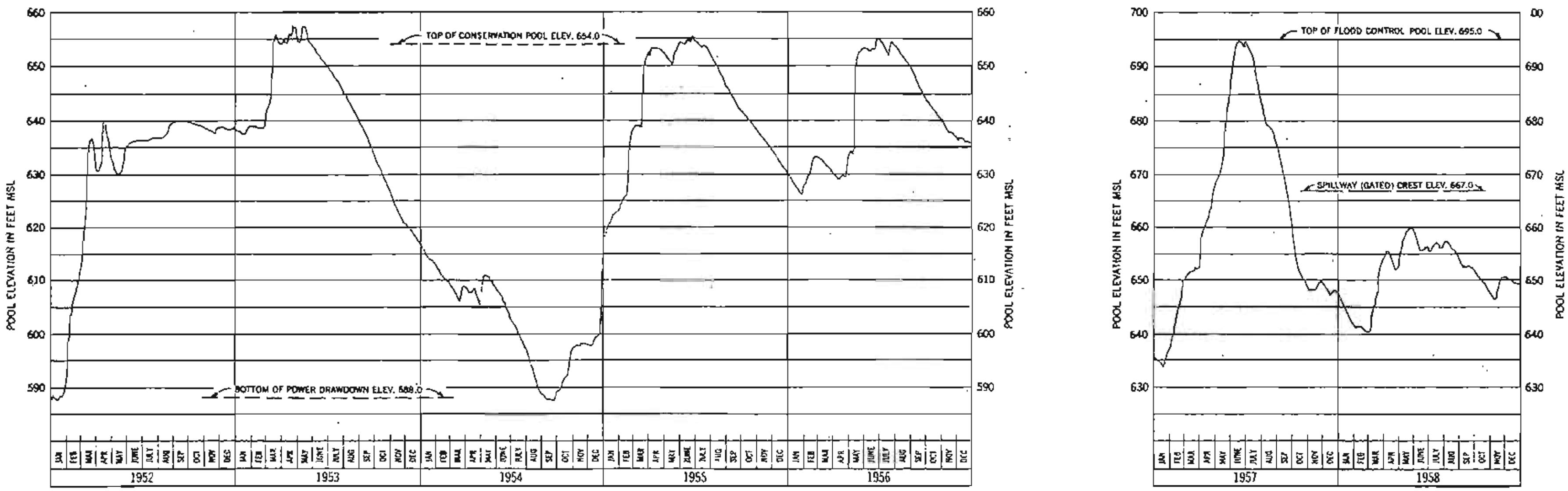
Norfork Lake is currently supplying Mountain Home with 3 million gallons per day municipal and industrial water. The water supply storage was made available by reallocating hydropower storage.

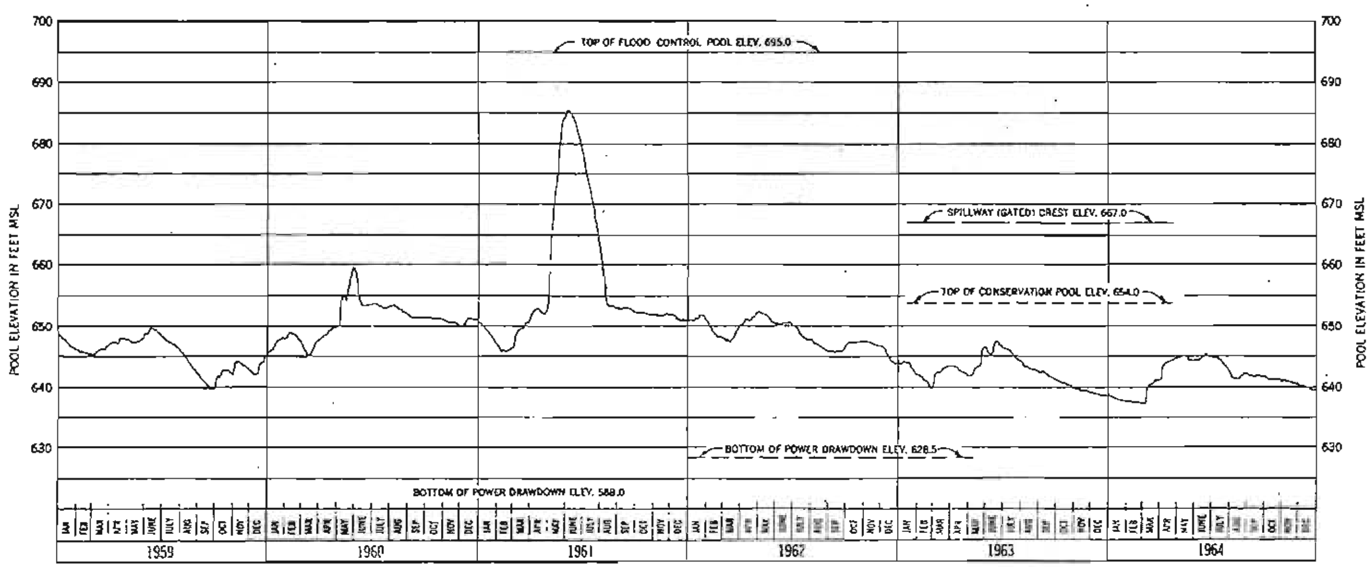
The hydropower facilities at Norfork Dam consists of two 42,275 kilowatt generators which have been in operation since June 1944. The Norfork hydropower units have produced a total of 6.5 billion kilowatt hours of electricity. The electric energy is scheduled and marketed by the Southwest Power Administration.

Norfork Lake is regulated in conjunction with Bull Shoals and the other White River lakes.

The Norfork Lake pool level has exhibited a pattern of higher elevations during January through June and declining levels during July through September. The maximum water level was recorded on May 11, 1973 at 579.0 feet NGVD and the minimum water level was elevation 510 NGVD during September 1954. The conservation pool has been at its maximum level 25 percent of the time (Corps of Engineers, file data). (Figure 3-10)

CORPS OF ENGINEERS U. S. ARMY





NOTES:

1. CONSTRUCTION OF THE PROJECT BEGAN IN APRIL 1946.
2. FILLING OF THE POWER POOL BEGAN JULY 1951.
3. POWER GENERATION BEGAN SEPTEMBER 1952.
4. FINAL TWO TURBINES (TOTAL OF EIGHT) WERE PLACED IN OPERATION AUGUST AND SEPTEMBER 1963
5. DURATION FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD APRIL 1953 THRU JUNE 1985.
6. BOTTOM OF POWER DRAWDOWN RAISED FROM ELEV. 588 TO 628.5 JANUARY 1962.
7. THE MAXIMUM WATER SURFACE ELEVATION OF 684.4 OCCURRED 20 JUNE 1957.
8. THE MAXIMUM WATER SURFACE ELEVATION OF 691.0 AS REGULATED BY BEAVER AND TABLE ROCK LAKES, OCCURRED 14 JUNE 1973.

WHITE RIVER WATERSHED WHITE RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS
BULL SHOALS LAKE

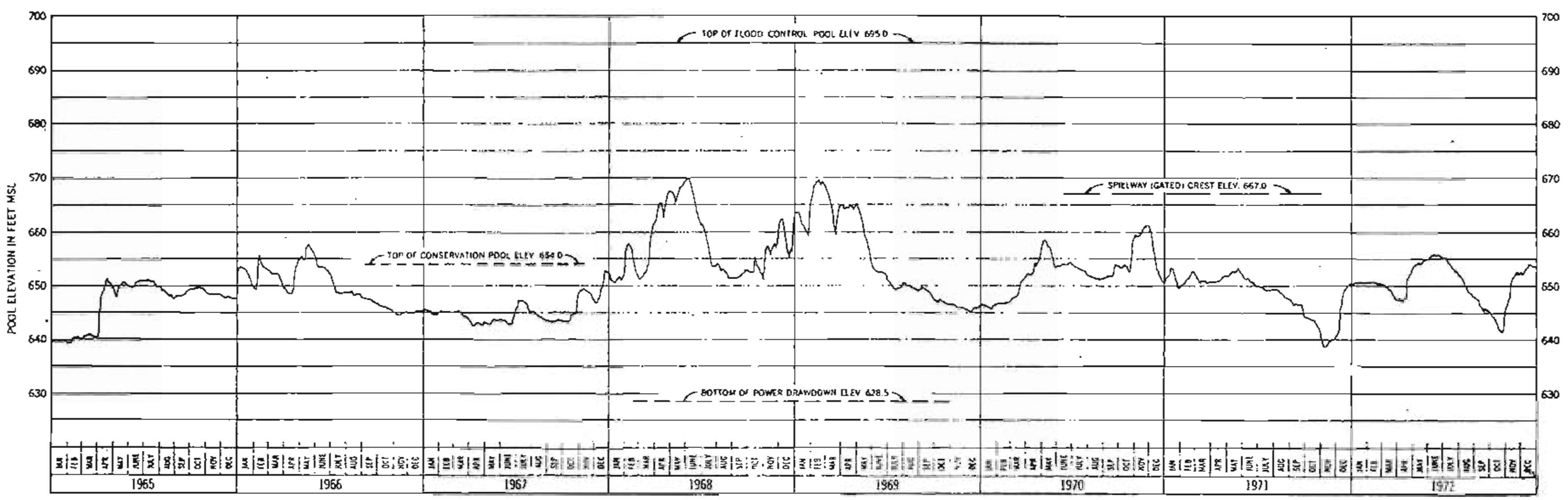
SCALE: AS SHOWN

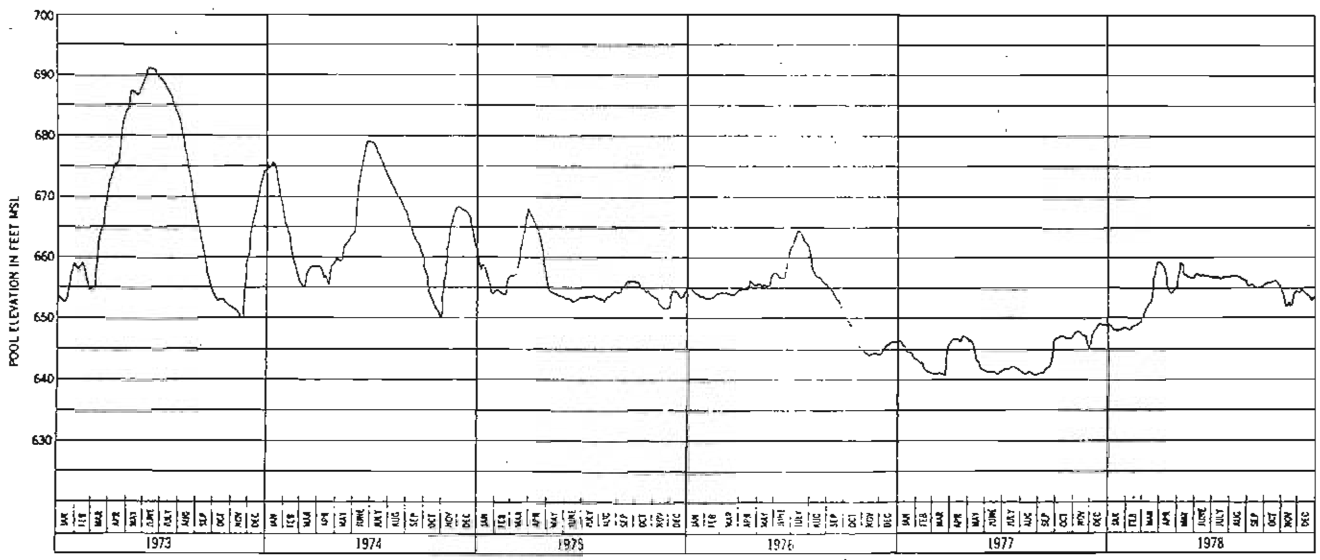
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-9

CORPS OF ENGINEERS

U. S. ARMY





NOTES:

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WHITE RIVER WATERSHED — WHITE RIVER, ARKANSAS

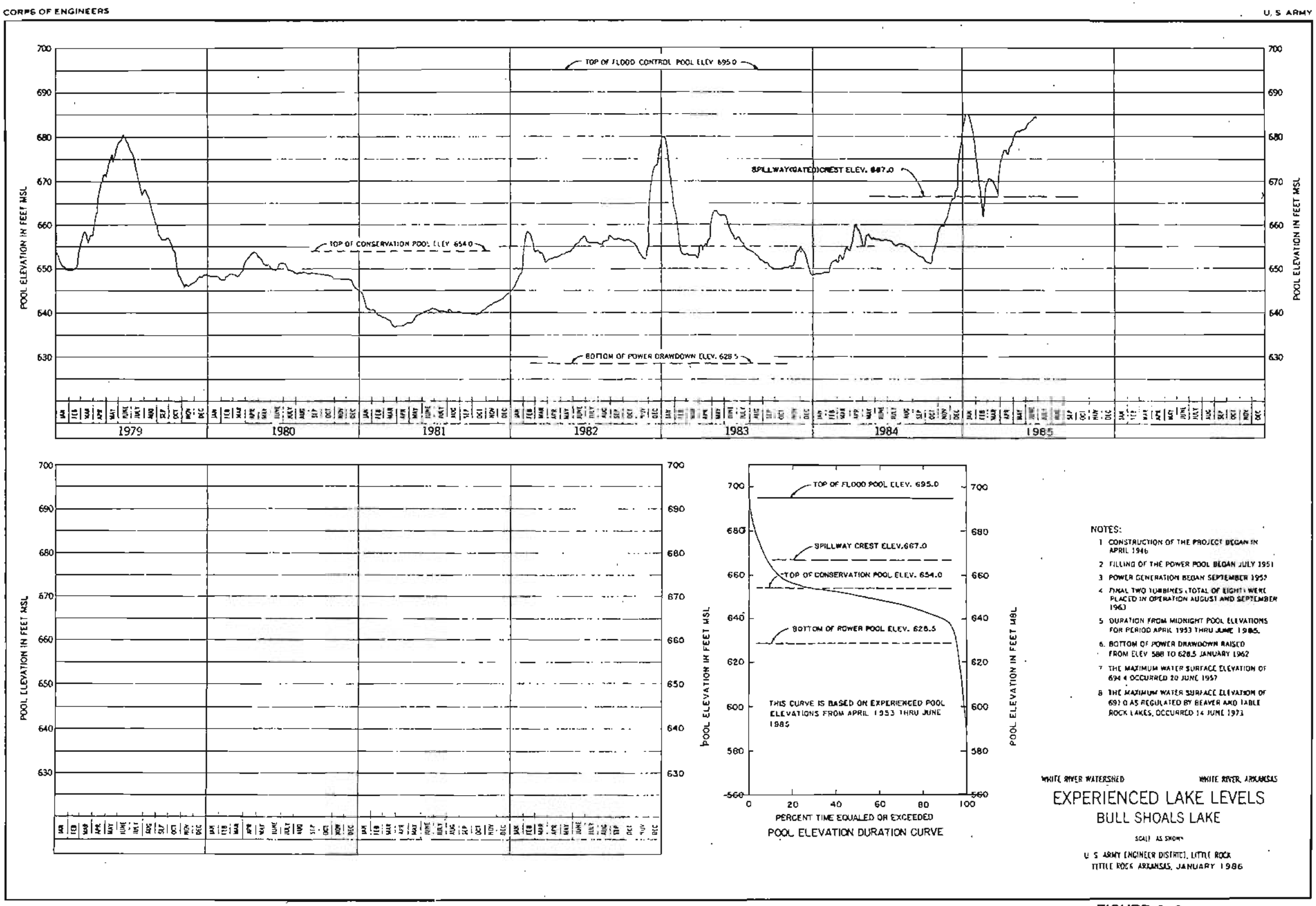
EXPERIENCED LAKE LEVELS

BULL SHOALS LAKE

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-9


CORPS OF ENGINEERS
U. S. ARMY
POOL ELEVATION IN FEET MSL
TOP OF FLOOD CONTROL POOL ELEV 695.0
SPILLWAY(GATED)CREST ELEV. 667.0
TOP OF CONSERVATION POOL ELEV 654.0
BOTTOM OF POWER DRAWDOWN ELEV. 628.5
1979
1980
1981
1982
1983
1984
1985
TOP OF FLOOD POOL ELEV. 695.0
SPILLWAY CREST ELEV.667.0
TOP OF CONSERVATION POOL ELEV. 654.0
BOTTOM OF POWER POOL ELEV. 628.5
THIS CURVE IS BASED ON EXPERIENCED POOL ELEVATIONS FROM APRIL 1953 THRU JUNE 1985
PERCENT TIME EQUALED OR EXCEEDED
POOL ELEVATION DURATION CURVE
NOTES:
1 CONSTRUCTION OF THE PROJECT BEGAN IN APRIL 1946
2 FILLING OF THE POWER POOL BEGAN JULY 1951
3 POWER GENERATION BEGAN SEPTEMBER 1952
4 FINAL TWO TURBINES (TOTAL OF EIGHT) WERE PLACED IN OPERATION AUGUST AND SEPTEMBER 1963
5 DURATION FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD APRIL 1953 THRU JUNE 1985.
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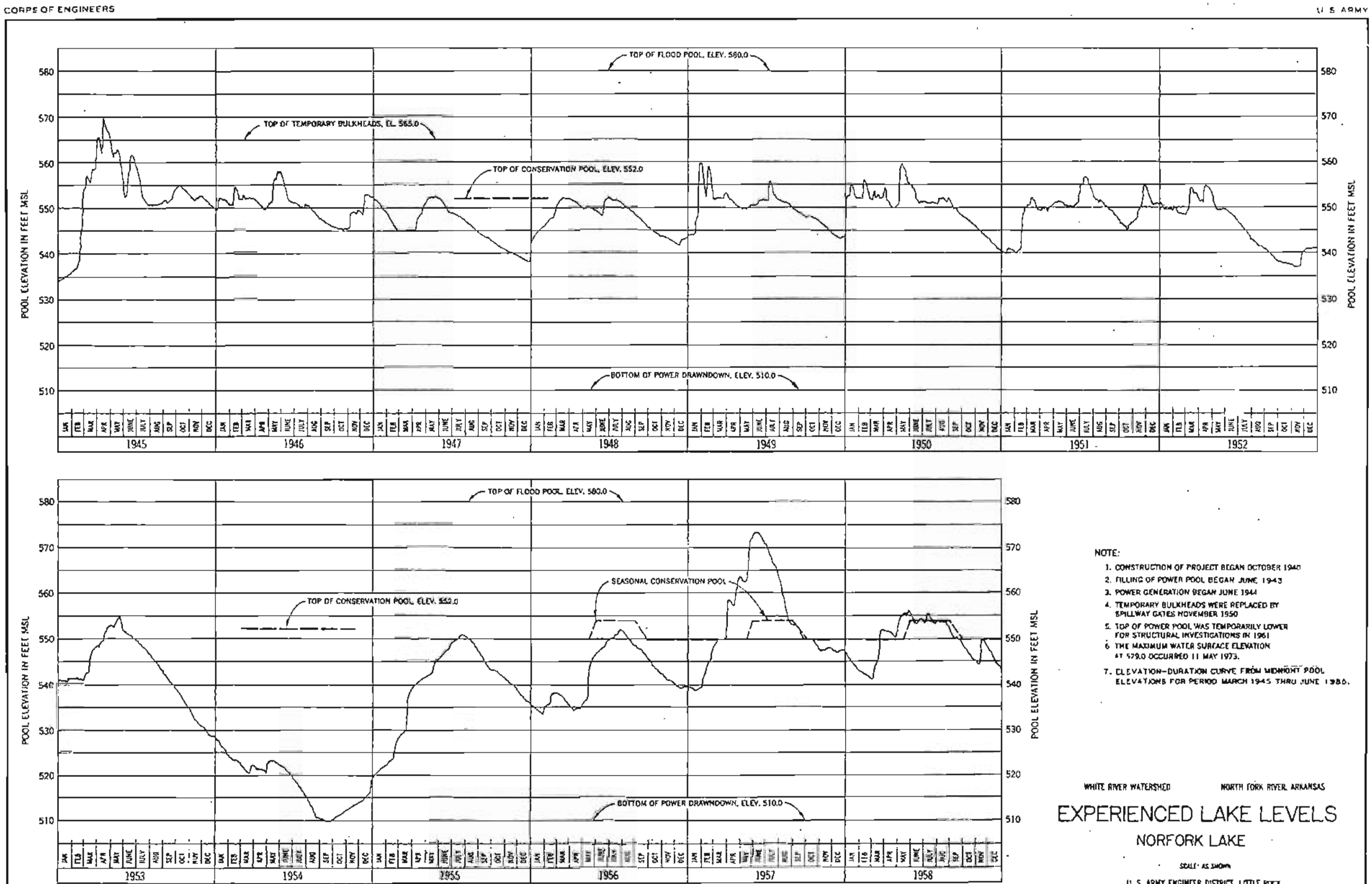
7 THE MAXIMUM WATER SURFACE ELEVATION OF 694.4 OCCURRED 20 JUNE 1957
8 THE MAXIMUM WATER SURFACE ELEVATION OF 693.0 AS REGULATED BY BEAVER AND TABLE ROCK LAKES, OCCURRED 14 JUNE 1973
WHITE RIVER WATERSHED
WHITE RIVER, ARKANSAS
EXPERIENCED LAKE LEVELS
BULL SHOALS LAKE
SCALE AS SHOWN
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK ARKANSAS, JANUARY 1986

FIGURE 3-9



NOTE:

1. CONSTRUCTION OF PROJECT BEGAN OCTOBER 1940
2. FILLING OF POWER POOL BEGAN JUNE 1943
3. POWER GENERATION BEGAN JUNE 1944
4. TEMPORARY BULKHEADS WERE REPLACED BY SPILLWAY GATES NOVEMBER 1950
5. TOP OF POWER POOL WAS TEMPORARILY LOWER FOR STRUCTURAL INVESTIGATIONS IN 1961
6. THE MAXIMUM WATER SURFACE ELEVATION AT 579.0 OCCURRED 11 MAY 1973.
7. ELEVATION-DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MARCH 1945 THRU JUNE 1986.

WHITE RIVER WATERSHED NORTH FORK RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS

NORFORK LAKE

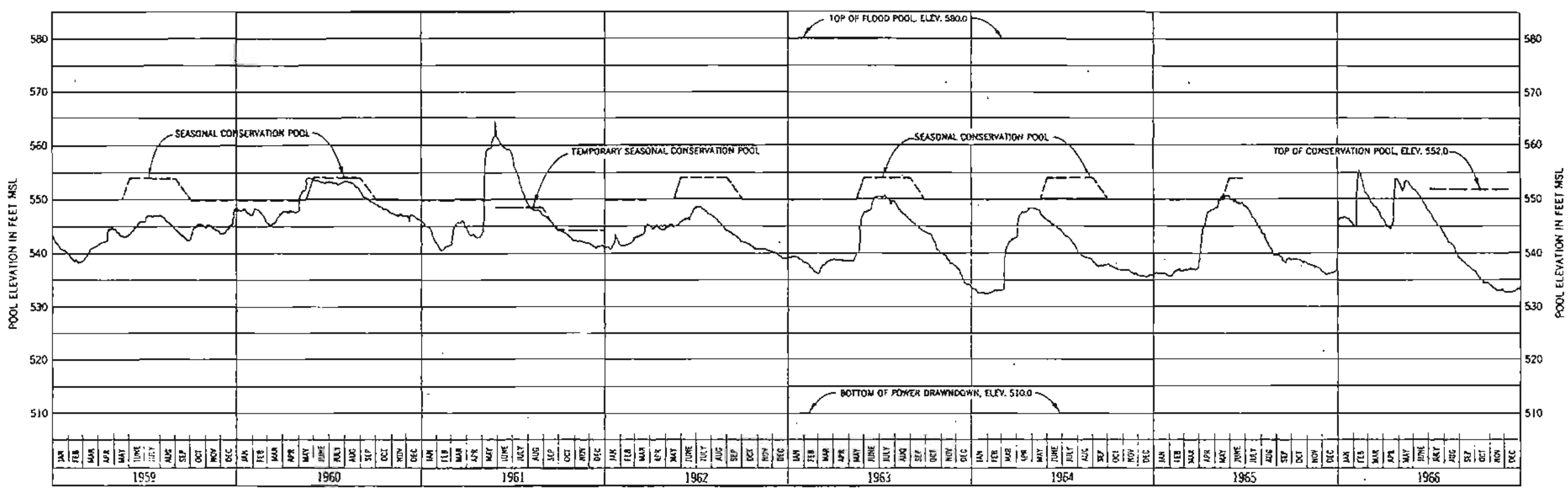
SCALE: AS SHOWN

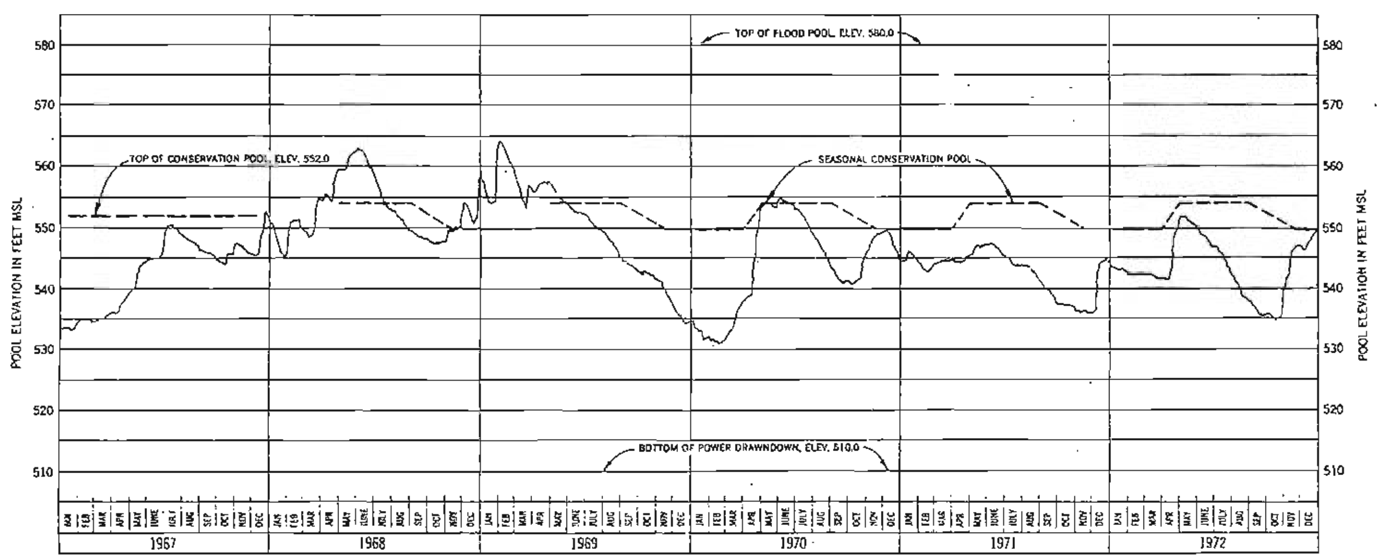
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-10

CORPS OF ENGINEERS

U S ARMY





NOTE:

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6. THE MAXIMUM WATER SURFACE ELEVATION AT 579.0 OCCURRED 11 MAY 1973.
7. ELEVATION-DURATION-CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MARCH 1945 THRU JUNE 1985.

WHITE RIVER WATERSHED　　NORTH FORK RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS

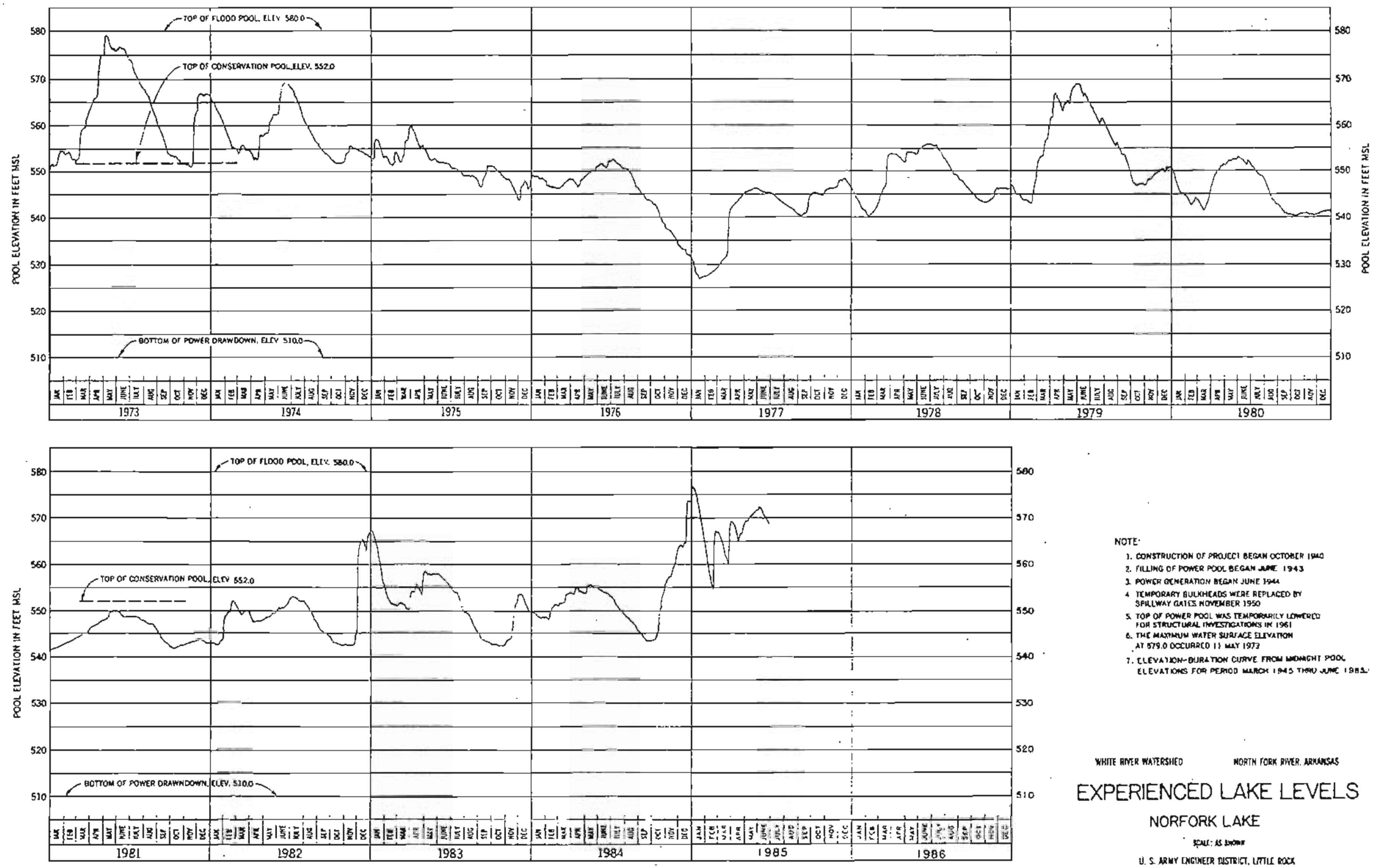
NORFORK LAKE

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-10

CORPS OF ENGINEERS — U S ARMY



NOTE:

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3. POWER GENERATION BEGAN JUNE 1944
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5. TOP OF POWER POOL WAS TEMPORARILY LOWERED FOR STRUCTURAL INVESTIGATIONS IN 1961
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7. ELEVATION-DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MARCH 1945 THRU JUNE 1985.

WHITE RIVER WATERSHED — NORTH FORK RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS

NORFORK LAKE

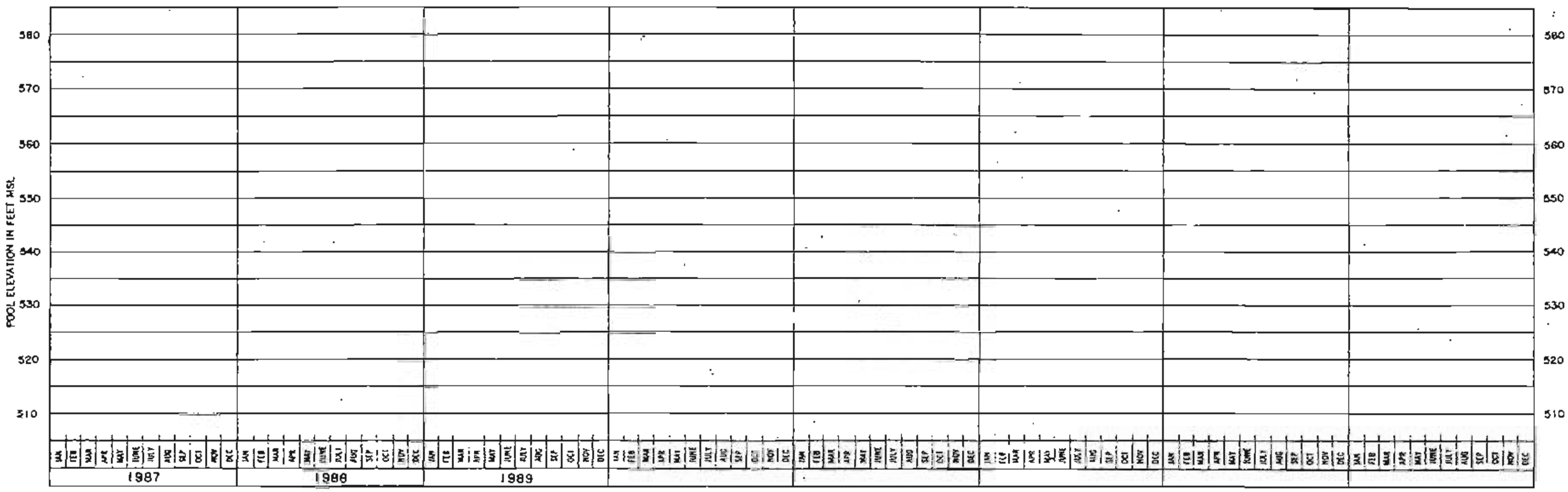
SCALE: AS SHOWN

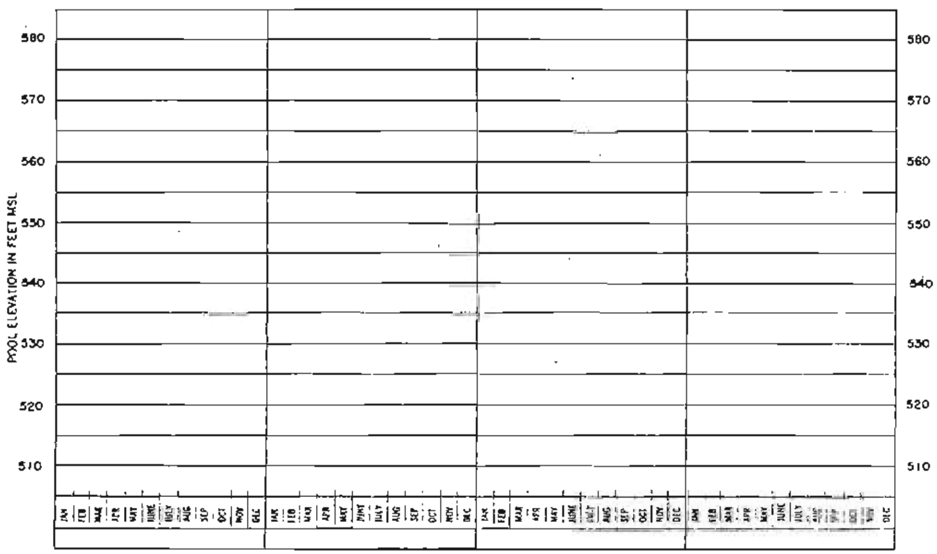
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

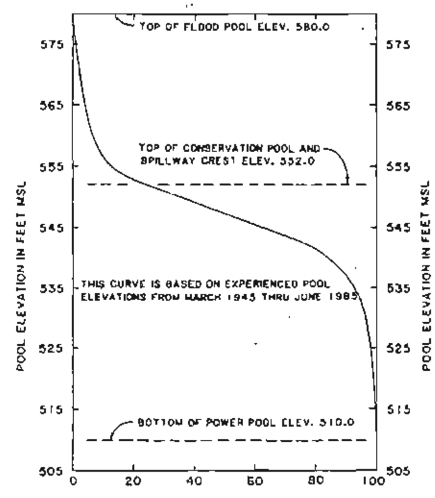
FIGURE 3-10

CORPS OF ENGINEERS

U S ARMY







POOL ELEVATION DURATION CURVE

NOTE:

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3. POWER GENERATION BEGAN JUNE 1944.
4. TEMPORARY BULKHEADS WERE REPLACED BY SPILLWAY GATES NOVEMBER 1950.
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6. THE MAXIMUM WATER SURFACE ELEVATION AT 579.0 OCCURRED 11 MAY 1973.
7. ELEVATION-DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MARCH 1945 THRU JUNE 1985.

WHITE RIVER WATERSHED NORTH FORK RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS

NORFORK LAKE

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-10

Greers Ferry Lake is formed by a concrete gravity dam on the Little Red River at Heber Springs. The dam is 1700 feet long and 240 feet high. The drainage area above the dam is 1,100 square miles. Construction was started in June 1957, flood control use began in January 1962, and project was complete in 1964.

Greers Ferry Lake at the top of conservation pool, elevation 461 feet NGVD, covers 31,500 acres with a volume of 1.9 million acre-feet. The flood control pool at elevation 487 feet NGVD has a volume of 930,000 acre-feet and covers 40,500 acres.

A small portion of the storage of Greers Ferry Lake has been reallocated from hydropower purpose to water supply purpose. Greers Ferry Lake is supplying water to the City of Heber Springs, the Community Water System, and the City of Clinton. The total municipal and industrial water use from Greers Ferry Lake was 1.6 million gallons per day during the period October 1985 to September 1986 (Corps of Engineers file data).

The controlling point for releases from Greers Ferry Dam is the gaging station at Georgetown. During the period December to April with the lake level in the flood pool, Greers Ferry Dam's releases are adjusted so that the 21-feet stage is not exceeded at Georgetown. During May with the lake level in the flood pool, Greers Ferry Dam's releases are adjusted so the 19-feet stage is not exceeded. With the lake level in the flood pool during June to November, Greers Ferry Dam's releases are adjusted so the 16-feet stage at Georgetown is not exceeded. At any time when the lake stage is within the power pool limits, the hydropower releases will be regulated to achieve maximum flood control.

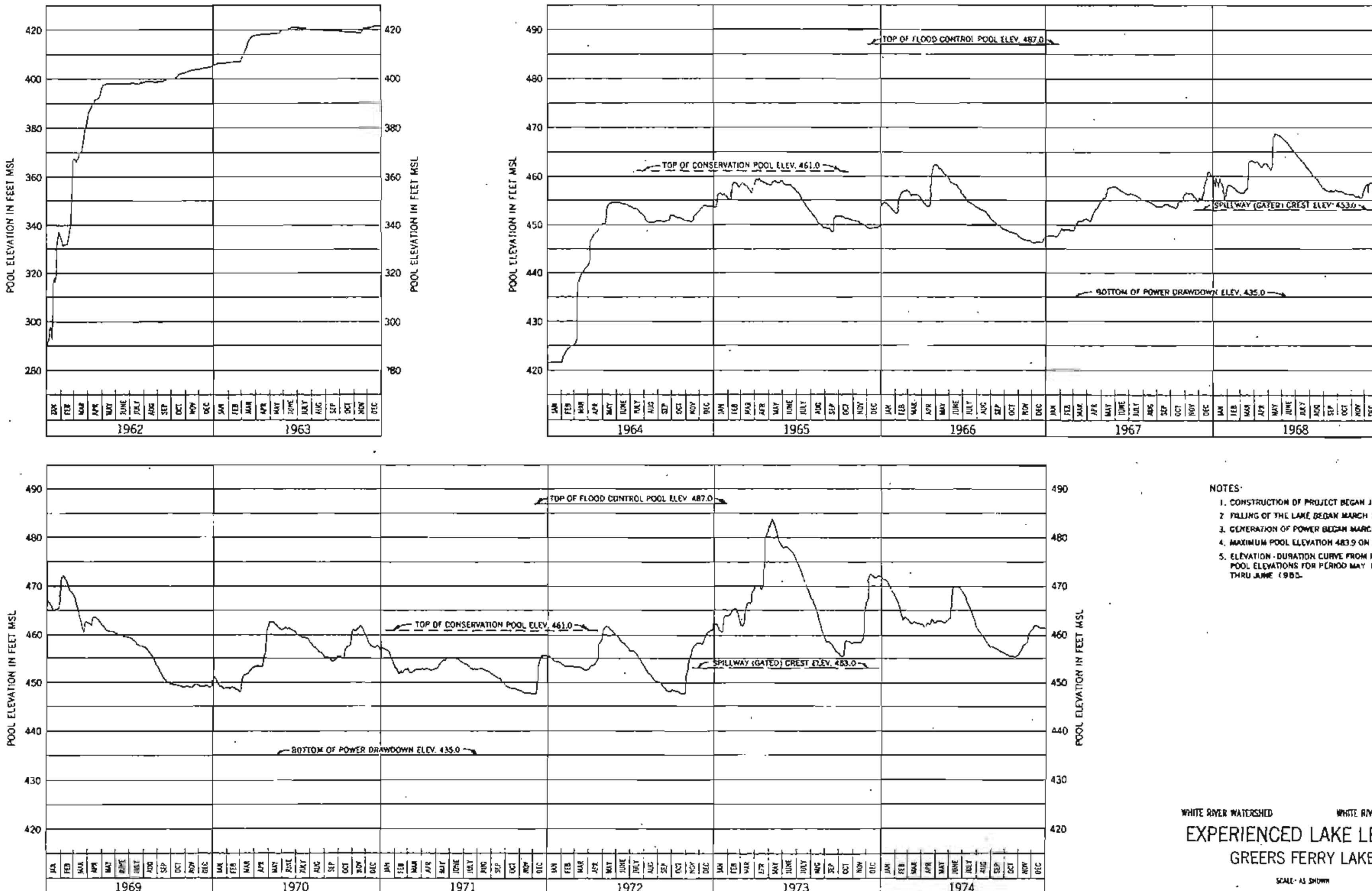
Greer Ferry Lake water level has exhibited a pattern similar to other flood control lakes in the Upper White River Basin. The water level is higher in the May through September period with the lower lake levels occurring during the October through April period. The maximum water surface elevation in Greers Ferry Lake was recorded on May 13, 1973 at elevation 483.9 feet NGVD and the minimum water surface elevation was recorded during January 1977 at 444 feet NGVD. (See Figure 3-11) The conservation pool has been at top elevation 25 percent of the time (Corps of Engineers, file data).

Clearwater Dam is a single-purpose flood control dam and is located on the Black River in Missouri, 126 river miles north of Corning, Arkansas. The flood control effects of the dam have been reduced by the time the Black River flows into Arkansas due to additional drainage area entering the river. The effects of Clearwater Dam on the Black River in Arkansas are the low-flow releases of 150 cfs which are made to maintain fish and wildlife and water quality.

White River Below Dams. With the major modification of the White River by five dams, the fishery of the river was modified downstream to Sylamore, Arkansas. The water releases from the dams are too cold to maintain a warm water fishery; therefore, trout fishing was spawned and several trout hatcheries were constructed on the White River and Little Red River to maintain the trout population in the streams. A major put and take trout fishery has developed.

Impoundment Water Quality

In Table 3-15, mean water quality values for 16 parameters at Beaver, Table Rock, Bull Shoals, Norfork, and Greers Ferry Lakes are presented. This data was compiled by the U.S. Army Corps of Engineers between 1975 and 1986.



NOTES:

1. CONSTRUCTION OF PROJECT BEGAN JUNE 1957.
2. FILLING OF THE LAKE BEGAN MARCH 1962
3. GENERATION OF POWER BEGAN MARCH 1964
4. MAXIMUM POOL ELEVATION 483.9 ON 13 MAY 1973.
5. ELEVATION - DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MAY 1964 THRU JUNE 1985.

WHITE RIVER WATERSHED WHITE RIVER, ARKANSAS

EXPERIENCED LAKE LEVELS

GREERS FERRY LAKE

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-11

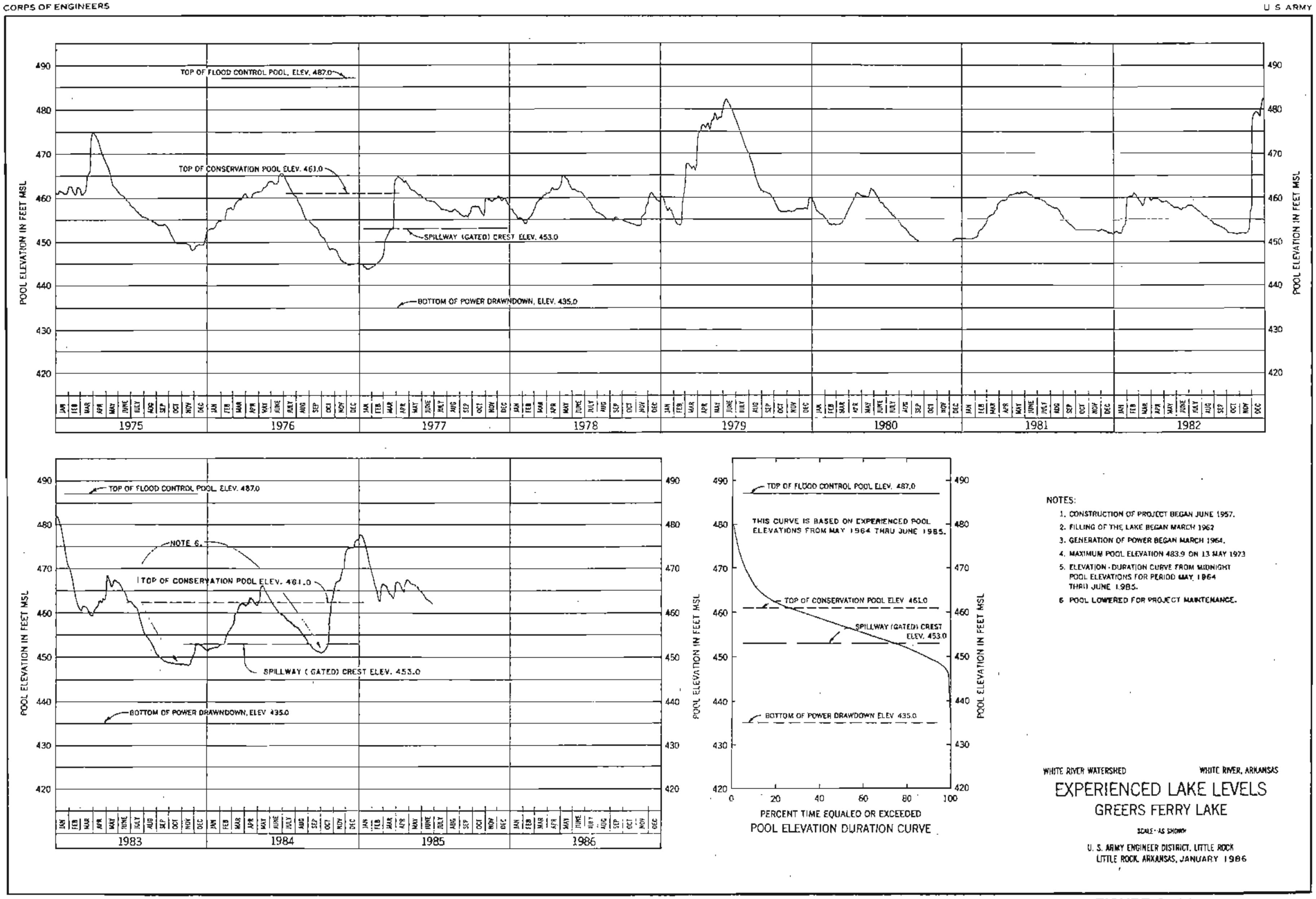

CORPS OF ENGINEERS
U S ARMY
POOL ELEVATION IN FEET MSL
TOP OF FLOOD CONTROL POOL, ELEV. 487.0
TOP OF CONSERVATION POOL ELEV. 461.0
SPILLWAY (GATED) CREST ELEV. 453.0
BOTTOM OF POWER DRAWNDOWN, ELEV. 435.0
1975
1976
1977
1978
1979
1980
1981
1982
NOTE 6.
BOTTOM OF POWER DRAWNDOWN, ELEV 435.0
1983
1984
1985
1986
THIS CURVE IS BASED ON EXPERIENCED POOL ELEVATIONS FROM MAY 1964 THRU JUNE 1985.
PERCENT TIME EQUALED OR EXCEEDED
POOL ELEVATION DURATION CURVE
NOTES:
1. CONSTRUCTION OF PROJECT BEGAN JUNE 1957.
2. FILLING OF THE LAKE BEGAN MARCH 1962
3. GENERATION OF POWER BEGAN MARCH 1964.
4. MAXIMUM POOL ELEVATION 483.9 ON 13 MAY 1973
5. ELEVATION - DURATION CURVE FROM MIDNIGHT POOL ELEVATIONS FOR PERIOD MAY 1964 THRU JUNE 1985.
6. POOL LOWERED FOR PROJECT MAINTENANCE.
WHITE RIVER WATERSHED
WHITE RIVER, ARKANSAS
EXPERIENCED LAKE LEVELS
GREERS FERRY LAKE
SCALE - AS SHOWN
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, JANUARY 1986

FIGURE 3-11

The water quality data base displayed in Table 3-15 was discussed with the Arkansas Department of Pollution Control and Ecology (ADPCE) Water Quality Ecologist.

Heavy metals and other parameters are discussed in relation to the ADPCE Guidelines (unofficial guidelines). Some parameters are discussed in relation to the ADPCE surface water standards.

The following parameters fall within the guidelines and standards for all the White River Lakes: Arsenic, chromium, iron, specific conductance, PH, dissolved oxygen (seasonal data was not examined, however), coliform, sulfate (slightly above the standard of 10 mg/l in a few cases but no significant concern) and chloride (slightly above the standard of 10 mg/l in a few cases but no significant concern).

The remaining parameters are discussed individually as there are a few instances among the lakes where the mean values are above ADPCE guidelines or standards. The degree of concern is also stated.

Phosphorus - The unofficial guidelines call for .50 mg/l for phosphorus. The upstream station for Beaver Lake has a mean of 0.694 mg/l. Fayetteville's sewer facility empties into this upstream area. A classical trend can be seen of higher phosphorous in upstream areas of the lakes.

Copper - ADPCE guidelines call for 5 ug/l and numerous locations exceed this level. This could be associated with the use of manure on the watershed. The levels seen in Table 3-15 may not be of environmental concern.

Lead - Lead normally runs high in this region of the state so the high readings are to be expected. ADPCE raises some concern when the levels are above 10 ug/l. The two sites of concern in Table 3-15 are the Dam at Bull Shoals (36.741 ug/l) and midlake at Greers Ferry (16.06 ug/l).

Mercury - ADPCE guideline calls for less than 1.0 ug/l. Only the upstream site at Beaver Lake exceeds this (1.136 ug/l).

Turbidity - ADPCE guideline calls for less than 10 ntu at all times. The upstream site at Beaver Lake (26 ntu) and the upstream site at Greers Ferry (13.185 ntu) exceed this. This is probably due to development in these areas. Best management practices could lessen these impacts.

Chloride - ADPCE guideline calls for 10 mg/l or less. Only the upstream site at Beaver Lake exceeds this (12.267 mg/l).

Nitrogen - This part of the state runs higher nitrogen concentrations than the rest of the state probably due to manure use in the watershed. The readings at the lakes are good compared to other surface

Table 3-15 Mean Water Quality Parameter Values for
the Major Lakes in the Upper White River Basin
Period of Record 1975 to 1986

Lake	Beaver		Table Rock		Bull Shoals		Norfork		Greers Ferry	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
** Specific Conductance (UMHOS)										
Upstream	149	161.570	68	294.780	37	231.700	66	309.700	34	39.324
Midlake	82	137.920	68	197.840	73	249.620	78	313.120	137	44.168
Dam	3603	134.940	3936	217.740	3402	252.260	3202	305.210	2064	38.054
Downstream of Dam	178	138.380	172	222.730	358	257.520	151	314.630	144	40.243
** PH (units)										
Upstream	207	7.330	62	7.368	33	7.761	67	7.982	33	7.039
Midlake	74	7.451	62	7.663	66	7.730	70	7.827	172	7.021
Dam	3530	7.642	3909	7.827	3362	7.933	3131	7.952	2981	6.986
Downstream of Dam	172	7.556	169	7.773	388	7.927	145	7.963	143	7.037
** Turbidity (ntu)										
Upstream	39	26.007	54	6.500	27	2.737	53	4.374	27	13.185
Midlake	53	7.242	50	2.115	48	1.671	52	2.989	88	9.096
Dam	45	.818	43	.729	42	.633	47	1.093	52	2.489
Downstream of Dam	27	1.791	24	2.104	20	2.120	24	2.075	26	3.308
** Oxygen, Dissolved (mg/L)										
Upstream	174	7.651	60	7.497	32	8.891	66	7.430	33	9.021
Midlake	65	6.615	61	6.052	67	6.810	69	6.970	176	8.381
Dam	3585	7.679	3911	6.478	3375	7.813	3158	7.067	3048	8.096
Downstream of Dam	174	7.651	170	8.867	260	8.883	146	9.317	143	10.127
** Coliform, Fecal (colonies/ 100 ml)										
Upstream	18	75.722	27	27.259	25	22.040	31	10.484	19	58.263
Midlake	26	.962	27	8.963	25	3.880	29	3.379	27	26.963
Dam	26	.308	14	.043	28	2.964	28	1.429	24	3.875
Downstream of Dam	27	24.220	25	15.280	27	5.037	29	10.379	24	11.833
** Sulfate, Dissolved (mg/L as SO4)										
Upstream	167	14.572	52	10.565	28	7.561	27	4.748	23	3.909
Midlake	60	6.707	52	6.948	50	7.446	50	4.940	133	4.074
Dam	55	6.847	51	6.861	51	7.327	52	5.179	45	3.956
Downstream of Dam	31	7.048	26	7.304	247	6.629	24	6.204	24	4.004
** Chloride, Dissolved (mg/L as CL)										
Upstream	169	12.267	52	11.056	29	4.966	9	2.778	26	2.389
Midlake	60	4.338	52	4.585	52	4.554	54	2.689	146	3.189
Dam	74	3.638	51	5.110	53	4.353	56	2.750	50	1.790
Downstream of Dam	40	3.453	26	5.396	256	4.464	26	5.915	26	1.596
** Nitrogen, NO2+NO3 Total (mg/L as N)										
Upstream	104	.745	60	1.002	36	.388	10	.280	24	.210
Midlake	61	.441	63	.317	63	.255	52	.225	98	.128
Dam	66	.228	70	.311	65	.217	68	.215	59	.162
Downstream of Dam	34	.332	34	.488	74	.283	33	.278	33	.221

N - Number of Samples.

SOURCE: Corps of Engineer file data

Table 3-15 Mean Water Quality Parameter Values for
the Major Lakes in the Upper White River Basin (cont.)
Period of Record 1975 to 1986

Lake	Beaver N	Beaver Mean	Table Rock N	Table Rock Mean	Bull Shoals N	Bull Shoals Mean	Norfork N	Norfork Mean	Greers Ferry N	Greers Ferry Mean
** Phosphorous, Total (mg/L as P)										
Upstream	185	.694	66	.143	33	.032	6	.020	32	.045
Midlake	61	.040	59	.021	51	.020	49	.028	126	.025
Dam	45	.020	59	.033	47	.030	53	.028	53	.020
Downstream of Dam	23	.036	31	.126	82	.018	29	.055	29	.036
** Arsenic, Total (ug/L as AS)										
Upstream	38	2.974	34	1.147	15	.867	17	.824	18	1.056
Midlake	45	1.045	30	.967	33	.939	36	1.167	39	2.103
Dam	39	1.077	27	.815	31	.968	36	1.111	26	.692
Downstream of Dam	21	1.238	16	.875	20	4.250	19	1.105	12	.583
** Chromium, Total Recoverable (ug/L as CR)										
Upstream	60	6.950	19	8.947	8	8.250	9	11.333	10	10.600
Midlake	61	10.645	17	7.353	20	10.100	19	7.316	35	6.657
Dam	29	9.483	20	11.750	17	7.059	18	6.833	21	9.048
Downstream of Dam	16	9.375	8	3.750	27	6.593	10	5.700	10	9.600
** Copper, Total Recoverable (ug/L as CU)										
Upstream	76	18.776	30	4.600	14	5	16	6.313	12	3.250
Midlake	45	3.956	25	3.760	30	5.233	29	4.796	69	13.884
Dam	50	12.500	26	5.423	27	6.815	29	4.345	29	3.276
Downstream of Dam	25	3.920	16	5	28	11.464	14	4.786	14	3.643
** Lead, Total Recoverable (ug/L as PB)										
Upstream	58	9.121	21	4.429	15	6.400	15	7.933	14	5.429
Midlake	44	4.023	23	4	30	6.700	25	4.560	67	16.060
Dam	42	4.443	21	4.238	27	36.741	26	4.539	29	5.586
Downstream of Dam	22	4.409	12	5.500	25	6.160	13	4.462	16	7.313
** Iron, Total Recoverable (ug/L as FE)										
Upstream	81	1359.900	52	307.500	28	157.500	29	123.450	26	320.770
Midlake	63	458.730	50	81.800	46	103.480	47	151.060	113	448.900
Dam	55	81.273	43	59.070	45	67.333	44	80.909	45	127.780
Downstream of Dam	33	135.760	37	125.140	36	73.028	38	130	26	192.690
** Mercury, Total Recoverable (ug/L as HG)										
Upstream	14	1.136	14	.036	7	.029	7	.229	6	.017
Midlake	21	.110	14	.050	13	.023	13	.162	13	.038
Dam	22	.255	14	.043	13	.054	14	.100	14	.171
Downstream of Dam	11	.073	7	.043	6	.017	6	.100	8	.175
** Zinc, Total Recoverable (ug/L as Zn)										
Upstream	105	73.514	33	51.212	13	27.692	19	74.211	20	48
Midlake	45	62.445	32	49.063	30	37	27	28.889	97	43.013
Dam	46	34.761	33	67.576	22	20.909	24	27.083	32	57.813
Downstream of Dam	21	52.286	16	55	45	16.933	12	30	16	55

N - Number of Samples

SOURCE: Corps of Engineer file data

waters. The upstream sites at Beaver and Table Rock Lakes exceed the level of concern by the ADPCE at 0.5 mg/l.

And in conclusion, Beaver Lake has in the last decade had a problem with eutrophication. The 1986 Water Resource Development Act authorized a water quality study for Beaver Lake in an effort to resolve some of the water quality concerns. This study is proposed in the near future.

Impoundment Water Use

The major use of impoundment water in the Upper White River Basin is hydropower. Since hydropower is a nonconsumptive use, the quantity of water used to generate electricity was not taken into consideration in the Water Use Section of this report. Hydropower uses over 3,700 million gallons of water per day to generate electricity.

Impounded surface water is also used as a source of municipal and industrial water supply. Heber Springs, Greers Ferry-Higden area, Mountain Home, Clinton, Fayetteville- Bentonville area and the Carroll-Boone County area uses impounded surface water as a water supply source. These communities used 33,563 acre-feet or 30 million gallons per day of water during October 1985 through September 1986 (Corps of Engineers file data).

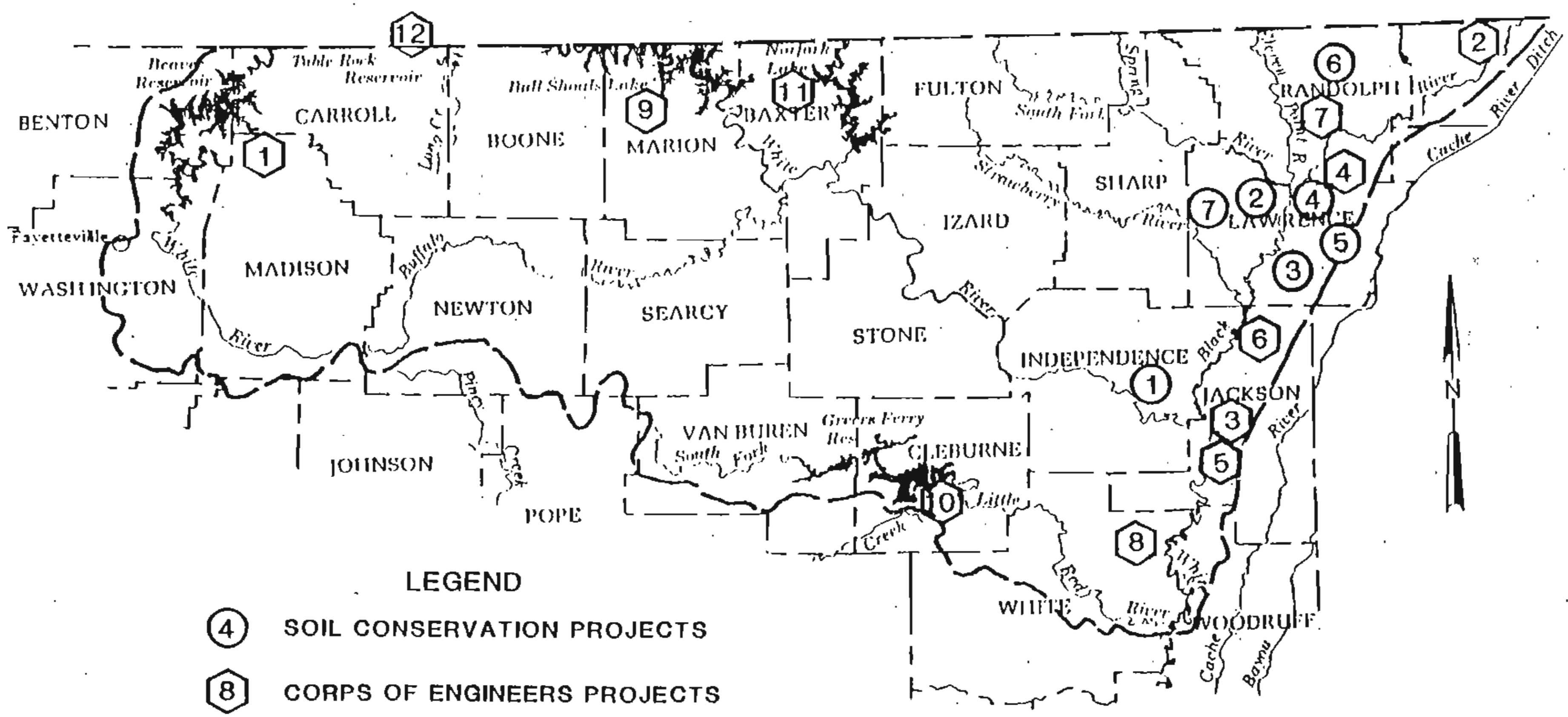
Recreation is an indirect beneficiary of the major lakes. Recreation is not an authorized purpose of the Corps of Engineers lakes but each of the lakes supports millions of visitor use days per year. The Corps of Engineers has built and maintains many parks and recreation areas on lake-front property.

Another important use of impoundment water in the Upper White River Basin is as a source of livestock water. Many farmers have built small ponds usually with a surface area of a quarter acre and a volume of a half acre-foot to supply their cattle with drinking water. A major portion of the 13.8 million gallons of water per day used for livestock is from impoundments.

WATER RESOURCE DEVELOPMENT PROJECTS

U. S. Army, Corps of Engineers

The U. S. Army Corps of Engineers have been active in the Upper White River Basin in developing the basin's water resources. The Little Rock District has overall responsibility for Corp interests in this basin. There are several Corp projects which are operated and maintained or have been assisted by the Corp of Engineers. The locations of these projects are shown on Figure 3-12. Table 3-16 lists the Corp involvement in the Upper White River Basin.



LIST OF CORPS OF ENGINEERS PROJECTS

No.	Name
1	Beaver Lake
2	Poplar Bluff to Knobel Levee
3	Newport Levee and Floodwall
4	Skaggs Ferry Levee
5	Village Cr., White R. and Mayberry Levee
6	Black River - Arkansas and Missouri
7	Current River - Arkansas and Missouri
8	White River Navigation
9	Bull Shoals Lake
10	Greers Ferry Lake
11	Norfork Lake
12	Table Rock Lake

LIST OF SCS PROJECTS

No.	Name
1	Mud Creek
2	Flat Creek
3	Big Running Water Ditch
4	Little Running Water
5	Fry - Kellow
6	Fourche Creek
7	Cooper Creek

UPPER WHITE RIVER BASIN

LOCATIONS OF FEDERALLY ASSISTED WATER RESOURCE PROJECTS

FEBRUARY 1988

FIGURE 3-12

TABLE 3-16 LIST OF CORPS OF ENGINEERS PROJECTS

Name	Purposes	Authority
Beaver Lake	fc, ws, hp	Flood Control Act of 1954
Poplar Bluff to Knobel Levee	fc	
Newport Levee and Floodwall	fc	
Skaggs Ferry Levee	fc	
Village Cr., White R. and Mayberry Levee	fc	
Black River - Arkansas and Missouri	n	River and Harbor Act of 1871
Current River - Arkansas and Missouri	n	River and Harbor Act of 1894
White River Navigation	n	River and Harbor Act of 1892
Bull Shoals Lake	fc, hp	Flood Control Act of 1941
Greers Ferry Lake	fc, hp	Flood Control Act of 1938
Norfork Lake	fc, hp, ws	Flood Control Act of 1938
Table Rock Lake	fc, hp	Flood Control Act of 1941

Legend: fc - flood control
ws - water supply
hp - hydroelectric generation
n - navigation

TABLE 3-17 LIST OF SCS WATER RESOURCE DEVELOPMENT PROJECTS

Name	Purpose	Works of Improvement	
		miles of channel	dams
Mud Creek	fc, d, wp	22.3	1
Flat Creek	fc, d, r, wp	11.7	6
Big Running Water Ditch	fc, d, wp	95.3	-
Little Running Water	fc, d, wp	41.0	-
Fry - Kellow	fc, d, wp	36.0	-
Fourche Creek	fc, wp	-	3
Cooper Creek	fc, wp	-	6

Legend: fc - flood control
d - drainage
r - recreation
wp - watershed protection

Soil Conservation Service

The United States Department of Agriculture through the Soil Conservation Service (SCS) participates in water resource development projects at the request of a local entity. The authority for these projects is Public Law 83 - 566 or the Watershed Protection and Flood Prevention Act. The local entity, which becomes the local sponsor, is required to contribute to the construction of the project as well as to acquire the land rights.

This Act authorizes the Secretary of Agriculture to cooperate with local organizations having authority under state law to carry out, maintain, and operate works of improvement for flood prevention or for the conservation, development, utilization, and disposal of water in watersheds or sub-watershed areas of 250,000 acres or less. SCS has the capability to provide technical and financial assistance to water resource development projects.

For planning purposes, SCS has delineated 79 watersheds in the Upper White River Basin. Nineteen of these watersheds are considered by SCS to have the potential to be studied for works of watershed improvement.

With the aid of Public Law 83-566 funds, works of improvements have been accomplished in 4 watershed areas. Another project, Fourche Creek, is currently under construction. Table 3-17 lists the improved watersheds and a summary of works of improvements. Figure 3-12 shows the locations of these projects.

Resource Conservation and Development (RC & D) funds have assisted in flood prevention and drainage improvements in 2 areas. The two areas are known as Little Running Water and Fry - Kellow projects.

SURFACE WATER QUANTITY PROBLEMS

Availability

The Upper White River Basin on an annual basis has an abundant supply of surface water, but there are some areas which have a shortage of water during parts of the year. Also, there are some areas which are projected to experience a shortage of water due to increased demands.

Areas such as the Middle Fork of the Little Red River and White River near Fayetteville have 7Q10's of 0 and 0.002, respectively. These 7Q10's indicate that during droughts there is little or no flow for use.

The communities of Calico Rock, Melbourne and Oxford in Izard County are experiencing shortages of water for their users during periods of peak demand. Jasper (Newton County), Bull Shoals, North White County Water Association, Community Water Association, Dennard Water Association (Van Buren County), Huntsville, Pfeiffer Water Association, Quitman Waterworks, Salesville Waterworks, Shirley (Vanburen County), Sulphur Springs, and Summit have a need for increased water supply (Appendix E and Arkansas State Health Dept., 1986).

The Upper White River Basin is expected to develop significantly in the future which will require a greater amount of water. Two counties have been identified as possibly needing a source of additional water in the future. Searcy and Van Buren counties are anticipated to need a greater quantity of water as development occurs (Appendix E).

Another water availability problem is in the area of navigation. The required flow to maintain navigation from Newport downstream is 7700 cfs. The navigation requirement flow has been recorded 87 percent of the time. The lack of flow for navigation is a problem for shippers wishing to move freight such as grain.

Water availability is a problem downstream of the Bull Shoals and Norfork dams on the White River on three day weekends during the warm summer months. When the air temperature is 85 degrees Fahrenheit or greater, it is possible for the water temperature to rise to a point where the trout are stressed.

The absence of an interstate compact between the states of Arkansas and Missouri is a problem in the Upper White River Basin. An interstate compact could: guarantee a percentage of the streamflow for either state; promote interstate social harmony; provide for a governing body for monitoring the agreed water distribution; and encourage the cooperation of the water resource agencies of the States of Arkansas and Missouri in the development of the Upper White River Basin's water resources.

Another water availability problem is the water allocation procedure established by the Arkansas Soil and Water Conservation Commission. During droughts it is probable that the water allocation case load could be so great that the Commission with its present staff could not handle the large number of allocation requests. The allocation emergency could pass before all cases are handled.

Flooding

Even with the current efforts to control flooding, a great amount of flood damage occurs annually. Almost all of the flooding is due to flows orginating downstream of the existing projects from uncontrolled areas such as the Buffalo River. The flood plain of the Upper White River is estimated to be 917,791 acres (Arkansas Resource Base Report). Table 3-18 shows the estimated land use of the flood plain.

In 1977, total damages from flooding were estimated to be over $22 million dollars (Arkansas Resource Base Report). This amount includes crop, grassland and forest flood damages, other agricultural damages, urban values, roads and bridges, and miscellaneous.

There have been many towns and cities which have had flood prone areas delineated on FEMA Flood Insurance Rate Maps, FEMA Flood Hazard Boundary Maps, Corps of Engineers Flood Plain Reports, or Soil Conservation Service Flood Plain Management Studies. Also, there are areas which are subject to flooding that have not been specifically mapped. Some of the towns and cities which have reported flood problems are Harrison, Heber Springs, Yellville, Clinton, Hardy, St. Joe, St. Paul, Walnut Ridge, Hoxie, Corning, Batesville, Augusta, Searcy, and Salem.

TABLE 3-18 1977 FLOOD PLAIN LANDUSE

Landuse	Acres
Cropland	
Cotton	12,764
Corn	222
Soybeans	176,103
Rice	33,912
Wheat	4,030
Grain Sorghum	14,546
Hayland	601
Total Cropland	242,178
Grassland	214,897
Forestland	460,716
Total Floodplain	917,791

SOURCE: Arkansas Resource Base Report

WATER QUALITY PROBLEMS

Introduction

Water quality problems can be attributed to two sources which are classified as point source and nonpoint source. Point sources are defined as pollution sources which can be traced to one point of origin. A nonpoint source of pollution is a condition where pollutants enter a waterway though many points. Soil erosion is an example of a serious nonpoint pollution source. Not only do soil particles cause an increase in turbidity, they also transport nutrients and pesticides which have become attached to soil particles into streams. Precipitation runoff can be a nonpoint source of pollution, if the runoff picks up undesirable chemicals as it flows overland.

In the following sections, a summary of water-quality conditions in the Upper White River Basin are discussed. Since soil erosion is a serious nonpoint pollutant, soil erosion estimates were included in the discussions.

Segment 4E - Little Red River: Headwaters to Mouth

Land use and physiographic characteristics are the major factors influencing water quality in Segment 4E. Sixty-four percent of this segment is forested resulting in very high quality waters in the upper portion of the segment. The southeastern part of the segment is intensively cultivated, causing increases in turbidity, sediment, and pesticide residues.

Of the 475.3 miles of streams in the segment, 152 miles were considered by the ADPC&E to have moderate use impairment and 323.3 miles were not impaired. The water quality of Greers Ferry Lake is not impaired by pollutants (Arkansas Water Quality Inventory Report, 1986).

Shown in Table 3-19 are water quality data which was collected in Segment 4E during 1984 and 1985.

Table 3-19 Chemical Water Quality Data for Segment 4E

Station: WHI 43 - Middle Fork Little Red River near Shirley, Arkansas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	16.5	24	30	1	8.6
D.O., mg/L	9.9	23	14.4	7.4	1.9
PH	7.4	24	7.7	7	0.23
Cl-, mg/L	3.1	24	5	1	1.1
SO4=, mg/L	6.9	20	12	1	2.8
TSS, mg/L	8	24	12	1	2.8
T. Phos, mg/L	0.04	21	0.11	0.01	0.02
NO2+NO3-N, mg/L	0.07	22	0.22	0.01	0.06
Turbidity, ntu	9.3	22	48	2	10.2
Fecal Coliform, #/100ml	126.4	23	1200	4	297
Cd, ug/L	1.5	23	4	0.5	1.1
Cr, ug/L	1.7	24	18	1	3.4
Cu, ug/L	27.6	22	94	10	19.5
Pb, ug/L	10.7	23	23	1	7.9
Zn, ug/L	34.2	18	143	3	33.4

SOURCE: Arkansas Water Quality Inventory Report, 1986

Table 3-19 Chemical Water Quality Data for Segment 4E (cont.)

Station: WHI 75 - Little Red River above Searcy, Arkansas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	14	21	29	3	7.2
D.O., mg/L	10.3	20	13.5	8.7	1.1
PH	6.7	20	7.2	6.2	0.27
Cl-, mg/L	3.5	20	5	1	1.3
SO4=, mg/L	4.4	20	9	1	1.9
TSS, mg/L	6.9	21	14	2	3.5
T. Phos, mg/L	0.03	17	0.1	0.01	0.02
NO2+NO3-N, mg/L	0.22	21	0.51	0.1	0.12
Turbidity, ntu	7.9	19	27	3	6.3
Fecal Coliform, #/100ml	122	22	1530	4	325
Cd, ug/L	0.5	19	0.6	0.5	0.02
Cr, ug/L	1.4	20	9	1	1.7
Cu, ug/L	12.7	20	20	10	2.8
Pb, ug/L	8.3	18	27	1	7.5
Zn, ug/L	39.5	15	94	3	23

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 59 - Little Red River below Searcy, Arkansas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	13.6	21	27	3	6.5
D.O., mg/L	10.1	21	12.7	8.6	0.96
PH	6.8	21	7.2	6.2	0.26
Cl-, mg/L	4.2	21	8	2	1.6
SO4=, mg/L	4.9	21	11	1	2.2
TSS, mg/L	8.4	22	18	2	4.7
T. Phos, mg/L	0.08	18	0.42	0.02	0.09
NO2+NO3-N, mg/L	0.23	22	0.49	0.11	0.11
Turbidity, ntu	11.5	20	54	3.5	12.2
Fecal Coliform, #/100ml	269.2	22	1920	12	414
Cd, ug/L	0.63	20	2	0.5	0.45
Cr, ug/L	1.1	21	4	0.1	0.74
Cu, ug/L	12.3	21	23	5	3.8
Pb, ug/L	16.9	18	160	1	36.2
Zn, ug/L	47.1	15	115	1	31.2

SOURCE: Arkansas Water Quality Inventory Report, 1986

Fecal coliform bacteria restricts the primary contact water sports as shown Table 3-19. All three stations show a wide variation in measured fecal coliform bacteria. The bacteria is from nonpoint sources which are runoff from pastures where cattle have grazed or runoff from areas where animal wastes have been surface applied.

High concentrations of lead, zinc, and copper are consistently evident, but cannot be attributed to any point source. The heavy metals are suspected to result from natural causes.

The increased turbidity, sediment, and pesticide residues can be attributed to soil erosion throughout Segment 4E. Table 3-20 shows the quantity and sources of erosion.

TABLE 3-20 SUMMARY OF EROSION IN SEGMENT 4E BY SOURCE

Erosion Source	Tons per Year	Percent of Total
Road Surface Erosion	99,943	3.6
Road Bank Erosion	262,949	9.3
Gully Erosion	15,290	0.5
Streambank Erosion	134,020	4.8
Sheet and Rill Erosion	2,307,323	81.8
Total	2,819,525	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979.

The majority of sheet and rill erosion, 51.9 percent, is from forest land at an average annual rate of 1.60 tons per acre per year. Orchard and vineyards have the highest average erosion rate, 19.79 tons per acre per year. Cropland erosion rates are high on cropland areas located in the Red River-Greers Ferry to Pangburn Watershed, Big Creek-Main Stem Little River River Watershed, Indian Creek Watershed, and Mingo Creek Watershed. See Table 3-21 for additional data on sheet and rill erosion by land use.

TABLE 3-21 SHEET AND RILL EROSION IN SEGMENT 4E BY LAND USE

Land Use	Percent of Total Land (tons/acre/year)	Avg. Erosion Rate Land Use	Percent of Erosion Contributed by Land Use
Cropland	4.8	7.39	19.9
Grassland	24.3	2.00	24.2
Orchards & Vineyards	0.4	19.79	4.0
Forest land	64.4	1.60	51.9
Urban & Built-Up	1.6	not computed	-
Water & Mines	4.5	not computed	-
Total	100.0	4.48	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979.

The movement of soil particles into streams contributes to the increased turbidity of water. Sediment reduces the oxygen carrying capacity of the water, therefore, adversely impacting fish reproduction and suffocating eggs in the nest.

Segment 4F - White River from Mouth of Black River to Mouth of Buffalo River

The water quality in Segment 4F is generally good due in part to 89 percent of the area in less intensive land uses such as forest land and grassland. There are localized problems due to point source discharges by some of the larger communities and/or industries.

Sixteen miles of streams are considered by ADPC&E to be severely current use impaired, while 298.5 miles of streams are not impaired. The source of the pollutant is pathogens from agricultural sources. The use of Norfork Lake is considered not impaired (Arkansas Water Quality Inventory Report, 1986).

Fecal coliform bacteria have frequently exceeded the standard for primary contact recreation. This parameter prevents the swimmable use designation from being met (refer to Table 3-22). The source of the fecal coliform bacteria is the land application of animal waste from confined operations or runoff from pastures.

Another water quality parameter which has frequently exceeded standards at all stations shown in Table 3-22, was turbidity. The major source of turbidity is soil erosion. Table 3-23 shows that over 3.5 million tons of soil are being eroded with 1.0 million tons of the eroded soil known as sediment delivered to the watershed outlets.

Table 3-22 Chemical Water Quality Data for Segment 4F

Station: WHI 29 - White River at Oil Trough

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.6	23	24	4	5.3
D.O., mg/L	10.3	20	13.3	8.5	1.4
PH	7.9	21	8.4	7.5	0.20
Cl-, mg/L	4.6	22	8.0	2.0	1.4
SO4=, mg/L	7.3	20	13	4	2.3
TSS, mg/L	22.8	20	99	4	24.6
T. Phos, mg/L	0.07	20	0.26	0.02	0.06
NO2+NO3-N, mg/L	0.37	21	0.57	0.29	0.08
Turbidity, ntu	18.1	21	110	3.2	29.1
Fecal Coliform, #/100ml	361	22	2100	8	590
Cd, ug/L	0.59	21	2	0.5	0.41
Cr, ug/L	1.7	21	6	1	1.5
Cu, ug/L	12.2	22	22	8	3.3
Pb, ug/L	2.9	18	5	1	1.5
Zn, ug/L	15.8	17	45	3	13.8

SOURCE: Arkansas Water Quality Inventory Report, 1986

Table 3-22 Chemical Water Quality Data for Segment 4F (cont.)

Station: WHI 46 - White River near Norfork

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	13.0	24	27	2	5.7
D.O., mg/L	9.8	23	12.5	7.4	1.3
PH	7.9	24	8.1	7.5	0.13
Cl-, mg/L	4.8	24	7.0	1.0	1.3
SO4=, mg/L	7.3	21	10	3	1.9
TSS, mg/L	29.9	24	558	1	112
T. Phos, mg/L	0.05	21	0.60	0.01	0.12
NO2+NO3-N, mg/L	0.34	22	0.66	0.13	0.13
Turbidity, ntu	20.0	22	340	1.0	71.8
Fecal Coliform, #/100ml	309	23	6100	4	1264
Cd, ug/L	0.58	23	1	0.5	0.21
Cr, ug/L	1.5	23	12	0.1	2.3
Cu, ug/L	21.9	22	67	10	15.8
Pb, ug/L	14.6	23	54	1	16.9
Zn, ug/L	21.6	18	66	3	15.8

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 60 - White River near Jacksonport

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	16.0	22	25	2	6.5
D.O., mg/L	9.5	20	13.1	7.3	1.4
PH	7.9	21	8.2	7.4	0.20
Cl-, mg/L	4.4	22	7.0	2.0	1.4
SO4=, mg/L	6.1	18	11	1	2.3
TSS, mg/L	32.5	20	59	13	14.3
T. Phos, mg/L	0.06	20	0.13	0.03	0.02
NO2+NO3-N, mg/L	0.31	21	0.45	0.11	0.09
Turbidity, ntu	23.2	21	61	2.0	14.3
Fecal Coliform, #/100ml	149	21	1040	4	246
Cd, ug/L	0.54	21	1	0.5	0.19
Cr, ug/L	1.4	21	3	1.0	0.67
Cu, ug/L	13.1	23	23	10	3.4
Pb, ug/L	5.7	18	14	1	2.9
Zn, ug/L	16.2	17	40	3	11.0

SOURCE: Arkansas Water Quality Inventory Report, 1986

Table 3-22 Chemical Water Quality Data for Segment 4F (cont.)

Station: WHI 63 - Mill Creek below Melbourne

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	14.6	23	22	5	xxx
D.O., mg/L	8.9	22	12.7	5.4	2.1
PH	7.7	23	7.9	7.5	0.12
Cl-, mg/L	13.3	23	30.0	2.0	8.1
SO4=, mg/L	5.3	20	8.0	1.0	1.8
TSS, mg/L	13.9	23	124	2.0	24.7
T. Phos, mg/L	0.14	20	0.51	0.03	0.10
NO2+NO3-N, mg/L	1.9	21	16.0	0.81	xxx
Turbidity, ntu	13.1	21	140	2.0	29.7
Fecal Coliform, #/100ml	531	20	2600	12	605
Cd, ug/L	0.51	22	0.8	0.5	0.06
Cr, ug/L	1.2	23	5.0	1.0	0.74
Cu, ug/L	25.1	20	71	10	15.5
Pb, ug/L	19.3	21	110	1	26.5
Zn, ug/L	28.6	16	66	4	16.5

SOURCE: Arkansas Water Quality Inventory Report, 1986

TABLE 3-23 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	104,888	2.9
Road Bank Erosion	342,937	9.5
Gully Erosion	107,141	3.0
Streambank Erosion	135,644	3.8
Sheet and Rill Erosion	2,899,792	80.8
TOTAL	3,590,402	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Forest land contributes 42.8 percent of the sheet and rill erosion. Other land uses contributing to the sheet and rill erosion are shown in Table 3-24.

Table 3-24 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Percent of Erosion Contributed by Land Use
Cropland	7.1	9.02	32.6
Grassland	26.5	1.91	24.6
Orchards & Vineyards	--	-	-
Forest land	62.8	1.41	42.8
Urban & Built-up	1.0	not computed	-
Water	2.6	not computed	-
Segment Total	100.0	2.06	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

The largest source of sheet and rill erosion is forest land. Even with the large total amount of sheet and rill erosion, the erosion rate per acre does not threaten soil productivity or contribute an extremely large amount of sediment to one stream.

The number two source of sheet and rill erosion in Segment 4F is cropland. The excessively eroding cropland is located in the following watersheds, Salado Creek-Main Stem Laterals, Mud Creek, and, Departee Creek. These watersheds have cropland which is located on sloping land (Nonpoint Source, 1979).

Segment 4G - Black River, Strawberry River and Tributaries

Water quality in this segment clearly reflects the differing land uses. Areas of row crop agriculture have degraded water quality and lost fishery habitat, while areas mostly covered in forest have excellent water quality. This diversity of land use is a direct result of two differing physiographic regions coming together in this segment generally along the Black River.

Eighteen miles of stream may be severely current use impaired due to point source pollution, while 442 miles of stream are not use impaired. The pollutants which are causing the impairment are sediment and pathogens from agriculture and mining operations. The major lake in the area, Lake Charles, is not use impaired (Arkansas Water Quality Inventory, 1986). Table 3-25 is a summary of water quality in Segment 4G.

Table 3-25 Chemical Water Quality Data for Segment 4G

Station: WHI 04 - Current River near Pocahantas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.2	23	25	4	6.6
D.O., mg/L	9.5	20	12.1	7.6	1.2
PH	7.9	22	8.2	7.4	0.21
Cl-, mg/L	3.3	23	7.0	1.0	1.4
SO4=, mg/L	5.8	19	19	1	3.9
TSS, mg/L	34.0	21	219	3.0	54.6
T. Phos, mg/L	0.07	21	0.33	0.02	0.08
NO2+NO3-N, mg/L	0.28	22	0.50	0.15	0.08
Turbidity, ntu	28.2	22	280	2.4	60.7
Fecal Coliform, #/100ml	131	23	690	0.06	211
Cd, ug/L	0.50	22	0.6	0.5	0.2
Cr, ug/L	3.1	22	24	1	4.8
Cu, ug/L	15.6	23	37	10	7.6
Pb, ug/L	9.0	19	37	1	10.4
Zn, ug/L	33.6	18	140	3	34.3

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 24 - Strawberry River near Smithville

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.8	23	26.0	1.0	7.1
D.O., mg/L	9.4	21	13.3	7.2	1.8
PH	8.0	22	8.4	7.7	0.17
Cl-, mg/L	3.5	23	6.0	2.0	1.2
SO4=, mg/L	5.7	19	10	1	2.8
TSS, mg/L	34.4	21	300	4.0	62.8
T. Phos, mg/L	0.05	21	0.24	0.01	0.04
NO2+NO3-N, mg/L	0.34	21	0.89	0.06	0.21
Turbidity, ntu	17.8	22	115	2.0	25.1
Fecal Coliform, #/100ml	311	23	1600	12	410
Cd, ug/L	0.50	22	0.6	0.5	0.02
Cr, ug/L	2.3	22	13	1	2.9
Cu, ug/L	15.1	23	32	9	5.9
Pb, ug/L	11.2	19	65	3	13.4
Zn, ug/L	25.6	18	113	5	23.0

SOURCE: Arkansas Water Quality Inventory Report, 1986

Parameters which exceeded standards in Table 3-25 are turbidity, and fecal coliform bacteria. The heavy metals, copper, lead and zinc, show high concentrations which could be of concern for some uses (Arkansas Water Quality Inventory Report, 1986).

Table 3-26 shows the sources of erosion which are directly related to the amount of sediment transported through the various streams. Approximately one million tons of sediment are delivered to watershed outlets annually.

Table 3-26 Summary of Erosion by Source

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	91,552	2.6
Road Bank Erosion	191,181	5.6
Gully Erosion	51,682	1.5
Streambank Erosion	180,839	5.3
Sheet and Rill Erosion	2,912,305	85.0
Total	3,912,305	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

The source of 56 percent of the 2.9 million tons of sheet and rill erosion is cropland which comprises over 23.6 percent of the segment area. Other land uses contributing to sheet and rill erosion are shown in Table 3-27.

TABLE 3-27 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Percent of Erosion Contributed by Land Use
Cropland	23.6	6.28	56.97
Grassland	34.4	1.68	21.79
Forest land	39.5	1.42	21.22
Urban & Built-up	1.9	not computed	-
Water, Mines & Misc.	0.6	not computed	-
Total	100.0	2.66	100.00

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Erosion on sloping cropland is excessive in several waterheds. These watersheds are Flat Creek, Big Running Water Ditch, and North Big Creek-Strawberry River (Nonpoint Source, 1979).

Segment 4H - Spring River, South Fork of Spring River and Eleven Point River

Water quality in this segment is considered to be good. Erosion is at a low level as shown in Table 3-28. The water quality problems that do occur are few and the impacts are localized. The problems are due to municipal point sources.

Table 3-28 Chemical Water Quality Data for Segment 4H

Station: WHI 5B - Eleven Point River near Pocahontas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.4	23	25.0	5.0	6.4
D.O., mg/L	9.6	21	11.8	7.8	1.1
PH	7.9	22	8.5	7.6	0.18
Cl-, mg/L	3.2	23	7.0	2.0	1.3
SO4=, mg/L	3.8	19	8.0	1.0	2.4
TSS, mg/L	9.2	21	62	5.0	15.9
T. Phos, mg/L	0.03	21	0.11	0.01	0.02
NO2+NO3-N, mg/L	0.56	22	0.76	0.37	0.11
Turbidity, ntu	17.5	22	160	2.0	34.4
Fecal Coliform, #/100ml	131	23	890	4.0	217
Cd, ug/L	0.50	22	0.5	0.5	0.00
Cr, ug/L	1.7	22	6.0	1.0	1.3
Cu, ug/L	13.0	23	26	10	4.6
Pb, ug/L	6.0	19	21	1.0	5.6
Zn, ug/L	19.7	18	43	5.0	11.3

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 6A - Spring River near Thayer

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	14.5	24	28.0	4.0	6.7
D.O., mg/L	8.9	23	12.4	5.9	1.7
PH	7.9	24	8.1	7.4	0.15
Cl-, mg/L	3.5	24	6.0	2.0	1.3
SO4=, mg/L	3.8	21	8.0	1.0	1.7
TSS, mg/L	9.5	24	26	3.0	5.1
T. Phos, mg/L	0.05	21	0.11	0.01	0.02
NO2+NO3-N, mg/L	0.67	22	1.2	0.32	0.24
Turbidity, ntu	6.0	22	18.0	2.0	4.4
Fecal Coliform, #/100ml	537	22	1900	68	445

Table 3-28 Chemical Water Quality Data for Segment 4H (cont.)

Station: WHI 6A - Spring River near Thayer

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Cd, ug/L	0.50	23	0.5	0.5	0.00
Cr, ug/L	1.9	24	6.0	1.0	1.4
Cu, ug/L	57.4	22	945	10	198
Pb, ug/L	2.7	23	11	1.0	2.9
Zn, ug/L	58.8	18	385	3.0	94.3

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 21 - Spring River at Ravenden

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.7	23	25.0	1.0	6.6
D.O., mg/L	9.5	21	13.0	7.0	1.7
PH	8.1	22	8.7	7.8	0.18
Cl-, mg/L	3.2	23	6.0	2.0	1.0
SO4=, mg/L	3.9	19	9.0	1.0	2.5
TSS, mg/L	22.3	21	104	5.0	22.5
T. Phos, mg/L	0.04	21	0.11	0.01	0.02
NO2+NO3-N, mg/L	0.52	22	0.82	0.17	0.16
Turbidity, ntu	12.7	22	62.0	3.0	14.6
Fecal Coliform, #/100ml	300	23	2600	0.006	639
Cd, ug/L	0.51	22	0.8	0.5	0.06
Cr, ug/L	1.7	22	5.0	1.0	1.1
Cu, ug/L	11.6	15	15	10	2.4
Pb, ug/L	9.0	19	33	1.0	8.5
Zn, ug/L	20.1	17	41	3.0	11.7

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 23 - South Fork Spring River at Saddle

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	14.7	24	27.0	1.0	8.2
D.O., mg/L	9.1	23	13.7	5.6	2.1
PH	7.9	24	8.2	7.4	0.17
Cl-, mg/L	3.6	24	6.0	2.0	1.1
SO4=, mg/L	3.9	21	8.0	2.0	1.0
TSS, mg/L	13.7	24	114	4.0	22.6
T. Phos, mg/L	0.04	21	0.12	0.01	0.03

Table 3-28 Chemical Water Quality Data for Segment 4H (cont.)

Station: WHI 23 - South Fork Spring River at Saddle

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
NO2+NO3-N, mg/L	0.40	22	1.1	0.08	0.31
Turbidity, ntu	11.0	22	80.0	2.0	17.7
Fecal Coliform, #/100ml	768	23	12000	4.0	2498
Cd, ug/L	0.53	23	0.9	0.5	0.09
Cr, ug/L	1.2	24	2.0	1.0	0.46
Cu, ug/L	55.1	22	684	10	140
Pb, ug/L	23.7	23	92	1.0	29.6
Zn, ug/L	72.5	18	592	7.0	134

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 25 - Black River at Pocahantas

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.1	23	25.0	2.0	6.8
D.O., mg/L	8.7	21	11.8	6.9	1.3
PH	7.8	22	8.9	7.4	0.33
Cl-, mg/L	3.2	23	6.0	2.0	1.0
SO4=, mg/L	6.2	29	11	1.0	2.6
TSS, mg/L	35.2	21	108	8.0	24.6
T. Phos, mg/L	0.07	21	0.19	0.04	0.03
NO2+NO3-N, mg/L	0.23	21	0.41	0.11	0.07
Turbidity, ntu	27.7	22	92.0	8.2	18.1
Fecal Coliform, #/100ml	181	23	1000	12	225
Cd, ug/L	0.50	22	0.5	0.5	0.00
Cr, ug/L	1.8	22	4.0	1.0	1.0
Cu, ug/L	14.4	23	30	10	6.2
Pb, ug/L	10.0	19	36	1.0	8.5
Zn, ug/L	25.0	18	66	3.0	18.7

SOURCE: Arkansas Water Quality Inventory Report, 1986

Parameters which exceeded standards are turbidity, fecal coliform, copper, lead, and zinc. The water quality monitoring station located on the South Fork Spring River at Saddle recorded very high levels of copper, lead, and zinc during 1984 and 1985.

TABLE 3-29 SUMMARY OF EROSION BY SOURCE

Land Use	Tons Per Year	Percent of Total
Road Surface Erosion	62,395	4.3
Road Bank Erosion	73,858	5.1
Gully Erosion	13,781	0.9
Streambank Erosion	29,683	2.2
Sheet and Rill Erosion	1,259,352	87.5
Total	1,439,069	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

The sheet and rill erosion is contributed by several land uses as shown in Table 3-30. Grassland is the major source of the sheet and rill erosion. Water Valley Dam Reach Watershed is an area of high erosion on cropland and grassland.

Due to the geology of the segment, the potential exists for sink holes to form by water dissolving the underlying limestone rock. If a sink hole develops under a toxic chemical holding lagoon, the chemical could rapidly flow into an aquifer and severely pollute the water.

TABLE 3-30 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Percent of Erosion Contributed by Land Use
Cropland	0.5	6.9	0.02
Grassland	30.9	4.1	60.0
Forest land	67.0	1.2	39.98
Urban and Built-up	1.5	not computed	0.0
Other	0.1	not computed	0.0
Total	100.0	2.2	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Segment 4I - White River from the Mouth of Crooked Creek to the Mouth of Long Creek

Water quality is considered good in segment 4I. Minor problems that are the result of occasional municipal point source discharges that do not meet water quality standards have caused localized degradation of water quality and have affected stream uses (Water Quality, 1986). Table 3-31 lists representative water quality parameters in segment.

Table 3-31 Chemical Water Quality Data for Segment 4I

Station: WHI 66 - Crooked Creek below Harrison

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.8	23	26.0	6.0	5.9
D.O., mg/L	9.9	23	13.5	6.9	1.9
PH	7.7	23	7.9	7.5	0.11
Cl-, mg/L	10.4	22	25	5.0	4.9
SO4=, mg/L	8.4	19	16	5.0	2.8
TSS, mg/L	10.5	22	28	2.0	7.5
T. Phos, mg/L	0.38	20	0.85	0.11	0.21
NO2+NO3-N, mg/L	1.9	22	3.7	1.4	0.48
Turbidity, ntu	9.2	22	35.0	3.0	8.2
Fecal Coliform, #/100ml	179	21	1060	4.0	342
Cd, ug/L	0.50	19	0.5	0.5	0.00
Cr, ug/L	2.0	22	14.0	1.0	2.7
Cu, ug/L	11.5	22	15	10	2.3
Pb, ug/L	1.5	23	4.0	1.0	0.84

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 67 - Crooked Creek above Harrison

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.5	23	25.0	4.0	5.6
D.O., mg/L	10.6	23	14.6	7.8	1.7
PH	7.6	23	7.8	7.4	0.10
Cl-, mg/L	6.4	22	13	4.0	2.0
SO4=, mg/L	5.4	19	111	2.0	2.0
TSS, mg/L	11.3	23	28	3.0	7.5
T. Phos, mg/L	0.04	20	0.10	0.02	0.02
NO2+NO3-N, mg/L	1.5	22	3.4	1.1	0.46
Turbidity, ntu	9.1	22	33.0	3.0	8.1
Fecal Coliform, #/100ml	431	20	2160	10.0	623
Cd, ug/L	0.52	19	1.0	0.5	0.11
Cr, ug/L	2.0	22	15.0	1.0	2.9
Cu, ug/L	10.3	22	15	10	3.6
Pb, ug/L	1.4	22	7.0	1.0	1.7
Zn, ug/L	8.2	21	26	3.0	6.5

SOURCE: Arkansas Water Quality Inventory Report, 1986

Table 3-31 Chemical Water Quality Data for Segment 4I (cont.)

Station: WHI 71 - Long Creek below Denver

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.1	23	28.0	5.0	7.0
D.O., mg/L	10.4	23	14.8	7.7	2.0
PH	7.9	23	8.1	7.4	0.14
Cl-, mg/L	7.3	22	13	3.0	2.7
SO4=, mg/L	8.0	20	16	5.0	2.8
TSS, mg/L	6.7	23	51	1.0	10.2
T. Phos, mg/L	0.04	20	0.13	0.02	0.02
NO2+NO3-N, mg/L	1.6	22	4.7	0.95	0.76
Turbidity, ntu	4.3	22	26.0	1.0	6.0
Fecal Coliform, #/100ml	100	22	350	8.0	83.9
Cd, ug/L	0.50	19	0.5	0.5	0.00
Cr, ug/L	1.0	22	1.0	1.0	0.00
Cu, ug/L	12.4	22	21	10	3.03
Pb, ug/L	1.3	23	4.0	1.0	0.76
Zn, ug/L	7.7	21	19	3.0	5.7

SOURCE: Arkansas Water Quality Inventory Report, 1986

Contributing to the good water quality are less intensive land uses of grassland and forest land. These two land uses have very low erosion rates if a minimum amount of care is exercised. Over 91 percent of the watershed is in either grassland or forest land. See Table 3-32 for sources of erosion and Table 3-33 for a break down of sources of sheet and rill erosion.

The water quality parameters which have exceeded the standards on occasion are copper, zinc, turbidity and fecal coliform bacteria. The concentrations of these parameters are not as great as in some of the other White River segments.

TABLE 3-32 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons per Year	Percent of Total
Road Surface Erosion	109,108	2.7
Road Bank Erosion	274,759	6.7
Gully Erosion	42,200	1.0
Streambank Erosion	94,147	2.3
Sheet and Rill Erosion	3,569,409	87.3
Total	4,089,623	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Watersheds with high rates of sheet and rill erosion are Long Creek, Table Rock Laterals, Taneycomo Laterals, Lower Bull Shoals Laterals, and Lower Crooked Creek-North Fork White River (Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979).

The potential exists for the degradation of water quality due to the improper handling of animal wastes. Large numbers of birds, mainly chickens, are raised in parts of this segment.

TABLE 3-33 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (Tons/Acre/Year)	Percent of Erosion Contributed by Land Use
Grassland	43.2	6.2	67.0
Forest land	48.7	2.6	33.0
Urban & Built-up	1.7	not computed	-
Water	6.4	not computed	-
Total	100.0	4.0	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Segment 4J - Buffalo River and Tributaries

The major stream in this segment is the Buffalo River. Due partially to its protected status by Federal ownership of adjacent lands, the Buffalo River has excellent water quality. Problems arising in this segment are due to minor point sources which create few problems other than occasional localized impacts.Table 3-34 lists representative water quality parameters in Segment 4J.

Table 3-34 Chemical Water Quality Data for Segment 4J

Station: WHI 49A - Buffalo River near St. Joe

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	17.8	24	31.0	3.0	8.8
D.O., mg/L	10.6	23	13.8	7.5	1.6
PH	7.9	24	8.4	7.4	0.24
Cl-, mg/L	3.2	23	5	1.0	0.99
SO4=, mg/L	6.2	20	11	2.0	2.2

Table 3-34 Chemical Water Quality Data for Segment 4J (cont.)

Station: WHI 49A - Buffalo River near St. Joe

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
TSS, mg/L	9.3	24	144	1.0	28.8
T. Phos, mg/L	0.30	21	0.16	0.01	0.03
NO2+NO3-N, mg/L	0.12	22	0.27	0.03	0.07
Turbidity, ntu	8.2	22	100.0	1.0	21.0
Fecal Coliform, #/100ml	56	23	760	4.0	159
Cd, ug/L	0.49	23	0.7	0.1	0.09
Cr, ug/L	1.3	24	4.0	1.0	0.92
Cu, ug/L	15.2	22	86	10	16.
Pb, ug/L	4.4	23	37.0	1.0	10.0
Zn, ug/L	13.0	18	63	3.0	13.8

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 64 - Bear Creek below Marshall

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	12.0	16	23.0	2.0	5.9
D.O., mg/L	11.1	13	14.8	6.5	1.9
PH	7.6	15	8.0	7.2	0.02
Cl-, mg/L	4.2	14	6	2.0	1.2
SO4=, mg/L	9.5	12	13	4.0	2.5
TSS, mg/L	6.2	15	34	1.0	8.0
T. Phos, mg/L	0.05	12	0.11	0.03	0.02
NO2+NO3-N, mg/L	0.41	14	0.64	0.22	0.11
Turbidity, ntu	5.5	14	26.0	1.0	6.2
Fecal Coliform, #/100ml	113.3	15	480	4.0	181.9
Cd, ug/L	0.52	14	0.7	0.5	0.05
Cr, ug/L	1.1	15	2.0	1.0	0.35
Cu, ug/L	20.0	14	43	10	9.5
Pb, ug/L	22.0	14	85.0	1.0	26.8
Zn, ug/L	21.4	11	39	6.0	11.5

SOURCE: Arkansas Water Quality Inventory Report, 1986

Water quality parameters exceeding standards on occasion are turbidity, fecal coliform bacteria, copper, lead, and zinc. On the average, turbidity and fecal coliform bacteria are within acceptable levels. However, soil erosion in segment 4J is a problem. Table 3-35 shows that over 2.9 million tons are eroded annually from the various sources of erosion. Sources of sheet and rill erosion are grassland and forest land as shown in Table 3-36.

TABLE 3-35 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons per Year	Percent of Total
Road Surface Erosion	68,189	2.4
Road Bank Erosion	196,273	6.7
Gully Erosion	17,359	0.6
Streambank Erosion	58,556	2.0
Sheet and Rill Erosion	2,572,186	88.3
Total	2,912,563	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin

The sheet and rill erosion is within accepted limits and does not present a problem Segment 4J.

TABLE 3-36 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (Tons/Acre/Year)	Percent of Erosion Contributed by Land Use
Cropland	0.1	0.0	0.0
Grassland	20.0	4.24	28.7
Forest land	79.5	2.64	71.3
Urban & Other	0.4	not computed	-
Total	100.0	2.95	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

Segment 4K - Upper White River and Kings River

Significant existing and potential water quality problems are present in this segment. Several municipal point sources have consistently affected downstream uses over the years. This segment also has widespread water quality problems as a result of the prolific number of confined animal feeding operations (chickens and hogs). Excessive concentrations of nutrients and fecal coliform bacteria from these operations have caused extensive problems with nuisance growths of aquatic vegetation, and an overall degrading of this segment's naturally high quality waters. (See Table 3-37.) The discharges from Berryville and Fayetteville are being closely monitored to measure the effect on receiving stream water quality. Periodic spills and/or accidents have caused fish kills due to the heavy oxygen demand of the waste released. Compounding these problems is the high rate of growth and urbanization that has taken place over the last 20 years in the segment's urban areas, which has brought with it all of the associated water quality problems. Major efforts have been made to correct non-compliant municipal discharges by the local and state agencies having jurisdiction over these problems. Related nonpoint source problems, however, will continue to have an impact for the foreseeable future (Arkansas Water Quality Inventory Report, 1984 and 1986).

Table 3-38 shows that soil erosion also contributes to water quality problems with over 5 million tons of erosion occurring annually. Table 3-39 shows that the main sources of sheet and rill erosion are grassland and forestland.

Water quality parameters exceeding standards are turbidity, fecal coliform bacteria, copper, lead, and zinc. The concentrations of lead and zinc exhibit a large range of variability.

Table 3-37 Chemical Water Quality Data for Segment 4K

Station: WHI 52 - White River near Goshen

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	15.3	26	29.0	1.0	8.9
D.O., mg/L	8.0	25	12.0	3.1	2.8
PH	7.3	25	7.8	6.9	0.19
Cl-, mg/L	14.7	24	62	3.0	16.2
SO4=, mg/L	17.0	22	38	5.0	9.1
TSS, mg/L	16.0	25	40	5.0	9.18
T. Phos, mg/L	0.83	22	3.1	0.05	0.89
NO2+NO3-N, mg/L	0.84	24	1.8	0.04	0.34
Turbidity, ntu	15.2	24	50.0	3.0	11.6
Fecal Coliform, #/100ml	131	24	740	4.0	193
Cd, ug/L	0.85	4	1.0	0.6	0.36
Cr, ug/L	1.8	18	5.0	1.0	1.0
Cu, ug/L	19.1	19	33	13	5.5
Pb, ug/L	10.4	23	38.0	2.0	9.6
Zn, ug/L	56.5	22	176	20	39.3

SOURCE: Arkansas Water Quality Inventory Report, 1986

Station: WHI 51 - W. Fork White River near Fayetteville

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Temperature, C	16.0	21	31.0	0.0	10.4
D.O., mg/L	9.3	21	14.3	5.8	2.4
PH	7.5	22	7.9	7.2	0.17
Cl-, mg/L	8.4	21	38	3.0	7.5
SO4=, mg/L	21.0	22	38	10.0	8.8
TSS, mg/L	13.7	21	24	6.0	6.2
T. Phos, mg/L	0.07	18	0.19	0.03	0.03
NO2+NO3-N, mg/L	0.51	21	2.1	0.05	0.48
Turbidity, ntu	12.8	22	32.0	2.0	7.8

Table 3-37 Chemical Water Quality Data for Segment 4K (cont.)

Station: WHI 51 - W. Fork White River near Fayetteville

Parameter	Mean	Number of Samples	Max.	Min.	Standard Deviation
Fecal Coliform, #/100ml	141	19	1140	4.0	258
Cd, ug/L	2.7	14	17.0	0.6	4.3
Cr, ug/L	1.8	15	4.0	1.0	0.86
Cu, ug/L	14.2	8	27	10	6.0
Pb, ug/L	16.2	18	105	1.0	25.8
Zn, ug/L	37.8	17	160	7.0	36.2

SOURCE: Arkansas Water Quality Inventory Report, 1986

TABLE 3-38 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	200,933	3.8
Road Bank Erosion	764,629	14.3
Gully Erosion	37,425	0.7
Streambank Erosion	114,680	2.1
Sheet and Rill Erosion	4,217,880	79.1
Total	5,335,547	100.0

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

TABLE 3-39 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (Tons/Acre/Year)	Percent of Erosion Contributed by Land Use
Cropland	0.6	7.04	0.39
Grassland	31.4	3.43	47.25
Forest land	62.6	2.70	52.33
Urban & Built-up	2.3	not computed	-
Water	2.6	not computed	-
Feedlots	0.2	0.44	0.03
Other Agricultural	0.3	not computed	-
Total	100.0	3.89	100.00

SOURCE: Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979

War Eagle Creek is the watershed with the highest average rate of sheet and rill erosion. The erosion rate is 8.50 tons per acre per year (Nonpoint Source Pollution Assessment Summaries for White River Basin, 1979).

DATA BASE PROBLEMS

Irrigated Cropland

Information on irrigated cropland should be available for planning purposes. Since about 74 percent of the total water use, excluding hydropower, in this basin is for irrigation, the total irrigated acreage of each crop should be known to determine the amount of water needed for irrigation.

Information on irrigated cropland is difficult to obtain. The Agricultural Stabilization and Conservation Service (ASCS) reports rice acreages, and the Crop and Livestock Reporting Service reports estimates of irrigated crops determined by sampling procedures. This information is only available by county. For planning purposes, information should be reported by hydrologic boundaries. The Soil Conservation Service sampled irrigated cropland and expanded the data for 1980 in its publication "Agricultural Water Study, Phase V, Arkansas Statewide Study"; however, the data were only for one year.

As long as irrigation is a major water use, it will be necessary to quantify the water used. A joint effort of all agencies involved will make the best use of human resources.

Streamflow Data

Streamflow data are collected in the Upper White River Basin by the monitoring of gaging stations in the area. Information for eighteen continuous streamflow gaging stations in northern Arkansas and southern Missouri were used in this report as the data base from which many of the mathematical computations were made. Extrapolation of the gaging station data to other reaches on gaged streams and to other ungaged streams was necessary to determine streamflow characteristics, instream flow requirements, and excess streamflow for the Upper White River Basin. Error may be introduced into the computations when data are extrapolated, particularly if knowledge of the basin characteristics and the effects of man-made practices are limited.

Streamflow characteristics for the two major streams, White River and Black River, are reasonably well defined from the gaging station information that has been collected. There are reaches of the White River, such as, between Calico Rock and Newport and between Newport and DeValls Bluff which do not have gaging stations. However, streamflow characteristics for other streams, such as the Buffalo River, are not well defined. Many small streams do not have a gaging station. Also, dams on the Upper White River have a significant effect on the streamflow characteristics.

Diversion Reporting

Annual registration of surface water diversions has been required since the passage of Act 180 of 1969 to amend Act 81 of 1957. All surface water diversions are included except those diversions from lakes or ponds owned exclusively by the diverter. Diversion registration is a necessary tool in the planning process for maximum development of the state's water resources along with being beneficial should periods of shortage make allocation necessary.

Failure to report surface water diversions will result in a diverter not being granted an allocation of surface water except for what is necessary for domestic purposes. The non-allocation to a riparian diverter shall not allow a non-riparian to use take priority over a riparian right (Rules, 1983).

Registration does not constitute a water right. This misconception could be the cause of some extremely high reported use rates. Should a period of allocation become necessary, then the portion of the available water to be allowed each registered riparian user would be based upon need and not exclusively on past water use reports. More care should be taken to give an accurate report of water use.

Some diverters choose not to report. This could be because they are not familiar with the diversion registration requirements or, they disregard the law because of the lack of a penalty (other than during allocation). Additionally, there are those that report initially then fail to report in subsequent years even though reporting is required annually.

PROBLEMS DETERMINING INSTREAM FLOW REQUIREMENTS

The Arkansas Soil and Water Conservation Commission has been mandated by Act 1051 of 1985 to determine the instream flow requirements for water quality, fish and wildlife, navigation, interstate compacts, aquifer recharge, and other uses such as industry, agriculture, and public water supply in the State of Arkansas. When these needs and future water needs are determined for each basin, the water available for other uses can be determined.

At the present time, there is limited information available to quantify instream flow requirements for streams in the Upper White River Basin. Problems for each of the instream flow categories are described below:

(1) Water quality - The 7Q10 stream discharge has been established as the instream flow requirement for water quality by the Arkansas Department of Pollution Control and Ecology. However, the low-flow characteristics have been determined for only a few sites in the Upper White River Basin. Flow in the Upper White River Basin is modified and varies greatly.

(2) Fish and wildlife - A new method, called the "Arkansas Method", has been developed by Filipek and others (1985) to determine instream flow requirements for fish and wildlife. The instream flow requirements determined by the "Arkansas Method" were used in the computations of excess streamflow, however, the "Arkansas Method" is theoretical and has not been verified with collection of field data.

Instream flow requirements determined by the "Arkansas Method" were not applicable for use in determining minimum streamflows in the basin. Minimum streamflow is defined as the lowest discharge that will satisfy minimum instream flow needs by fish biological season. Instream flow requirements determined by the "Arkansas Method" represent flow requirements for "excellent" fisheries habitat.

(3) Navigation - Instream flow requirements for navigation have been defined for the major streams in the Upper White River Basin by the Corp of Engineers, and pose no problem for determination of minimum streamflow or excess streamflow in this basin. Smaller streams are not of interest to commercial navigation interests.

(4) Interstate compacts - The interstate compact require- ments have not been defined for the streams of the Upper White River Basin. The absence of an interstate compact presents a problem when trying to determine available water and stream flows. An interstate compact would make it necessary to perform a detailed accounting of runoff, streamflow and water diversions.

(5) Aquifer recharge - Instream flow requirements necessary to recharge the aquifers in the Upper White River Basin are currently unknown. Since the aquifer recharge has occurred before the water reaches a gaging station, there is not a problem quantifying the aquifer recharge requirement.

(6) Riparian use - Riparian use is recorded in the Arkansas Soil and Water Conservation Commission files of registered diversions. As previously stated, there are some problems with water use reporting. Since the water has already been removed from the stream, quantification of the amount of water diverted is not a critical element for the determination of excess streamflow in the basin.

CRITICAL SURFACE WATER AREAS

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to define critical water areas and to delineate areas which are now critical or which will be critical within the nest thirty years. A critical surface water area is defined as any area where current water use, projected water use, and/or quality degradation have caused, or will cause, a shortage of useful water for a period of time so as to cause prolonged social, economic, or environmental problems.

Based on the previous information and the critical surface water definition, it was determined that there are no critical surface water areas in the Upper White River Basin.

SOLUTIONS AND RECOMMENDATIONS

Surface Water Quantity - Availability

The solution to water supply shortages involves water conservation and utilization of existing water storage or new storage site development. Economics, also, should be a major factor in solving water availability problems.

Water conservation should be practiced in all categories of use. In household use, conservation could be practiced by using flow restrictors, limiting duration of water use, and washing full loads of items where possible. In agricultural uses especially irrigation, increased application efficiency, more efficient water delivery systems, tailwater recovery systems, and proper timing are conservation practices which will reduce water requirements. New manufacturing techniques and water recycling are two ways to reduce water needs for industry.

Another solution to a water availability problem is to use existing water storage by connecting to a nearby municipal water system. In the case of a municipal system or large water user, the solution is to contract with a private, state, or federally owned water storage facility such as Bull Shoals Lake. It is possible for the Corps of Engineers to reallocate water storage from existing reservoirs and sell the right of storage by contract for municipal and industrial purposes. In effect, this solution would mean the formation of an area water distribution system.

As listed in the Potential for Development section, there are water storage sites available for development. These sites are usually difficult to develop due to cultural or environmental reason(s). In choosing this alternative, it would be most desirable from a financial standpoint for a group of users to jointly develop a new water source.

The solution to the potential backlog of cases during times of water allocation is for the Arkansas Soil and Water Conservation Commission to be staffed at maximum levels. With the staffs at maximum levels, they would be better equiped to serve the people of the state. Also, with a staff of this size, the Commission could assist the staffs of other state agencies such as the Department of Pollution Control and Ecology and State Health Department.

Surface Water Quantity - Flooding

For the areas which are subject to periodic flooding, there are two basic types of solutions. One type of solution is considered a nonstructural method. The second type of solution is a structural method.

Nonstructural solutions do not alter the flood height or flood frequency, but they reduce flood damages by keeping the flood water from the damageable items. Examples of nonstructural solutions are land use change, acquisition, zoning, floodproofing, raising the structures, building a levee around individual structures and flood insurance. Flood insurance differs from the other examples in that the flood damage continues to occur but parties owning the damaged property are partially reimbursed for the damages based on the amount of insurance coverage.

Structural solutions are modifications of the drainage area so that flood heights are reduced. Flood water retarding dams, channel modifications, and leveed floodways are examples of structural solutions to flooding problems. Structural solutions for flood related problems are high cost items.

Even though there are many solutions to flood problems, a careful study should be made to determine the least cost alternative. Nonstructural solutions usually cost less than structural solutions. Also, there is governmental assistance available for water resource problems which meet certain requirements. For an additional discussion of governmental assistance, see the section entitled Govermental Assistance.

Quality of Surface Water

As mentioned earlier in this report, soil erosion is a major source of nonpoint pollution in the Upper White River Basin. There are many ways to reduce soil erosion. The methods used to control soil erosion are frequently referred to as Best Management Practices (BMP's). There are BMP's which are effective in controlling erosion caused by different operations. Table 3-40 lists some of the BMP's for the different operations.

TABLE 3-40 BEST MANAGEMENT PRACTICES

Agricultural BMP's
1. Conservation tillage (minimum till - no till).
2. Proper disposal of pesticide containers
3. Proper use of pesticides
4. Irrigation water management
5. Crop rotation
6. Cover crops
7. Irrigation system tailwater recovery
8. Grass cover on turn rows and ditches
9. Underground irrigation pipelines
10. Crop residue management
11. Land leveling
12. Contour cultivation
13. Rotation grazing
14. Terraces
15. Field drains.
16. Waste management systems
17. Establish and manage permanent pasture and hayland
18. Farm ponds
19. Grassed waterways
20. Proper fertilization

Forestry BMP's
1. Proper construction and maintenance of roads
2. Limited clear cutting on steeper slopes
3. Stream side management zones
4. Correct pesticide application
5. Minimized mechanical damage
6. Livestock exclusion
7. Firebreaks
8. Critical area planting
9. Traffic barriers
10. Clearing on contour
11. Skid logs on contour
12. Temporary vegetative cover

TABLE 3-40 BEST MANAGEMENT PRACTICES (cont.)

Construction BMP's
1. Mulching
2. Traffic barriers
3. Limited soil disturbance
4. Site planning and proper timing of operation
5. Temporary vegetative cover
6. Conservation of natural vegetation
7. Diversions
8. Water control structures
9. Hard surface heavy use areas
10. Roadside stabilization

Subsurface Disposal BMP's
1. Proper installation
2. Provide sewer service
3. Sanitary landfills
4. Recycling
5. Alternate systems for sewage disposal
6. Limited housing density

Urban Runoff BMP's
1. Grade stabilization structures
2. Grassed waterways
3. Sediment basins
4. Flood water control structures
5. Mulching
6. Diversions
7. Ponds
8. Critical area treatment
9. Lined waterways

Mining BMP's
1. Reclamation of mined lands
2. Grassed waterways
3. Diversions
4. Revegetation
5. Sediment basins
6. Spread, smooth, and vegetate spoil lands
7. Proper fertilizing and use of lime
8. Fencing
9. Tree planting
10. Access roads
11. Reshaping strip mines
12. Mandatory reclamation plans for new mines

Hydrological Modifications BMP's
1. Grade stabilization structures
2. Dikes
3. Streambank protection
4. Surface drainage
5. Revegetation after construction
6. Spoil spreading

TABLE 3-40 BEST MANAGEMENT PRACTICES (cont.)

Hydrological Modifications BMP's (cont.)

7. Water control structures
8. Dams
9. Rock lined waterways
10. Designing of side slopes to facilitate revegetation and maintenance
11. Floodways
12. Construction of irrigation reservoirs
13. Irrigation return systems
14. Levees to prevent flooding
15. Low water weirs
16. Clearing and snagging

Disposal Sites BMP's

1. Diversions
2. Filter strips
3. Fencing
4. Sites for disposal of pesticide containers
5. Solid waste collection systems
6. County wide refuse disposal plan
7. Daily processing: Cover and vegetate abandoned dumps.

Road BMP's

1. Topsoiling ditch banks
2. Paving
3. Diversions
4. Critical area planting
5. Mulching
6. Lined waterways
7. Water conveyance structures
8. Limited road grading
9. Riprap
10. Proper site selection for new road construction

Streambank BMP's

1. Grade control structures
2. Streambank vegetation including trees
3. Reshaping banks
4. Rock riprap
5. Concrete mats
6. Lined waterways
7. Controlled grazing
8. Revetments and jetties
9. Buffer zones
10. Snagging

Gully BMP's

1. Terraces
2. Diversions
3. Critical area shaping
4. Mulching
5. Critical area planting
6. Fencing

Anticipated reduction in nonpoint pollution sources will enhance the environment by improving water quality in Beaver Lake and throughout the region. It is expected that fish habitat and the opportunities for body contact sports will be significantly improved. Wildlife habitat will be enhanced because of improved cover and diversity throughout the region.

In addition to enhancing the environment, implementation of the BMP's is expected to result in economic and social benefits.
The soil and water resources will be protected. It is anticipated that agricultural production will be increased, additional recreational activities will become available, area residents will take more pride in their community, and social consciousness will be increased.

Point source pollution sources should be reduced. Education and information campaigns should be used to make the public aware of the pollution problems. Increased public awareness might prevent some of the water quality problems before they occur. Increased enforcement of pollution control regulations could reduce the occurrence of problem spills.

Problem sheet and rill erosion can be reduced by employing the appropriate agricultural BMP's listed in Table 3-40.

Conservation - Agricultural Water Use

Agricultural water use is the largest consumptive user of water in the Upper White River Basin. Since this water use is the largest user of water, the potential exists for the greatest conservation of water. There are many ways farm managers may conserve water.

One of the most important methods of conserving water is to increase the infiltration rates of the surface soils. By increasing the infiltration rate, a larger percent of the rainfall is absorbed by the soil and is stored in the soil pores for later use by the plant. The infiltration rate is increased by keeping the soil pores open and slowing the rate of water runoff from an area. To keep the soil pores open, the management alternatives of stubble mulch tillage, no-tillage and cover crops can be used. Methods to slow the rate of water runoff are contour farming, terraces and conservation tillage.

Water delivery systems are items that should be evaluated for loss of water. Water losses range from 40 percent to 10 percent for earth canals and 5 percent to 0 percent for pipelines (Arkansas Agricultural Water Study, 1983). Seventy-five miles of earth canals, both permanent and temporary, comprise 40 percent of the length of delivery systems in this basin. Increased efficiency can be gained by installing pipe irrigation water delivery systems. Also, the land area previously occupied by the canal can be planted to crop, therefore contributing to increased production.

Application methods have a wide range of efficiencies for each method and between the different methods. Table 3-32 shows the various application methods and their range of efficiencies.

TABLE 3-41 ESTIMATED EFFICIENCIES OF APPLICATION METHODS

Application Method	Efficiencies (percent)
Furrow (without return)	30 - 85
Furrow (with return)	80 - 95
Levee (without return)	40 - 80
Levee (with return)	80 - 95
Traveling Sprinkler	75 - 90
Center-pivot Sprinkler	75 - 90
Solid Set or Portable Set	75 - 90
Drip Irrigation	85 - 95

Source: Arkansas Agricultural Water Study, 1983

Eighty-four percent of the irrigated acreage is irrigated by the contour levee application method (Arkansas Agricultural Water Study, 1983) Contour levee irrigation method is one of the least efficient irrigation methods. Efficiency of an irrigation method may be improved by more intensively managing the existing method or changing the method of irrigation application.

Another aid in conservation of water in agricultural irrigation is the proper scheduling of applications. Proper scheduling allows the water user to apply water only when the plants need it. Important factors in irrigation scheduling are soil properties, plant characteristics, weather, and management practices. If all factors are considered, an efficient irrigation schedule may be developed.

Engineering planning is the process which utilizes all of the previously mentioned factors to use water in the most efficient manner. In addition, engineering planning makes recommendations on field layout, land leveling needs, water pump placement, and delivery system needs.

Conservation - Public Supply

Conservation in the public supply category can lessen the demand on water sources. Water saving methods include installing water flow restrictors, repairing all leaks in water lines, limiting bathing water, watering lawns in cooler parts of the day and washing items only when there is a full load. Also, another use reduction measure is pricing techniques. Price variance has proven to be a means of controlling water consumption. Using cheap water rates to entice industry should be discouraged. With the implementation of these and other conservation measures, a significant quantity of water can be conserved.

Conservation - Self-Supplied Industries

Self-supplied industry is urged to examine its operating procedure for areas in which water could be conserved. Practices to be considered include water recycling and manufacturing process revision.

Conservation - Wastewater Reuse, Recyling and Land Application

Municipal wastewater effluent has the potential to be a source of supplemental water. There are uses of untreated or limited treated wastewater which will reduce the total disposal cost of the effluent. Recycling has the potential of benefiting both the source and the user. If the chemical composition of the wastewater is within acceptable limits, it may be used as irrigation water or fertilizer. An example of wastewater reuse is to use the wash water from a water treatment plant to irrigate an orchard. As treatment costs increase, recycling or land application becomes a more attractive option.

Governmental Assistance

There are several government programs which are intended to aid communities and organizations in solving water resource problems. Table 3-42 is a list of selected government programs and their administering agency. If after reading the table, a person is interested in additional information about a program, contact the administering agency.

Purposes of the programs vary. Purposes included in the different programs include flood prevention, water supply, wastewater treatment, technical assistance or land use planning.

Forms of assistance range from technical assistance to grants. Some of the programs require cost sharing from the local sponsor. Cost sharing is when the sponsoring local organization is required to pay a percentage of the costs of the project.

Data Bases - Irrigated Cropland

The U. S. Department of Agriculture has three agencies that are involved with reporting cropland acreages. The Agricultural Stabilization and Conservation Service (ASCS) reports crop acreages of those land controllers who participate in their programs. The only irrigated crop acreages that ASCS collects is rice because it is only grown by irrigated methods. Land controller participation is estimated at 99 percent. The Crop and Livestock Reporting Service reports irrigated cropland based on sampling procedures. As part of the Arkansas Statewide Study - Agricultural Water Supply Report, the Soil Conservation Service sampled irrigation systems in 26 eastern Arkansas counties and conducted a census of irrigation systems in the remaining counties in the state. The U. S. Geological Survey estimates the annual irrigation water use by applying a water use rate by crop to the crop acres published by the USDA Statistical Reporting Service.

As directed by Act 1051 of 1985, the Arkansas Soil and Water Conservation Commission began collecting irrigation data by the water user filling out questionnaires. The annual deadline for reporting irrigation water use for the previous water year is March 1 of each year.

TABLE 3-42 SUMMARY OF SELECTED GOVERNMENT PROGRAMS TO AID IN SOLVING WATER RESOURCE PROBLEMS

Program Name	Type of Assistance	Program Objective	Administering Agency Level	Administering Agency Name
Act 417 of 1985	Financial	To encourage the development of on-farm water storage by offering state income tax incentatives.	State	Arkansas Soil and Water Conservation Commission (AS&WCC)
Water Development Fund	Grants or Loans	Fund may be used for the payment of water development costs of any project included in the Arkansas Water Plan. The primary responsibility is to insure the proper development of the state's water resources without placing an undue financial burden on her citizens. All other possible sources of funds for a given project must be exhausted before applying for these monies.	State	Arkansas Soil and Water Conservation Commission
General Obligation Bond Program	Loans	Funds may be use for projects to conserving or developing surface or subsurface water resources, projects controlling or developing water treatment facilities, or other water storage projects.	State	Arkansas Soil and Water Conservation Commission
Arkansas Community and Economic Development Program	Grants	To achieve the development of viable communities by providing decent housing, a suitable living environment, and expanding economic opportunities, principally for persons of low to moderate income.	State	Arkansas Industrial Development Commission
Community Facilities Loans	Insured Loans	To construct, enlarge, extend, or otherwise improve community facilities providing essential services to rural areas.	Federal	USDA, Farmers Home Administration
Industrial Development Grants	Grants	To facilitate the development of business, industry and and related employment for improving the econnomy in rural communities.	Federal	USDA, Farmers Home Administration
Grants and Loans for Public Works and Development Facilities	Grants and Loans	To assist in the construction of public facilities needed to initiate and encourage long-term economic growth in designated geographic areas where economic growth is lagging behind the rest of the nation.	Federal	USDOC, Economic Development Administration
Community Development Block Grants	Formula Grants	To develop viable urban communities, including decent housing, and suitable living environment and expand economic opportunities, principally for persons of low and moderate incomes.	Federal	USHUD, Housing and Urban Development
Flood Insurance	Insurance	To enable persons to purchase insurance on real and personal property where flood plain management measures have been adopted and are enforced.	Federal	Federal Emergency Management Agency or AS&WCC
Watershed Protection & Flood Prevention Act (PL 83-566)	Technical and Financial	Assist local organizations in planning and carrying out a program for the development, use and conservation of soil and water resources.	Federal	USDA, Soil Conservation Service

TABLE 3-42 SUMMARY OF SELECTED GOVERNMENT PROGRAMS TO AID IN SOLVING WATER RESOURCE PROBLEMS (cont.)

Program Name	Type of Assistance	Program Objective	Administering Agency Level	Administering Agency Name
Resource Conservation and Development	Technical and Financial	Designed to carry out a program of land conservation and land utilization, accelerated economic development, reduction of chronic unemployment or underemployment in an area where these activities are needed to foster a local economy.	Federal	USDA, Soil Conservation Service
Soil Survey	Technical	To provide published soil surveys of counties to locate soils suitable for homesites, subdivisions, commercial and industrial sites, farms, wildlife and recreational areas prime agricultural land, highways and airports.	Federal	USDA, Soil Conservation Service
Conservation Operations	Technical	To provide assistance identifying natural resources of an area and help determine the effect of urban land uses on these resources. Provide technical assistance in developing plans and installing conservation measures to protect the natural resources. Provide technical assistance to those persons responsible in drafing regulations dealing with soil and water.	Federal	USDA, Soil Conservation Service
Section 205, Flood Control Act of 1948, as amended	Technical, Financial, Construction	To assist local sponsors in planning, designing, and construction of local flood protection projects, including dams, reservoirs, channels, and levees.	Federal	DA, Corps of Engineers
Section 14 of the Flood Control Act of 1946, as amended	Technical, Financial, Construction	To prevent erosion damages to endangered public works and non-profit public services; e.g., construction or repair of streambank and shoreline protective works for highways, highway bridge approaches, public works, schools, public and private non-profit hospitals, churches, schools, and other non-profit public facilities.	Federal	DA, Corps of Engineers
Section 208, Flood Control Act of 1954, as amended	Technical, Financial, Construction	Clearing and snagging of channels for flood control.	Federal	DA, Corps of Engineers
Water Supply Act of 1958, as amended	Technical, Financial, Construction (100 percent reimbursable)	To insure a continuing supply of fresh water, adequate in quantity for urban and rural needs by cooperating with states, and local interests in the development of water supplies for domestic, municipal, and industrial water storage in reservoir projects.	Federal	DA, Corps of Engineers
Section 107, River and Harbor Act of 1960, as amended	Technical, Financial, Construction, Maintenance	To aid in the planning, design, and construction of small navigation projects.	Federal	DA, Corps of Engineers

SOURCE: Community Assistance Program, Univ. of Arkansas and Legislative Joint Performance Review Committee, Arkansas General Authority and Various Federal Agencies

A joint effort is needed between all water use data collection agencies to accurately report irrigated cropland periodically for planning purposes. Through such an effort, accurate and consistent information will be developed and enhance water resource planning in the state.

Data Bases - Streamflow Data

One solution to the lack of streamflow gaging station data in the Upper White River Basin would obviously be to install more gaging stations on streams in the basin. Additional gages on streams with limited gages would be particularly helpful to define streamflow characteristics at other locations on the stream, and to quantify the amount of water diverted from the stream during the agricultural growing season.

Construction of additional gages would not be an appropriate solution for the limited streamflow data available for some stream reaches in the Upper White River Basin. Due to the channel and flood plain characteristics of certain locations in the basin, streamflows above bankfull stage can not be accurately determined by present streamflow gaging techniques. However, the U. S. Geological Survey has developed a digital model, called the "BRANCH" model, which may be applicable for determining streamflow in the lower reaches of the Black River and White River. The model is capable of computing the discharge at any point on a reach of stream using input hydrographs from continuous gaging stations at each end of the reach along with cross section information at selected points within the reach.

Another solution to the problem of limited streamflow data would be to conduct detailed studies on selected streams as Freiwald (1987). A series of stream discharge measurements made at numerous sites along a stream reach and at tributary inflow points during a short period of time could add greatly to the knowledge of low-flow information of an area (Freiwald, 1987).

Data Bases - Diversion Reporting

Surface water diversion registration was required by Act 180 of 1969. The diversion reports have been useful to determine water use in the state. The importance of the report was magnified by Act 1051 of 1985 that required the Arkansas Soil and Water Conservation Commission to determine the water requirements of riparian land owners. Without diversion registrations this determination would prove costly and time consuming. This determination of riparian water use is necessary to insure that an over-utilization of a stream or lake does not occur or if currently over utilized; to what degree.

One solution to the problems of non-reporting, over reporting, or one time only reporting is to amend the current law to include a penalty, other than nonpreference in allocation proceedings. This is not to say that a substantial penalty should be considered, but a fine large enough to be an incentive to report. Also, the Arkansas Soil and Water Conservation Commission should be able to make adjustments to reports that appear inaccurate. This would not be used to grant water quantity rights. It would only be used for planning purposes to accurately determine water use.

Determining Instream Flow Requirements

Determination of instream flow requirements for interstate compact, water quality, fish and wildlife, and aquifer recharge for streams in the Upper White River Basin is a problem at the present time with no short term solution. Quantification of the amount of water in this basin that is available for other uses is not possible until these instream flow needs are identified.

The solution to the problems associated with the lack of an interstate compact is for the states of Arkansas and Missouri to negotiate a compact with the consent of the United States Government. A compact would set limits on the volume of water a state could use. Also, minimum flows between states would set.

The criteria for water quality flow requirements has been established by ADPC&E, but the low-flow characteristics have been determined for only a relatively small number of sites in the Upper White River Basin. A solution to this problem would be to conduct additional detailed studies on streams as Freiwald (1987) had done.

Instream flow requirements necessary to recharge the aquifers in the Upper White River Basin are currently unknown. Additional studies, including the development of computer models, would add greatly to the knowledge of aquifer recharge requirements, but there is no exact scientific answer at this time.

The instream flow requirements for fish and wildlife have been addressed by Filipek and others (1985) using the "Arkansas Method." The accuracy of the Arkansas method could be verified by a study of instream flow requirements using the Instream Flow Incremental Methodology (IFIM) developed by a the Instream Flow Group at Colorado State University (How the IFIM Got Its Name, 1986). This methodology may also be applicable for the determination of minimum instream flow requirements for fish and wildlife.

An alternative or modification to the method of determining fish and wildlife requirements could be the development of an instream flow needs priority matrix for recommending the level of protection which should be afforded a stream. Barnes (1986) recommended that establishing stream priorities in a given basin is an approach to determine streamflow that is a method that enables the use of a flexible approach for determining instream needs based on a priority of historic uses of the streams.

In developing streams priorities in each basin of the state, consideration should be given to: (1) the presence of endangered species, (2) water quality, (3) recreation use, (4) fishery value, (5) special stream designation, e.g., Wild and Scenic Rivers, Arkansas Natural Scenic Rivers Registry, or Arkansas Natural and Scenic Rivers System, and (6) riparian uses. The stream priority matrix was prepared based on a multi-agency consultation in the areas of water quality, fishery quality, scenic river status, recreation use, and endangered species. The Arkansas Department of Parks and Tourism, the Scenic River Commission, the Endangered Species Office of the U. S. Fish and Wildlife Service, the Arkansas Game and Fish Commission, the Arkansas Department of Pollution Control and Ecology, and the Arkansas Soil and Water Conservation Commission were consulted for input into the matrix. Other features could be added to refine the matrix including state species of special concern and degree of municipal, industrial and agricultural use of the lotic systems.

The different factors would be assigned a point value by a rating committee and the respective points would be totalled for each stream to get a composite score in a format as shown in Table 3-43. The rating committee should be composed by representatives from different interests. Arbitrary stream designations of high, medium and low priority streams would be based on a range of points. The minimum flows should be based on a percentage of the historic flow for the stream for that season (Barnes).

A comparison of the recommended minimum flows should be made to the probability of exeedance by historical flows. This comparison would indicate the percent of time these minimum flows have been equaled or exceeded.

TABLE 3-43 EXAMPLE PRIORITY MATRIX FOR DETERMINING STREAM FLOW PROTECTION LEVELS

STREAM OR SEGMENT OF STREAM	ENDANGERED SPECIES	WATER QUALITY	RECREATION USE	FISHERY QUALITY	SENIC RIVER STATUS	RIPARIAN WATER USE	COMPOSITE SCORE	STREAM PROTECTION LEVEL
	YES - pts	HIGH - pts	HIGH - pts	HIGH - pts	WS - pts	HIGH - pts		HIGH
	NO - pts	MEDIUM - pts	MEDIUM - pts	MEDIUM - pts	NRI - pts	MEDIUM - pts	0 -	MED
		LOW - pts	LOW - pts	LOW - pts	SR - pts	LOW - pts		LOW
					(only one counts)			

Stream Flow Protection Levels Are:
High percent of the Seasonal Mean Flow as Minimum
Medium percent of the Seasonal Mean Flow as Minimum
Low percent of the Seasonal Mean Flow as Minimum

SENIC RIVER STATUS:
WS - Wild and Scenic River
NRI - National Rivers Inventory
SR - State Systems

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

CHAPTER 4

GROUND-WATER RESOURCES OF THE UPPER WHITE RIVER BASIN

By John M. Kilpatrick and A.H. Ludwig

Administrative Report

Prepared for the

U.S. ARMY CORPS OF ENGINEERS

Little Rock, Arkansas

1988

CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, rather than the inch-pound units used in this report, the following conversion factors may be used:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallon per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	3,785	cubic meter per day (m^3/d)

INTRODUCTION

The study area consists of the entire upper White River basin (fig. 4-1), most of which lies in the Ozark Plateaus physiographic province. The area is dominated by deeply dissected plateaus which are as much as 2,400 feet (ft) above sea level[1] in the south (Brewster and Williams, 1951). The rocks underlying the Ozark Plateaus range in age from Ordovician to Pennsylvanian (fig. 4-2). They are composed primarily of nearly horizontal beds of limestone, shale, dolomite, sandstone, and chert. The beds dip gently to the south at the rate of about 50 feet per mile (ft/mi). The dip increases gradually toward the Arkansas Valley on the south. Small quantities of ground water, generally less than 10 gallons per minute (gal/min), are available at shallow depths in these units from secondary openings such as joints, fractures, and solution cavities. Yields of up to 300 gal/min are possible from three deeply buried limestone and dolomite units which are regionally important sources of ground water. These units occur at depths ranging from 1,000 to 3,500 ft below land surface.

A small part of the southeastern corner of the study area lies in the Arkansas Valley section of the Ouachita province. This area is described by Fenneman (1938) as being little different from the southern Ozark Plateaus.

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[1] Sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Seal Level of 1929."

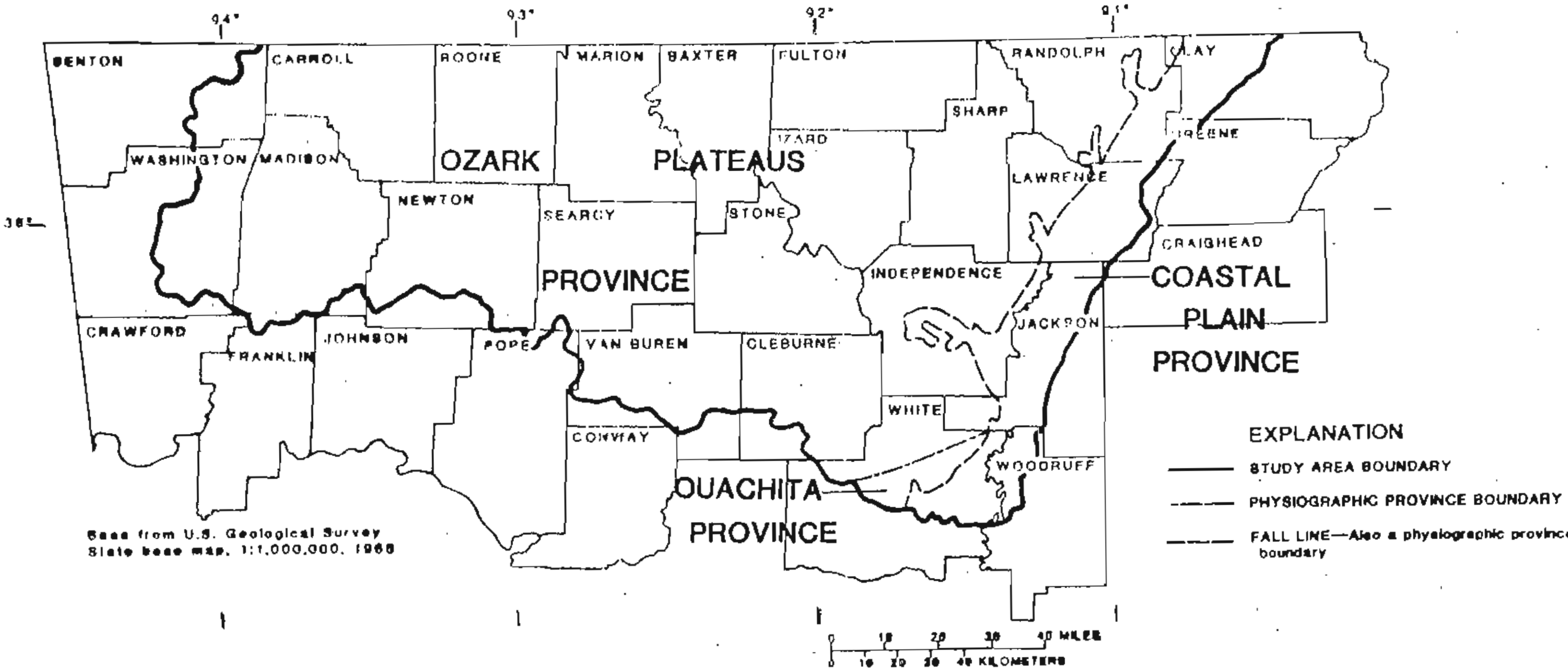

Figure 4-1.--Location and physiography of the study area.

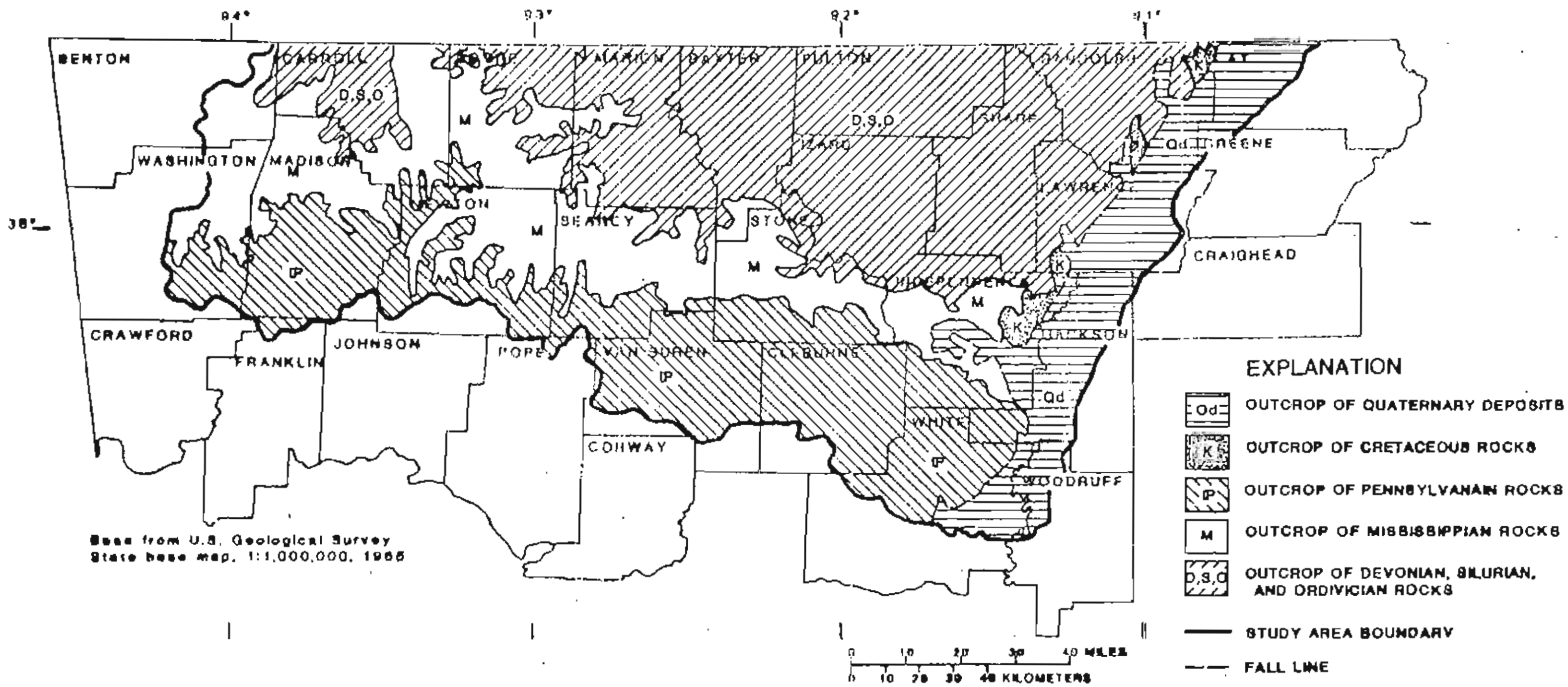

Figure 4-2.--Geology of the upper White River basin (modified from Haley, 1976).

A narrow strip along the eastern edge of the study area, ranging from 10 to 20 miles in width, lies in the Mississippi Alluvial Plain section of the Coastal Plain province. This area is characterized by nearly flat topography and is underlain by as much as 155 ft of Quaternary aged alluvial sediments composed of gravel, sand, silt, and clay. These deposits are the most productive ground-water source in the study area. Properly constructed wells in these deposits yield as much as 2,500 gal/min of water. The Quaternary deposits lie unconformably on a sequence of older, unconsolidated deposits that dip gently to the east-southeast. These deposits are composed of sand, clay, marl, and chalk of Tertiary and Cretaceous ages. Sand units within this sequence are capable of yielding from 50 to 500 gal/min to wells.

Information concerning the lithology and water-bearing characteristics of each of the geologic units in the study area is contained in the stratigraphic column (table 4-1).

PURPOSE AND SCOPE

This report was prepared for the U.S. Army Corps of Engineers, Little Rock District to describe the ground-water resources of the upper White River basin. The contents of this report will be incorporated by the Corps of Engineers into the upper White River basin report, one of eight River Basin Reports to be published as a component of the 1986 Arkansas State Water Plan.

Table 4-1.--Generalized stratigraphic column for the study area

(modified from Caplan, 1957; Caplan, 1960; and Albin and others, 1967)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
	Quaternary	Alluvial and terrace deposits	0-155	Sand, fine to very coarse, and gravel; contains much silt and clay near surface	Can yield up to 2,500 gal/min from a large diameter well
	Tertiary	Wilcox Group	0-200	Sand, silt, and clay, gray and greenish to dark brown	Not considered a potential source of water in the study area
		Midway Group	0-380	Clay, silty in part with minor quantities of sandy, fossiliferous limestone at the base	Not considered sources of water in the study area
	Cretaceous	Arkadelphia Marl	0-30	Clay, silty and sandy in part, interbedded light and dark gray, lignitic in part	
		Nacatoch Sand	0-300	Sand, medium to coarse, clayey in part, glauconitic, phosphatic, maroon to brown, contains minor layers of reddish-brown clay	Utilized in the study area only for domestic purposes in the outcrop
		Saratoga Chalk	0-117	Upper unit - clay. Middle unit - interbedded sand and clay. Lower unit - chalk.	Not considered a source of water in the study area
	Pennsylvanian	Atoka Formation	0-4,600	Sandstone, medium grained, interbedded with dark shale.	Yields small quantities of water to wells in the weathered zones in the outcrop area. Most wells yield 2 to 5 gal/min. In some areas, fracture zones and bedding planes may yield up to 25 gal/min.
		Bloyd Shale	0-628	Shale, dark, fissile; contains beds of sandy, gray limestone	
		Hale Formation	0-980	Upper part - massive limestone, shaly layers. Lower part - shale, fissile, dark.	
	Mississippian	Pitkin Limestone	0-219	Limestone, crystalline, gray-black	
		Fayetteville Shale	0-297	Shale, dark, black sandstone beds near top	
		Batesville Sandstone	0-457	Sandstone, medium grained with basal limestone	
		Ruddell Shale		Shale, fissile, dark gray-green	
		Moorefield Formation		Shale, platy, gray-black	
		Boone Formation (including St. Joe Limestone member)	0-388	Chert, dense or cherty limestone contains a basal pink to maroon finely crystalline limestone	Weathered rubble of limestones yield 2 to 5 gal/min to wells. Wells tapping solution channels can yield up to 25 gal/min.
		Chattanooga Shale	0-70	Shale, black, bituminous, with basal sandstone	
	Devonian	Pentera chert	0-260	Chert, gray to black, with interbedded limestone	
	Silurian	Lafferty limestone	0-254	Limestone, earthy, thinly bedded, red to gray	Commonly yield 5 to 10 gal/min from solution channels, bedding planes, and fractures. Yields from some wells may exceed 50 gal/min.
		St. Clair limestone		Limestone, pinkish-gray	
		Brassfield limestone		Limestone, light gray, containing vugs	
	Ordovician	Cason shale	0-57	Shale, platy to fissile, black and gray	
		Fernvale Limestone	0-108	Limestone, coarsely crystalline, white, gray, pink	
		Kimmswick Limestone	0-400	Limestone, sacchroidal, white to gray, fossiliferous	
		Plattin Limestone		Limestone, dense, light gray to blue gray	
		Joachim Dolomite	0-117	Dolomite, silty, gray to brown, some sandstone	
		St. Peter Sandstone	0-158	Sandstone, medium grained, white, frosted	

Table 4-1.--Generalized stratigraphic column for the study area (con.)

(modified from Caplan, 1957; Caplan, 1960; and Albin and others, 1967)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
	Ordovician	Everton Formation	0-1,180	Dolomite, dense, gray to brown and sandstone	
		Powell Dolomite	0-404	Dolomite, silty, shaly, sandstone and sandy dolomite	Solution channels and fractures yield 5 to 10 gal/min. Yields in some wells may exceed 50 gal/min.
		Cotter Dolomite	0-527	Dolomite, light gray to brown, cherty	
		Jefferson City Dolomite	100-496	Dolomite, cherty, silty, gray to brown. Minor beds of sandstone.	
		Roubidoux Formation	132-455	Dolomite, dolomitic sandstone, and chert	Average yield is less than 150 gal/min but up to 450 gal/min is possible
		Gasconade-Van Buren Formations (including Gunter Sandstone member)	319-600	Dolomite, cherty, light brown-gray. Basal sandstone-Gunter member, white to gray quartz sandstone.	Wells commonly yield 150 to 300 gal/min. Can yield up to 500 gal/min.
	Cambrian	Eminence-Potosi Formations	307-389	Dolomite, cherty, light colored	Little is known about water yields of these formations in Arkansas. With the exception of the Eminence-Potosi, these formations yield less than 50 gal/min in southern Missouri. The Eminence-Potosi has reportedly yielded up to 230 gal/min in a Benton County well.
		Derby-Doerun Formations		Dolomite, granular, cherty, sandy, silty	
		Davis Formation		Dolomite, sandy, shaly	
		Bonneterre dolomite	0-71	Dolomite, light gray, glauconitic	
		Lamotte Sandstone	0-59	Quartzose sandstone, locally arkosic	
	Precambrian	Igneous Rocks			

The purpose of this report is to (1) describe the general geologic and hydrologic characteristics of the basin, (2) describe the significant water-bearing units in more detail, and (3) examine specific ground-water problems and potential problems. General physiographic and geologic characteristics of the study area including topography, geologic structure, and lithologies present, are described in this report. In addition general hydrologic characteristics of the study area including ground-water availability, ground-water use, and ground-water quality, are described. Several regionally important water-bearing units are described in more detail. These units included the Eminence-Potosi Formations, Gasconade-Van Buren Formations, Roubidoux Formation, and outcropping Paleozoic units in the Plateaus, and the Nacatoch Sand and Quaternary deposits in the Coastal Plain. The availability and quality of water from each of these units are discussed in detail. Ground-water availability and quality problems in the study area are also described in detail.

The study area includes all of the upper White River basin. For convenience, water-use figures were assembled by county for the 17-county area shown in figure 4-3. The 17-county area does not correspond exactly to the study area.

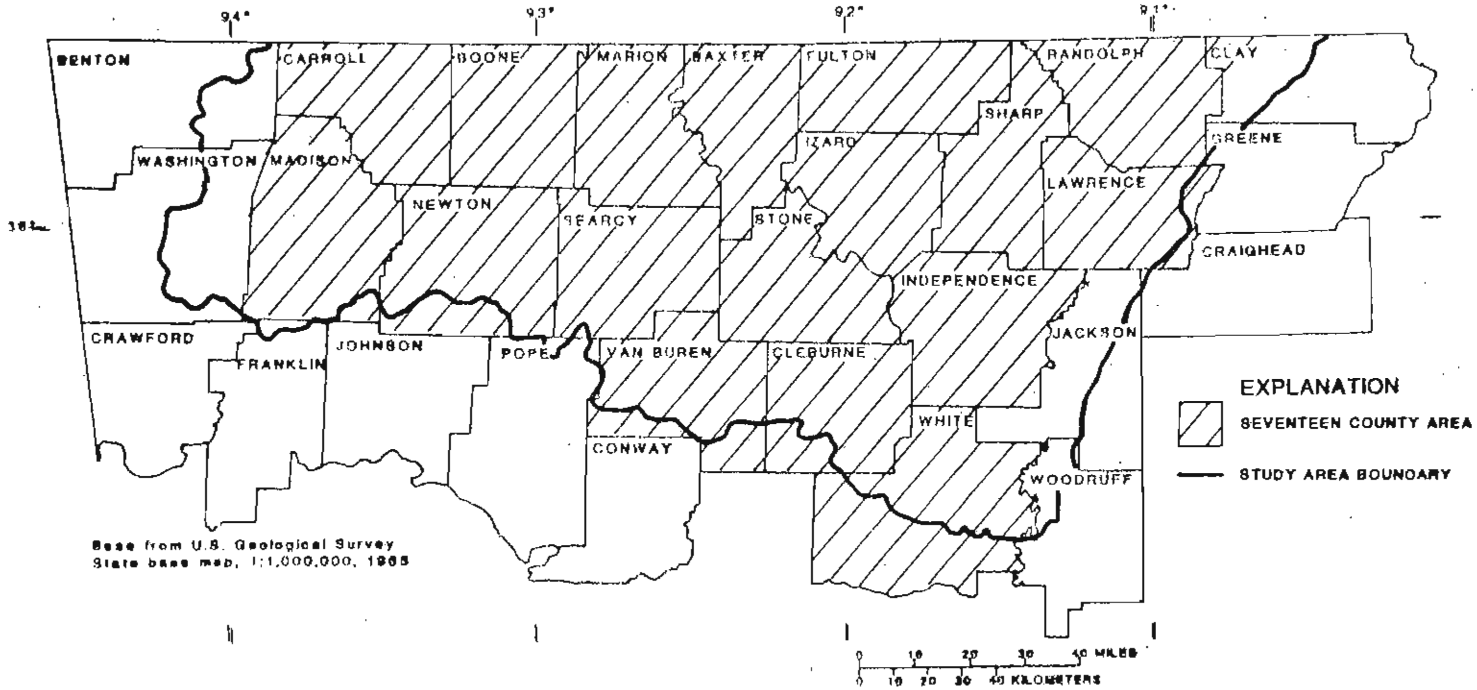

Figure 4-3.--Location of the seventeen county area used for water-use data compilation.

GENERAL HYDROLOGY OF THE STUDY AREA

Ground water is available from nearly all of the geologic units in the study area. However, many of the units do not yield enough water even for domestic use. Several subsurface Paleozoic units yield large amounts of water in the Ozark Plateaus, but the depth of these units makes drilling expensive. In the Plateaus the only economical ground-water sources are the outcropping Paleozoic units, but they commonly yield less than 10 gal/min. In the Coastal Plain, the Quaternary deposits at the surface yield up to 2,500 gal/min of good quality water.

Ground-water withdrawals in the 17-county area approximating the study area totaled 304 million gallons per day (Mgal/d) in 1985 of which almost 92 percent (278 Mgal/d) was withdrawn from the Quaternary alluvial deposits outcropping along the eastern edge of the basin in Randolph, Lawrence, Independence, and White Counties (Holland, 1987). Pumpage from the Paleozoic rocks that underlie the majority of the 17-county area accounted for the remaining 8 percent (25 Mgal/d) of the total water withdrawn.

While most of the ground water withdrawn in the 17-county area is pumped from wells in Quaternary deposits, the aquifers in the Paleozoic rocks are far more significant areally; in most areas, they provide the only source of ground water (table 4-2). Additional information on ground-water use in the 17-county area is contained in tables 4-3 and 4-4.

Table 4-2.--Withdrawals of ground water from aquifers in the study area in 1985

[from Holland, 1987; withdrawals in million gallons per day]

County	Rocks of Paleozoic age, undifferentiated	Deposits of Quaternary age	County total
Baxter	2.31	---	2.31
Boone	2.66	---	2.66
Carroll	2.82	---	2.82
Cleburne	1.23	---	1.23
Fulton	.94	---	.94
Independence	1.79	32.55	34.34
Izard	1.49	---	1.49
Lawrence	.16	153.39	153.55
Madison	1.49	---	1.49
Marion	4.75	---	4.75
Newton	.89	---	.89
Randolph	.44	42.03	42.47
Searcy	.92	---	.92
Sharp	1.89	---	1.89
Stone	.84	---	.84
Van Buren	.83	---	.83
White	---	50.48	50.48
Area total	25.45	278.45	303.90

Table 4-3.--Use of water in the study area, by county and use category

[Withdrawals in million gallons per day]

County	Public supply [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985	Self-supplied industry [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Baxter	0.20	0.34	0.46	0.38	0.55	0.46	0.01	0.07	0.25	0.28	0.14	0.39
Boone	.61	.02	.05	1.94	1.98	1.22	.0	.01	1.65	.0	.05	.0
Carroll	.07	.55	1.11	1.42	1.46	1.75	.01	.0	.01	.01	.01	.00
Cleburne	.0	.02	.05	.05	.12	.13	.01	.04	.12	.09	.13	.44
Fulton	.08	.12	.16	.29	.38	.34	1.30	.0	.0	.0	.02	.00
Independence	.04	.04	.10	.59	1.17	1.13	.25	.0	.03	.04	.09	.04
Izard	.14	.11	.17	.64	1.22	.86	.0	.0	.0	.01	.01	.02
Lawrence	.39	.71	.86	1.20	1.28	1.43	1.00	.0	.0	.01	.01	.01
Madison	.0	.0	.0	.01	.02	.02	.0	.0	.01	.0	.01	.16
Marion	.02	.08	.19	.41	.56	.50	.07	.07	.04	.08	.22	.32
Newton	.0	.0	.03	.08	.10	.09	.0	.0	.04	.12	.17	.12
Randolph	.0	.0	.06	.10	.16	.21	.0	.02	.01	.01	.01	.04
Searcy	.11	.11	.17	.15	.25	.24	.09	.0	.0	.0	.01	.01
Sharp	.05	.09	.98	1.05	1.42	1.30	.0	.0	.0	.0	.01	.0
Stone	.05	.09	.00	.0	.02	.02	.0	.01	.01	.03	.05	.01
Van Buren	.0	.0	.10	.02	.04	.04	.01	.0	.0	.0	.01	.0
White	.43	.33	.28	.30	.55	.49	.15	.04	.05	.05	.04	.02
Total	2.19	2.61	4.77	8.63	11.28	10.23	2.90	.260	2.22	.73	.99	1.58

County	Rural [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985	Irrigation[g] [a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Baxter	0.38	0.31	0.77	0.92	1.13	1.46	0.0	0.06	0.07	0.05	0.0	0.0
Boone	.45	.48	.76	1.34	1.09	1.44	.0	.03	.05	1.87	.11	.0
Carroll	.61	.50	.79	1.27	.80	1.07	.0	.01	.03	.0	.0	.0
Cleburne	.35	.41	.73	.71	.78	.66	.0	.01	.01	.0	.0	.0
Fulton	.27	.26	.42	.84	.58	.60	.0	.0	.0	.0	.0	.0
Independence	1.12	.71	1.15	.83	1.13	1.52	1.5	2.05	4.70	7.08	17.44	31.65
Izard	.33	.27	.43	.66	.53	.58	.0	.0	.01	.0	.09	.03
Lawrence	.45	.46	.58	.81	.68	1.77	19.61	16.72	23.33	75.34	152.14	150.34
Madison	.87	.60	.96	1.43	1.13	1.31	.0	.21	.19	.0	.0	.0
Marion	.23	.25	.34	.77	.63	3.93	.0	.03	.0	3.46	3.97	.0
Newton	.25	.28	.42	.65	.56	.68	.0	.03	.01	1.73	.0	.0
Randolph	.35	.37	.56	1.00	.79	1.14	3.16	2.97	3.57	18.16	42.32	41.08
Searcy	.29	.33	.45	.80	.66	.67	.0	.0	.0	.0	.0	.0
Sharp	.24	.20	.22	.35	.46	.55	.0	.0	.01	.0	.0	.04
Stone	.36	.26	.46	.78	.76	.81	.0	.0	.01	.04	.02	.0
Van Buren	.38	.32	.52	.56	.66	.77	.0	.0	.0	.0	.02	.02
White	1.02	1.08	1.85	1.99	1.65	2.54	1.42	2.87	4.66	13.59	50.21	47.43
Total	7.95	7.09	11.41	15.71	14.02	21.50	25.69	24.99	36.65	121.32	266.32	270.59

[a] Stephens and Halberg, 1961
[b] Halberg and Stephens, 1966
[c] Halberg, 1972
[d] Halberg, 1977
[e] Holland and Ludwig, 1981
[f] Holland, 1987
[g] Includes fish and minnow farms

Table 4-4.--Total ground-water use from the study area, by county, 1960 through 1985

[Withdrawals in million gallons per day]

County	Total ground-water use					
	[a]1960	[b]1965	[c]1970	[d]1975	[e]1980	[f]1985
Baxter	0.59	0.78	1.55	1.63	1.82	2.31
Boone	1.06	.54	2.51	5.15	3.23	2.66
Carroll	.69	1.06	1.94	2.70	2.27	2.82
Cleburne	.36	.48	.91	.85	1.03	1.23
Fulton	1.65	.38	.58	1.13	.98	.94
Independence	2.91	2.80	5.98	8.54	19.83	34.34
Izard	.47	.38	.61	1.31	1.85	1.49
Lawrence	21.45	17.89	24.77	77.36	154.11	153.55
Madison	.87	.81	1.16	1.44	1.16	1.49
Marion	.32	.43	.57	4.72	5.38	4.75
Newton	.25	.31	.5	2.58	.83	.89
Randolph	3.51	3.36	4.20	19.72	43.28	42.47
Searcy	.49	.44	.62	.95	.92	.92
Sharp	.29	.29	1.21	1.40	1.89	1.89
Stone	.41	.36	.48	.85	.85	.84
Van Buren	.39	.32	.62	.58	.73	.83
White	3.02	4.32	6.84	15.93	52.45	50.48
Area total	38.73	34.95	55.05	146.39	292.61	303.90

[a] Stephens and Halberg, 1961
[b] Halberg and Stephens, 1966
[c] Halberg, 1972
[d] Halberg, 1977
[e] Holland and Ludwig, 1981
[f] Holland, 1987

Ground-water withdrawals from the Paleozoic rocks in the 17-county area have recently declined while withdrawals from Quaternary deposits have consistently increased. Ground-water withdrawals from Paleozoic rocks, after increasing for 15 years, peaked in 1980 and declined 16 percent between 1980 and 1985. With this sharp decline, withdrawals in 1985 fell 9 percent below the withdrawals in 1975 (fig. 4-4). In contrast, withdrawals from Quaternary deposits in the 17-county area increased 136 percent over the same period. Pumpage from Quaternary deposits increased only 4 percent between 1980 and 1985.

In 1985, 89.0 percent (270.59 Mgal/d) of the water withdrawn in the 17-county area was used for irrigation. Over 99 percent of this water was pumped from the Quaternary deposits in four counties along the eastern edge of the 17-county area. This is the only part of the 17-county area where significant irrigation occurs. Rural use accounted for the majority of ground water withdrawn in the remaining counties. Self-supplied industry accounted for only 0.5 percent (1.53 Mgal/d) of the ground water withdrawn in the 17-county area in 1985. Fluctuations in pumpage in each of these categories over the past 25 years are shown in figure 4-5.

Water-use data for the Ozark Plateaus, which are underlain by consolidated rocks, are undifferentiated as to source unit. The uncertainty of source unit occurs because wells in the consolidated rocks are generally uncased, except at the surface. As a result, water withdrawn from a well may have been contributed by any unit exposed to the well bore.

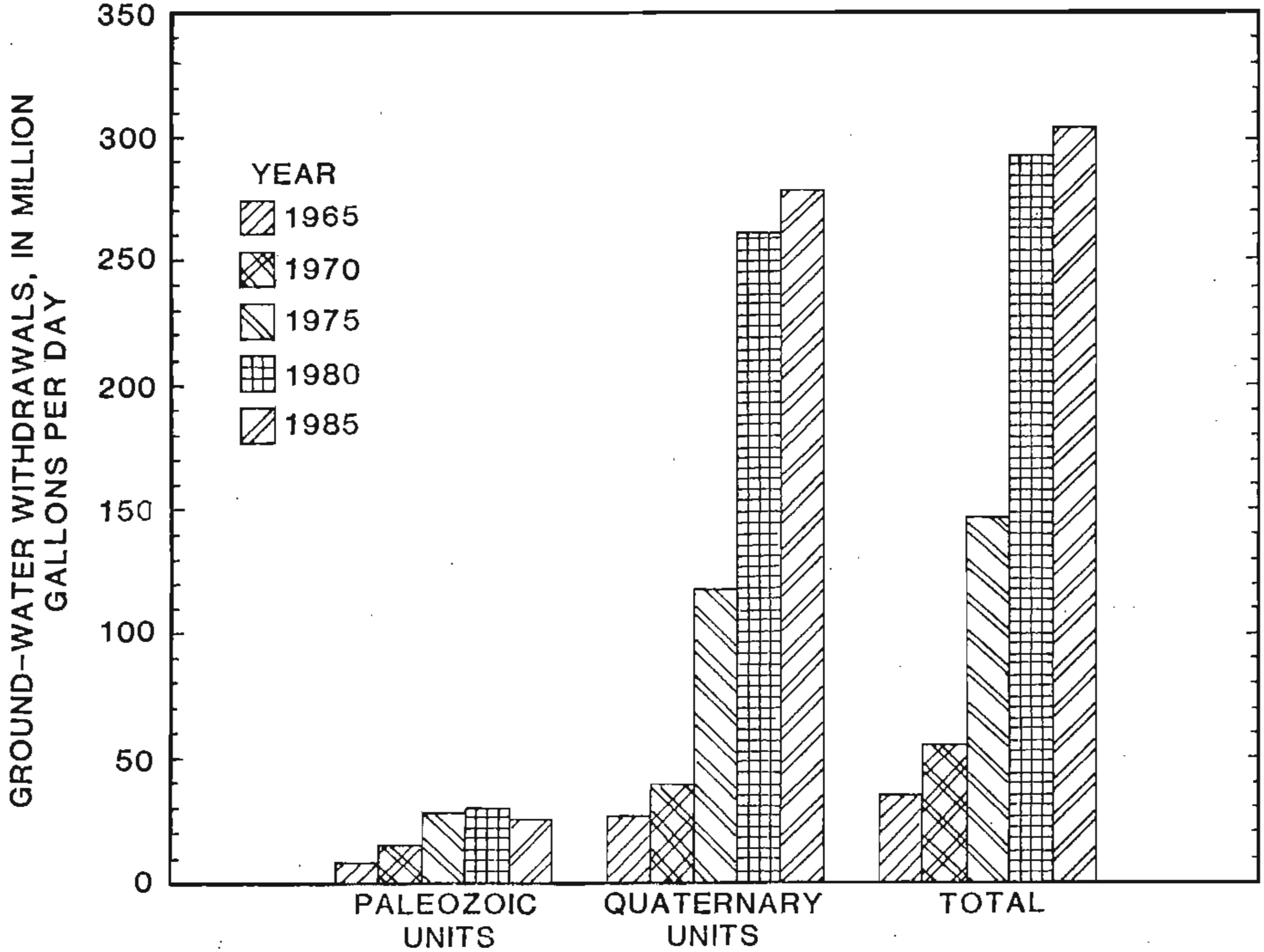

Figure 4-4.--Ground-water withdrawals between 1965 and 1985.

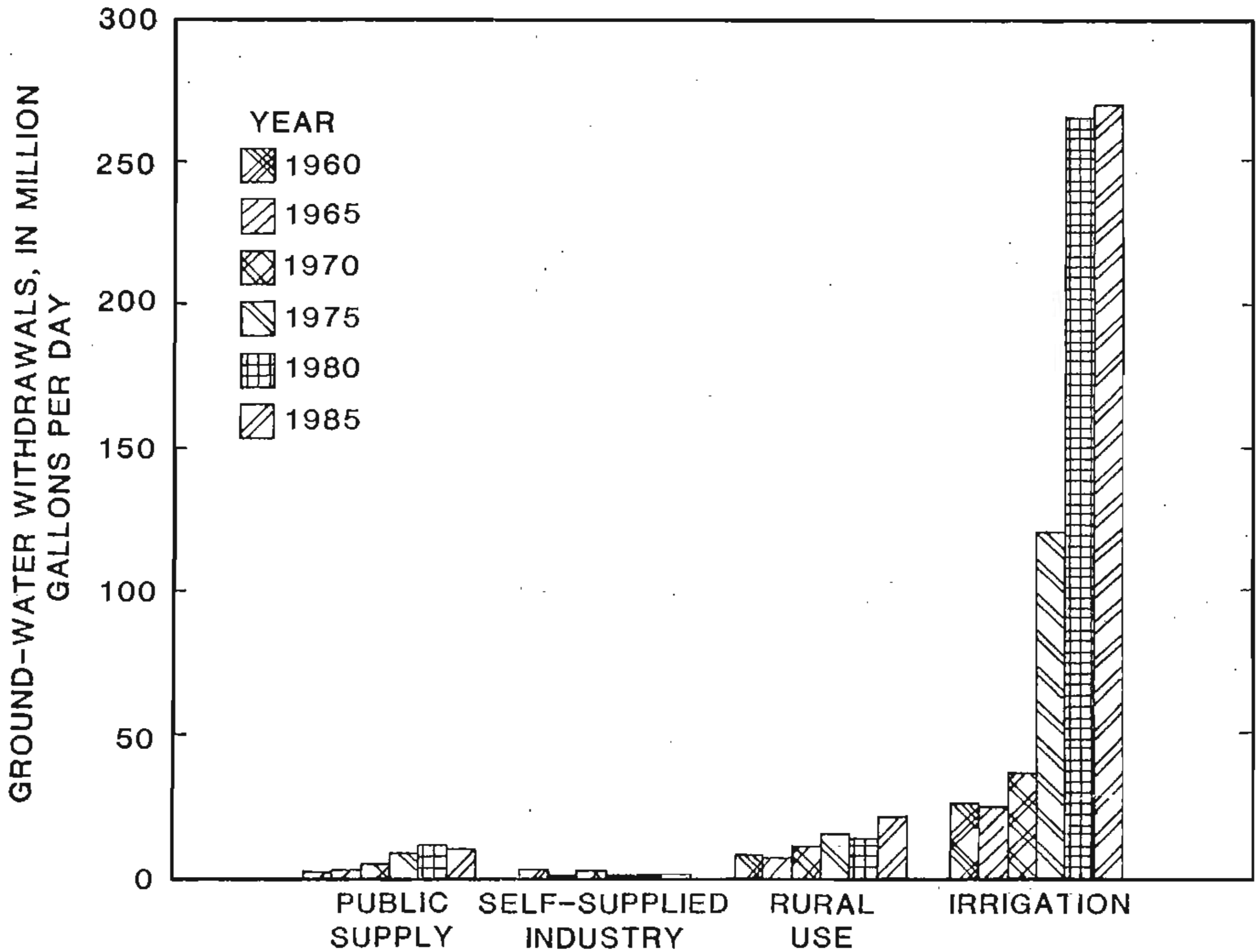

Figure 4-5.--Ground-water withdrawals for each use category between 1960 and 1985.

Ground-water quality in the Ozark Plateaus in the study area is closely related to the mineral content of the Paleozoic geologic units. The ground water at shallow depths in the Plateaus is primarily of the calcium and magnesium bicarbonate type (Lamonds and others, 1969) and generally contains excessive amounts of iron and is very hard (Lamonds, 1972). Ground water in the Plateaus is generally usable without treatment for rural, domestic, and some industrial uses; but requires softening and removal of iron to be made acceptable for municipal supplies and most industrial uses (Lamonds and others, 1969).

The Quaternary deposits of the Mississippi Alluvial Plain yield a hard to very hard, calcium magnesium bicarbonate water (Lamonds and others, 1969). Ground water from these deposits is also characterized by excessive iron concentrations. Locally high chloride concentrations have been observed in ground water from these deposits near Cord and Bald Knob (Bryant and others, 1985).

Ground-water quality data by geologic unit are listed in table 4-5. The recommended limits for several of these constituents, as established under the Safe Drinking Water Act (U.S. Environmental Protection Agency, 1986a; 1986b), can be found in tables 4-6 and 4-7. The Arkansas Department of Health uses the National Primary Standards to set State standards for public water-supply systems.

Table 4-5.—Ground-water quality of geologic units

[Values are means; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

Geologic unit	Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)	Dissolved iron (µg as Fe) (01046)
Quaternary system	17.3	5.0	895	7.2	200	---	168	184	52.2	13.1	2,822
Cretaceous	19.0	---	695	7.7	450	---	368	390	85.0	42.0	---
Paleozoic rocks, undifferentiated	16.4	3.3	460	7.3	235	1	187	206	59.0	14.2	43
Gunter	16.2	4.1	440	7.8	264	0	225	190	42.4	22.6	504
Roubidoux	15.5	5.3	420	7.8	288	0	231	248	50.7	26.3	56
Eminence Potosi	---	5.0	450	8.0	255	0	212	258	39.2	52.5	30

Geologic unit	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Quaternary system	23.0	0.75	2.77	[a]202.5	22.1	0.17	30.4	290	1.46
Cretaceous	32.0	.70	2.10	18.0	56.0	.10	16.0	447	0.
Paleozoic rocks, undifferentiated	14.8	.66	2.52	14.8	20.9	.22	11.3	310	1.52
Gunter	21.4	1.57	2.44	12.1	15.5	.45	9.6	294	1.19
Roubidoux	14.4	.55	2.21	11.2	18.6	.71	8.2	266	2.79
Eminence Potosi	8.7	.27	1.90	13.2	17.5	.24	9.9	270	3.01

[a] The median value was 18 mg/L, and more than 75 percent of the values are less than 100 mg/L.

Table 4-6.--National interim primary drinking-water regulations[1]

[Data in milligrams per liter; tu = turbidity; pCi/L = picocurie per liter; mrem = millirem (one thousandths of a rem)]

Constituent	Maximum concentration
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10
Selenium	0.01
Silver	0.05
Fluoride	4.0
Turbidity	1.5 tu
Coliform bacteria	1/100 mL (mean)
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP (silvex)	0.01
Total trihalomethanes [The sum of the concentrations of bromodichloromethane, dicromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)]	0.10
Radionuclides:	
Radium 226 and 228 (combined)	5 pCi/L
Gross alpha particle activity	15 pCi/L
Gross beta particle activity	4 mrem/year

[1]U.S. Environmental Protection Agency, 1986a

Table 4-7.--National secondary drinking-water regulations[1]

[Data in milligrams per liter unless otherwise specified]

Constituent	Maximum level
Chloride	250
Color	15 color units
Copper	1
Corrosivity	Noncorrosive
Dissolved solids	500
Foaming agents	0.5
Iron	300 µg/L
Manganese	0.05
Odor	3 (threshold odor number)
pH	6.5-8.5 units
Sulfate	250
Zinc	5

[1]Modified from U.S. Environmental Protection Agency, 1986b

SIGNIFICANT WATER-BEARING UNITS

Eminence-Potosi Formations

Geology

These formations are undifferentiated and occur only in the subsurface at a depth of approximately 2,000 ft below land surface. The Eminence Formation marks the top of the Cambrian section in Arkansas. These formations consist of over 300 ft of light-colored, crystalline dolomite with some associated chert.

Hydrology

The Eminence-Potosi Formations are an important source of ground water in southern Missouri, but are relatively unused in Arkansas because of the availability of water from the overlying Roubidoux Formation and Gunter Sandstone. Only a few wells in the study area are producing from these formations. Melton (1976) reports a well producing from the Eminence-Potosi Formations in Benton County with a yield of 230 gal/min. U.S. Geological Survey files contain the record of two additional wells in Carroll and Boone Counties, each with a yield of approximately 260 gal/min. These two wells range in depth from 1,400 to 2,100 ft. This information suggests that the Eminence-Potosi Formations can yield usable amounts of water in the northwestern portion of the study area in Benton, Carroll, and Boone Counties. Elsewhere, these formations contain saline water or are inaccessible because of their great depth.

Very little information exists concerning exactly which horizons in the Eminence-Potosi Formations yield water. Melton (1976) maintains that production is from the Potosi, the lower of the two formations. This assertion is supported by the fact that many wells penetrate the top of the Eminence without any increase in yield. In addition, in southern Missouri, where water from these formations is heavily used, the Potosi yields up to 20 times as much water as the Eminence.

Water levels in wells tapping the Eminence-Potosi Formations have increased as much as 190 ft between 1981 and 1986. These large increases are indicative of the extreme variability in water levels in these formations. Depth to water ranges from 210 to 450 ft below land surface depending on the altitude of the well.

All available water-quality data for the Eminence-Potosi Formations are summarized in table 4-8. The tabulation includes six sample analyses from Benton, Boone, and Carroll Counties. The limited number and distribution of samples precludes an accurate evaluation of the quality of water from the Eminence-Potosi Formations throughout the whole study area. However, these data do indicate that the water quality is good in at least some areas in the northwestern part of the study area. The only constituent exceeding or approaching National Primary Drinking Regulations (U.S. Environmental Protection Agency, 1987a) is nitrate. One sample showed nitrate levels at the limit, 10 mg/L as nitrogen, but other samples showed little or no nitrate, indicating that high nitrate levels probably are local problems that do not occur throughout the entire extent of the aquifer.

Table 4-8.--Eminence-Potosi Formations ground-water quality

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Benton	No. samples	0	1	1	2	1	1	1	3	3	2
	Minimum	—	5	450	7.6	220	0	184	180	37.0	21.0
	Maximum	—	5	450	7.8	220	0	184	680	43.0	140.0
	Mean	—	5	450	7.7	220	0	184	347	40.0	80.5
Boone	No. samples	0	1	0	1	1	1	1	2	1	1
	Minimum	—	5	—	8.1	290	0	240	120	49.0	30.0
	Maximum	—	5	—	8.1	290	0	240	250	49.0	30.0
	Mean	—	5	—	8.1	290	0	240	185	49.0	30.0
Carroll	No. samples	0	0	0	1	0	0	0	1	1	1
	Minimum	—	—	—	8.4	—	—	—	140	27.0	19.0
	Maximum	—	—	—	8.4	—	—	—	140	27.0	19.0
	Mean	—	—	—	8.4	—	—	—	140	27.0	19.0

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Benton	No. samples	1	1	1	1	3	3	2	1	1	3
	Minimum	20.0	12.0	0.4	1.9	21.0	13.0	0.20	9.9	222.0	0.0
	Maximum	20.0	12.0	.4	1.9	25.0	19.0	.38	9.9	222.0	10.0
	Mean	20.0	12.0	.4	1.9	22.7	16.0	.29	9.9	222.0	3.4
Boone	No. samples	1	1	1	0	2	2	2	0	1	2
	Minimum	40.0	11.0	.3	—	2.5	20.0	.20	—	318.0	.01
	Maximum	40.0	11.0	.3	—	5.0	21.0	.23	—	318.0	5.00
	Mean	40.0	11.0	.3	—	3.8	20.5	.22	—	318.0	2.51
Carroll	No. samples	0	1	1	0	1	1	1	0	0	0
	Minimum	—	3.0	.1	—	3.5	16.0	.20	—	—	—
	Maximum	—	3.0	.1	—	3.5	16.0	.20	—	—	—
	Mean	—	3.0	.1	—	3.5	16.0	.20	—	—	—

Gasconade-Van Buren Formations

Geology

These Ordovician age formations are undifferentiated in Arkansas, and consist chiefly of light-colored, vuggy dolomites with associated chert. The only exception to this description is the Gunter Sandstone member at the base of the Gasconade-Van Buren Formations which has been described as both a dolomitic sandstone (Melton, 1976) and a sandy dolomite (Caplan, 1960). The Gasconade-Van Buren Formations are from approximately 300 to 600 ft thick excluding the Gunter member, which ranges in thickness from 20 to 100 ft (fig. 4-6).

Hydrology

Most of the water withdrawn from the Gasconade-Van Buren interval is from the basal Gunter Sandstone member. Yields of wells tapping the Gunter member ine the study area average greater than 100 gal/min, with yields locally of over 500 gal/min (Melton, 1976). The vuggy dolomites that make up the rest of the interval yield water in smaller quantities (Caplan, 1960). Recent measurements (1987) indicate that water levels in the Gunter Sandstone range from 14 to 485 ft below land surface (Freiwald and Plafcan, 1987). Water levels vary greatly from year to year in the Gunter. Water-level changes of over 60 ft occurred in three wells in the basin between 1985 and 1986 (Edds and Remsing, 1986). The rate of change of water levels also varies areally. While some wells have water levels almost 100 ft higher in 1986 than 1981, others show declines of over 40 ft during the same 5-year period (Edds and Remsing, 1986). The variation in water levels is believed to be related to temporal variations in pumpage from the formation.

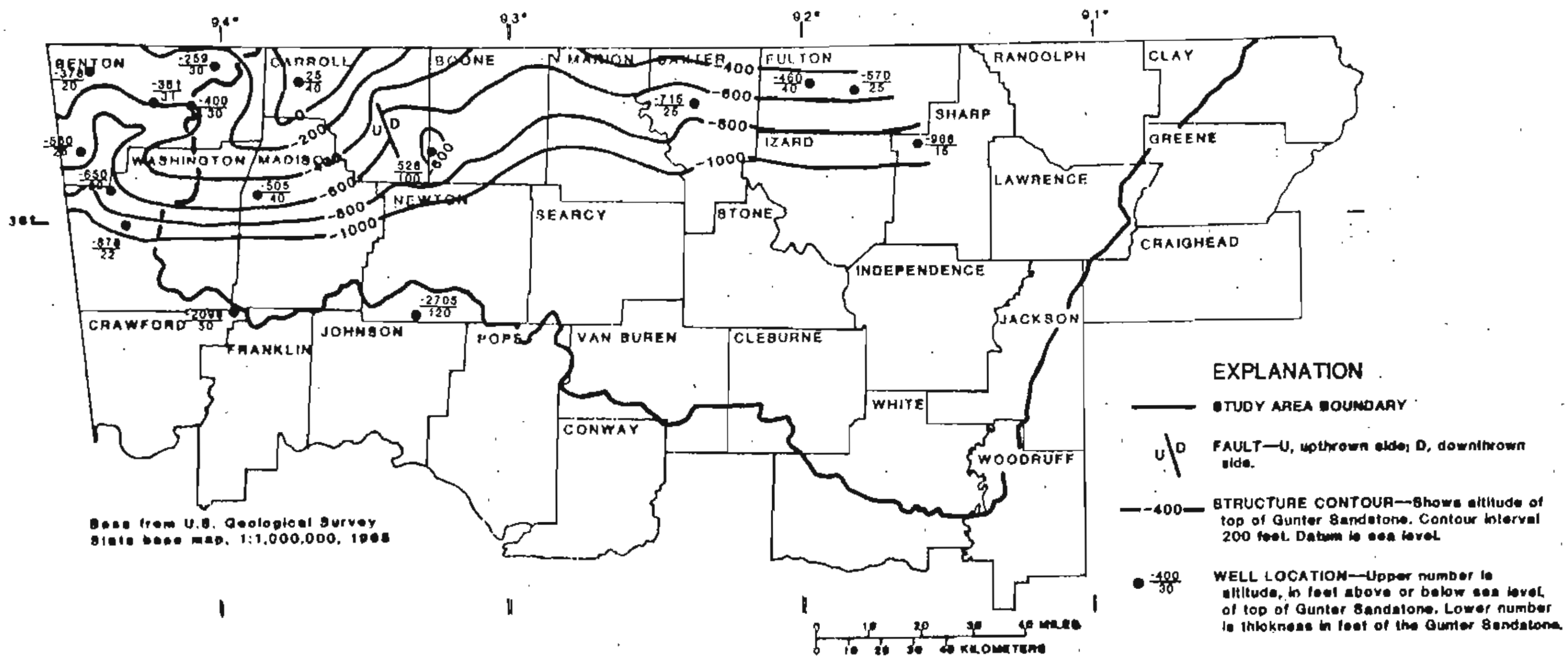

Figure 4-6.--Structure of the top of the Gunter Sandstone (modified from Lamonds, 1972).

Analyses of samples from wells penetrating the Gunter Sandstone member show that water in this unit is a hard to very hard, calcium magnesium bicarbonate water. A summary of the available water-quality data can be found in table 4-9. With the exception of the iron concentrations in Baxter County, the quality of water from the Gunter is well within the limits established by drinking water standards.

Table 4-9.—Gasconade Formation, Gunter Sandstone member ground-water quality

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Baxter	No. samples	0	0	0	1	1	0	0	2	2	2
	Minimum	—	—	—	7.5	380	—	—	260	50.0	33.0
	Maximum	—	—	—	7.5	380	—	—	290	60.0	35.0
	Mean	—	—	—	7.5	380	—	—	275	55.0	34.0
Benton	No. samples	0	1	0	0	0	0	0	1	1	1
	Minimum	—	5	—	—	—	—	—	170	37.0	18.0
	Maximum	—	5	—	—	—	—	—	170	37.0	18.0
	Mean	—	5	—	—	—	—	—	170	37.0	18.0
Boone	No. samples	1	1	2	4	4	4	4	5	4	4
	Minimum	16.0	2	353	7.3	210	0	170	36	33.0	19.0
	Maximum	16.0	2	370	8.1	220	0	182	190	42.0	22.0
	Mean	16.0	2	362	7.7	215	0	175	149	39.3	20.3
Carroll	No. samples	0	1	0	2	0	0	0	4	2	2
	Minimum	—	5	—	8.2	—	—	—	150	34.0	16.0
	Maximum	—	5	—	8.4	—	—	—	230	48.0	27.0
	Mean	—	5	—	8.3	—	—	—	195	41.0	21.5
Fulton	No. samples	3	3	4	4	2	2	4	4	4	4
	Minimum	15.0	0	428	7.7	290	0	234	23	6.2	1.8
	Maximum	18.0	2	479	8.2	320	0	270	250	52.0	29.0
	Mean	16.7	1	452	7.9	305	0	250	186	38.8	21.5
Madison	No. samples	0	2	0	0	0	0	0	2	1	1
	Minimum	—	5	—	—	—	—	—	130	34.0	19.0
	Maximum	—	5	—	—	—	—	—	160	34.0	19.0
	Mean	—	5	—	—	—	—	—	145	34.0	19.0
Marion	No. samples	0	0	0	1	0	0	0	1	1	1
	Minimum	—	—	—	7.7	—	—	—	280	58.0	33.0
	Maximum	—	—	—	7.7	—	—	—	280	58.0	33.0
	Mean	—	—	—	7.7	—	—	—	280	58.0	33.0
Newton	No. samples	0	2	0	1	0	0	0	3	2	2
	Minimum	—	5	—	7.5	—	—	—	130	37.0	18.0
	Maximum	—	5	—	7.5	—	—	—	230	54.0	23.0
	Mean	—	5	—	7.5	—	—	—	177	45.5	20.5
Searcy	No. samples	1	0	1	1	0	0	1	1	1	1
	Minimum	15.0	—	550	7.7	—	—	320	180	44.0	18.0
	Maximum	15.0	—	550	7.7	—	—	320	180	44.0	18.0
	Mean	15.0	—	550	7.7	—	—	320	180	44.0	18.0
Sharp	No. samples	0	0	0	0	0	0	0	2	1	1
	Minimum	—	—	—	—	—	—	—	260	52.0	30.0
	Maximum	—	—	—	—	—	—	—	280	52.0	30.0
	Mean	—	—	—	—	—	—	—	270	52.0	30.0
Stone	No. samples	0	1	0	0	0	0	0	1	1	1
	Minimum	—	10	—	—	—	—	—	130	28.0	15.0
	Maximum	—	10	—	—	—	—	—	130	28.0	15.0
	Mean	—	10	—	—	—	—	—	130	28.0	15.0

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Baxter	No. samples	1	2	2	1	2	2	2	0	1	0
	Minimum	3,600	1.0	0.00	6.1	2.8	14.0	0.20	—	370.0	—
	Maximum	3,600	5.0	.10	6.1	3.0	14.0	1.00	—	370.0	—
	Mean	3,600	3.0	.05	6.1	2.9	14.0	.60	—	370.0	—
Benton	No. samples	0	0	0	0	1	1	1	0	0	1
	Minimum	—	—	—	—	7.5	16.0	0.32	—	—	0.02
	Maximum	—	—	—	—	7.5	16.0	0.32	—	—	.02
	Mean	—	—	—	—	7.5	16.0	0.32	—	—	.02
Boone	No. samples	2	2	2	2	5	4	5	2	1	3
	Minimum	40	3.3	0.10	1.60	1.3	7.70	0.10	8.50	216.0	0.00
	Maximum	1,100	5.1	.20	1.70	9.4	20.00	.50	8.80	216.0	.23
	Mean	570	4.2	.15	1.65	3.7	14.18	.28	8.65	216.0	.11
Carroll	No. samples	0	2	2	0	4	4	3	0	0	2
	Minimum	—	2.0	0.10	—	2.2	11.0	0.20	—	—	1.10
	Maximum	—	2.0	.10	—	4.0	24.00	.20	—	—	5.00
	Mean	—	2.0	.10	—	3.0	16.00	.20	—	—	3.05
Fulton	No. samples	4	4	4	4	4	4	4	4	4	0
	Minimum	0	1.2	0.00	0.7	1.6	2.00	0.00	8.40	205.0	—
	Maximum	17	170.0	16.00	3.2	74.0	8.20	.40	11.00	453.0	—
	Mean	[a] 9	43.7	4.00	1.5	20.1	4.45	[b] .16	9.45	285.3	—
Madison	No. samples	1	0	0	0	2	2	2	0	0	2
	Minimum	2	—	—	—	3.0	20.00	0.22	—	—	0.23
	Maximum	2	—	—	—	110.0	49.00	3.20	—	—	4.00
	Mean	2	—	—	—	56.5	34.50	1.71	—	—	2.12
Marion	No. samples	0	0	0	0	1	1	1	0	0	1
	Minimum	—	—	—	—	9.2	7.0	0.20	—	—	0.07
	Maximum	—	—	—	—	9.2	7.0	.20	—	—	.07
	Mean	—	—	—	—	9.2	7.0	.20	—	—	.07
Newton	No. samples	1	0	0	0	2	3	3	0	0	3
	Minimum	70	—	—	—	3.6	17.00	0.21	—	—	0.20
	Maximum	70	—	—	—	12.0	28.00	.85	—	—	.68
	Mean	70	—	—	—	7.8	23.33	.44	—	—	.43
Searcy	No. samples	1	1	1	1	1	1	1	1	1	0
	Minimum	190	53.0	2.0	4.1	17.0	17.00	0.80	12.0	330.0	—
	Maximum	190	53.0	2.0	4.1	17.0	17.00	.80	12.0	330.0	—
	Mean	190	53.0	2.0	4.1	17.0	17.00	.80	12.0	330.0	—
Sharp	No. samples	0	0	1	0	2	2	1	0	0	0
	Minimum	—	11.0	0.3	—	1.5	3.0	0.20	—	—	—
	Maximum	—	11.0	.3	—	3.0	16.0	.20	—	—	—
	Mean	—	11.0	.3	—	2.3	9.50	.20	—	—	—
Stone	No. samples	0	0	0	0	1	1	1	0	0	1
	Minimum	—	—	—	—	2.5	22.00	0.76	—	—	3.40
	Maximum	—	—	—	—	2.5	22.00	.76	—	—	3.40
	Mean	—	—	—	—	2.5	22.00	.76	—	—	3.40

[a] This mean value included one <10 value that was changed to 5.0.
[b] This mean value included one <0.1 value that was changed to 0.05.

Roubidoux Formation

Geology

The Roubidoux Formation, of Ordovician age, exists only in the subsurface in the study area. It crops out in southern Missouri and dips to the south (fig. 4-7). The Roubidoux ranges from approximately 130 to 455 ft in thickness and consists chiefly of dolomite, sandstone, and chert (Caplan, 1960). The top of the formation ranges from 1,100 ft below land surface near the Arkansas-Missouri State line to about 3,500 ft below land surface at the Boston Mountains escarpment.

Hydrology

Recharge to the Roubidoux occurs primarily in the outcrop area in Missouri. The formation can yield as much as 600 gal/min but generally yields less than 150 gal/min.

The hydrograph of a well completed in the Roubidoux Formation (fig. 4-8), owned by the city of Yellville, indicates the considerable variability of water levels from year to year. Water levels in other wells completed in the Roubidoux increased by as much as 180 ft and decreased nearly by as much as 28 ft between 1985 and 1986. This variability probably results from changes in pumping. Because of the large temporal variations in depth to water and large spatial variations due to topographic relief, the depth to water can vary greatly. Water levels in the Roubidoux are generally nearest (less than 50 ft) to land surface near the Arkansas-Missouri State line and deepest (more than 200 ft) in wells tapping the Roubidoux on the crest of the Boston Mountains.

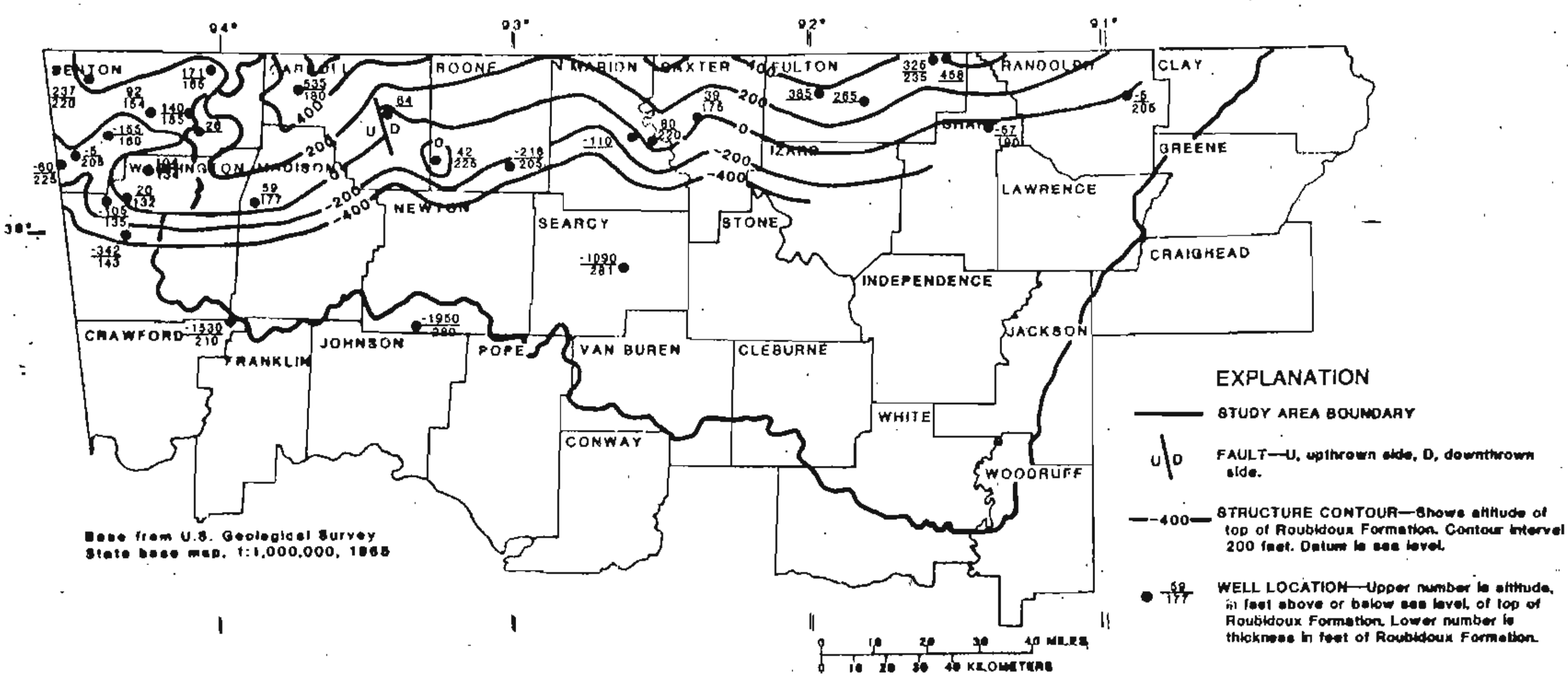

Figure 4-7.--Structure of the top of the Roubidoux Formation (modified from Lamonds, 1972).

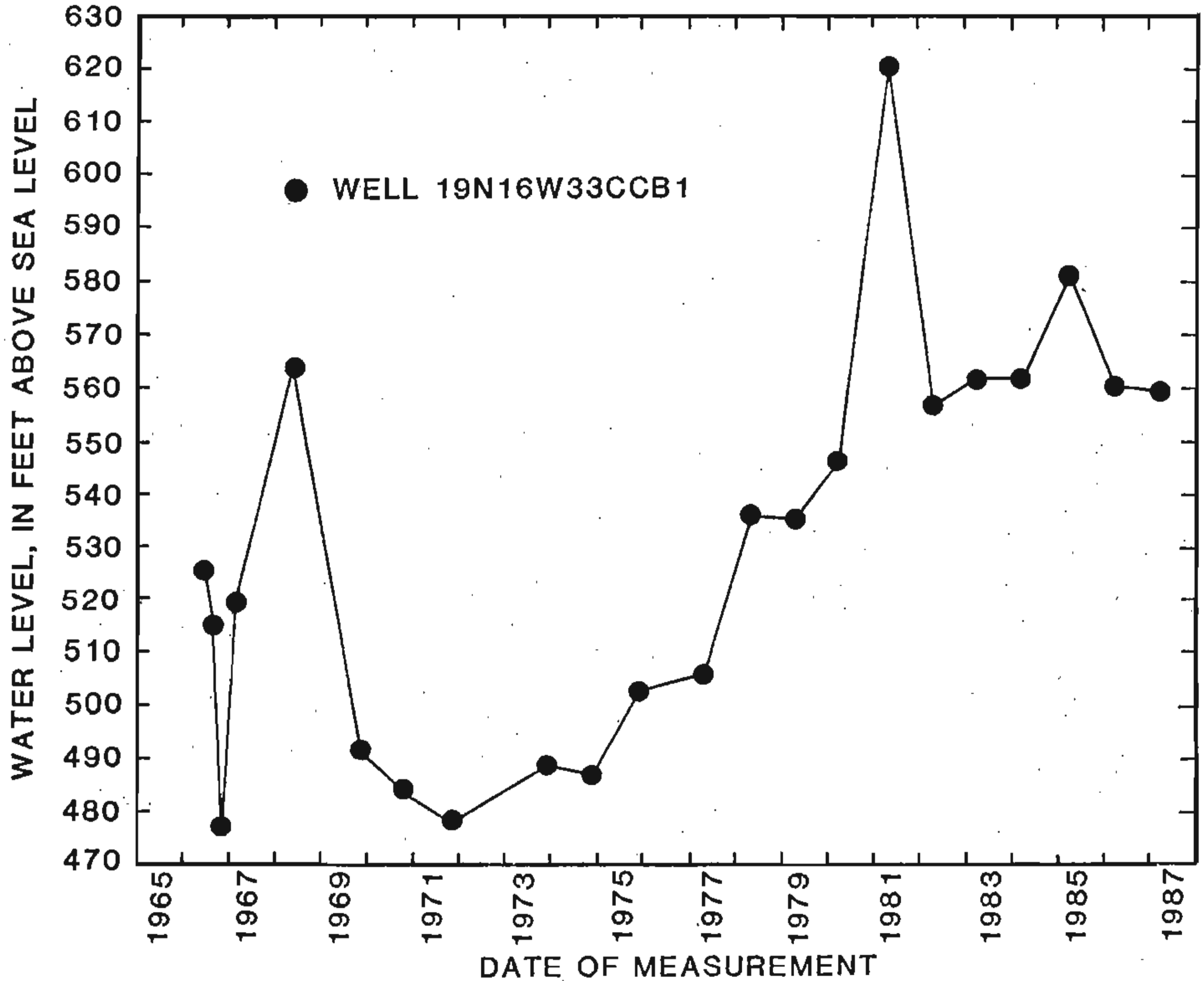

Figure 4-8.--Hydrograph of a well penetrating the Roubidoux Formation near Yellville.

Analysis of samples from the Roubidoux Formation indicate that the water is a hard to very hard calcium magnesium bicarbonate water. A complete summary of the available water quality data can be found in table 4-10. One sample in Baxter County contained an iron concentration exceeding the allowable limit (U.S. Environmental Protection Agency, 1986b), although all other samples from the Roubidoux had iron concentrations well below the limit. Nitrate concentrations exceeding the allowable limit have been found in at least one sample from a well in Marion County, but other samples from the Roubidoux have shown little or no nitrate. This seems to indicate that high nitrate concentrations in ground water from the Roubidoux are a local problem. In general, the Roubidoux Formation will yield good quality freshwater in the northernmost counties in the study area.

Outcropping Paleozoic Units, Undifferentiated

Geology

Paleozoic units ranging in age from Ordovician to Pennsylvanian crop out in the study area. Almost all sedimentary lithologies are represented but limestones and dolomites dominate. These units dip to the south and are overlain by successively younger units in the direction of dip.

Table 4-10.--Roubidoux Formation ground-water quality

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Baxter	No. samples	0	2	0	0	0	0	0	4	2	3
	Minimum	—	5	—	—	—	—	—	100	30.0	6.8
	Maximum	—	20	—	—	—	—	—	400	51.0	21.0
	Mean	—	13	—	—	—	—	—	223	40.5	15.6
Benton	No. samples	0	0	0	1	0	0	0	2	2	2
	Minimum	—	—	—	8.4	—	—	—	110	43.0	1.0
	Maximum	—	—	—	8.4	—	—	—	190	43.0	21.0
	Mean	—	—	—	8.4	—	—	—	150	43.0	11.0
Boone	No. samples	0	0	0	3	3	3	3	3	3	3
	Minimum	—	—	—	7.3	230	0	190.0	210	45.0	25.0
	Maximum	—	—	—	8.1	310	0	250.0	470	50.0	83.0
	Mean	—	—	—	7.8	277	0	227.3	310	48.0	46.0
Carroll	No. samples	0	1	0	1	0	0	0	2	2	2
	Minimum	—	1	—	8.3	—	—	—	250	54.0	28.0
	Maximum	—	1	—	8.3	—	—	—	280	58.0	34.0
	Mean	—	1	—	8.3	—	—	—	265	56.0	31.0
Fulton	No. samples	3	2	4	4	3	3	3	4	4	4
	Minimum	15.0	0	380	7.3	270	0	180.0	190	38.0	22.0
	Maximum	16.0	1	439	7.8	300	0	242.0	240	48.0	35.0
	Mean	15.5	1	422	7.5	287	0	214.3	223	42.5	27.8
Izard	No. samples	0	1	0	1	0	0	0	2	2	1
	Minimum	—	5	—	8.4	—	—	—	270	7.3	33.0
	Maximum	—	5	—	8.4	—	—	—	300	55.0	33.0
	Mean	—	5	—	8.4	—	—	—	285	31.2	33.0
Madison	No. samples	0	1	1	1	1	1	1	1	1	1
	Minimum	—	1	402	8.1	240	0	197.0	140	31.0	14.0
	Maximum	—	1	402	8.1	240	0	197.0	140	31.0	14.0
	Mean	—	1	402	8.1	240	0	197.0	140	31.0	14.0
Marion	No. samples	0	3	2	3	1	1	1	4	3	2
	Minimum	—	1	10	7.4	370	0	301.0	290	58.0	35.0
	Maximum	—	20	634	7.8	370	0	301.0	390	79.0	39.0
	Mean	—	9	322	7.5	370	0	301.0	330	69.0	37.0
Newton	No. samples	0	1	0	1	0	0	0	3	1	1
	Minimum	—	5	—	8.3	—	—	—	110	32.0	14.0
	Maximum	—	5	—	8.3	—	—	—	140	32.0	14.0
	Mean	—	5	—	8.3	—	—	—	127	32.0	14.0
Randolph	No. samples	0	0	0	0	0	0	0	1	0	0
	Minimum	—	—	—	—	—	—	—	320	—	—
	Maximum	—	—	—	—	—	—	—	320	—	—
	Mean	—	—	—	—	—	—	—	320	—	—
Searcy	No. samples	1	2	2	2	2	2	2	2	2	2
	Minimum	15.5	0	478	7.3	250	0	207.0	230	67.0	4.9
	Maximum	15.5	7	487	7.5	290	0	239.0	250	91.0	16.0
	Mean	15.5	4	483	7.4	270	0	223.0	240	79.0	10.5
Sharp	No. samples	0	2	1	2	1	1	1	4	3	4
	Minimum	—	4	502	7.9	330	0	272.0	260	46.0	7.6
	Maximum	—	5	502	8.5	330	0	272.0	380	76.0	46.0
	Mean	—	5	502	8.2	330	0	272.0	300	61.7	30.4

Table 4-10.—Roubidoux Formation ground-water quality—Continued

County		Dis-solved iron (µg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Baxter	No. samples	1	1	1	0	5	4	4	0	0	2
	Minimum	300	58.00	3.00	—	2.0	7.0	0.20	—	—	0.20
	Maximum	300	58.00	3.00	—	10.0	52.0	2.00	—	—	.74
	Mean	300	58.00	3.00	—	4.6	25.0	.90	—	—	.47
Benton	No. samples	0	1	1	0	2	2	2	0	1	0
	Minimum	—	8.00	0.30	—	4.0	13.0	0.22	—	202	—
	Maximum	—	8.00	.30	—	17.0	18.0	.51	—	202	—
	Mean	—	8.00	.30	—	10.5	15.5	.37	—	202	—
Boone	No. samples	0	3	3	0	2	3	3	0	0	1
	Minimum	—	1.50	0.00	—	2.0	11.0	0.20	—	—	0.90
	Maximum	—	11.00	.30	—	5.0	40.0	.25	—	—	.90
	Mean	—	7.50	.20	—	3.5	23.7	.23	—	—	.90
Carroll	No. samples	0	1	1	0	2	2	2	0	1	2
	Minimum	—	2.00	0.00	—	2.8	11.0	0.20	—	337	0.04
	Maximum	—	2.00	.00	—	10.0	32.0	.25	—	337	2.30
	Mean	—	2.00	.00	—	6.4	21.5	.23	—	337	1.17
Fulton	No. samples	3	4	4	4	4	4	3	3	4	0
	Minimum	<10	1.50	0.00	1.3	1.5	1.2	0.00	8.5	185	—
	Maximum	90	1.90	.10	1.9	3.3	2.4	.00	11.0	298	—
	Mean	[a]34	1.73	.05	1.6	2.1	1.8	[b].03	10.2	237	—
Izard	No. samples	0	1	1	0	2	2	2	0	0	1
	Minimum	—	2.00	0.00	—	1.0	12.0	0.2	—	—	0.14
	Maximum	—	2.00	.00	—	2.0	13.0	.2	—	—	.14
	Mean	—	2.00	.00	—	1.5	12.5	.2	—	—	.14
Madison	No. samples	0	1	1	1	1	1	1	1	1	1
	Minimum	—	36.00	1.00	5.2	7.7	14.0	1.2	7.9	214	0.0
	Maximum	—	36.00	1.00	5.2	7.7	14.0	1.2	7.9	214	.0
	Mean	—	36.00	1.00	5.2	7.7	14.0	1.2	7.9	214	.0
Marion	No. samples	2	1	1	1	5	3	3	1	1	4
	Minimum	10	2.50	0.10	3.8	2.5	8.0	0.0	8.5	360	0.05
	Maximum	20	2.50	.10	3.8	10.0	23.0	2.0	8.5	360	29.00
	Mean	15	2.50	.10	3.8	7.2	16.3	.7	8.5	360	9.41
Newton	No. samples	2	1	1	0	3	3	3	0	0	3
	Minimum	1	100.0	4.0	—	41.0	34.0	2.5	—	—	0.40
	Maximum	110	100.0	4.0	—	120.0	44.0	3.2	—	—	.45
	Mean	56	100.0	4.0	—	69.0	38.3	2.9	—	—	.42
Randolph	No. samples	1	0	0	0	1	1	1	0	0	1
	Minimum	30	—	—	—	10.0	25.0	0.2	—	—	4.0
	Maximum	30	—	—	—	10.0	25.0	.2	—	—	4.0
	Mean	30	—	—	—	10.0	25.0	.2	—	—	4.0
Searcy	No. samples	1	2	2	2	2	2	2	2	2	2
	Minimum	10	5.80	0.20	1.0	5.5	16.0	0.1	0.8	286	0.11
	Maximum	10	13.00	.40	2.3	11.0	36.0	.8	9.0	294	.72
	Mean	10	9.40	.30	1.7	8.3	26.0	.5	4.9	290	.42
Sharp	No. samples	1	2	2	1	4	4	4	1	1	4
	Minimum	30	1.10	0.00	1.2	1.0	10.0	0.0	8.7	287	0.03
	Maximum	30	2.00	.10	1.2	6.2	12.0	2.0	8.7	287	8.00
	Mean	30	1.55	.05	1.2	4.1	11.3	.6	8.7	287	2.65

[a] This mean value includes one <10 value that was changed to 5.0.
[b] This mean value includes two <0.1 values that were changed to 0.05.

Hydrology

Ground water in these surficial units occurs mostly in secondary openings such as fractures, joints, bedding planes, and solution channels. These secondary openings are generally larger and more numerous near the surface. Consequently, the quantity of ground water in these units generally decreases with depth (Lamonds, 1972). Wells in these units are generally less than 300 ft deep and yield less than 10 gal/min. The yield of a well depends on the number and size of openings penetrated by the well bore. The depth to water ranges from 5 to 25 ft below land surface and fluctuates primarily in response to variations in precipitation. No long-term water-level declines have been observed. Water levels in these units form a subdued reflection of the land surface, and are closest to the land surface in the valleys (Lamonds, 1972).

Numerous perennial springs issue from the limestone formations, primarily the Boone Formation, in the Springfield-Salem Plateaus. Discharges from the springs range from nearly zero to several hundred gallons per minute. The largest spring is Mammoth Spring which has an average discharge of 330 gal/min and is used as the source of water for the town of Mammoth Springs. Twenty springs in the study area have average discharges greater than 450 gal/min. Many of the smaller springs have been developed as water supplies for rural homes or for livestock. In addition, the discharges from the many springs provide the sustained base flow for several streams in the study area, most notably the Spring River, Strawberry River, Kings River, and Buffalo River.

The outcropping Paleozoic units yield a hard to very hard, calcium bicarbonate water. The quality of this water varies with the lithology of the units, but the water is generally suitable for most uses. Ground-water quality also varies spatially within the units. Local concentrations of dissolved solids, nitrate, chloride, iron, and sulfate may exceed allowable limits in some areas within the study area. Low pH values and color are problems in other areas. These problems are all of a local nature. In most areas, the quality of water from these units is well within the limits established for drinking water standards. Additional quality data are summarized in table 4-11.

Nacatoch Sand

Geology

The Nacatoch Sand crops out along the Fall Line and underlies the Quaternary deposits in the eastern part of the study area. The formation dips to the southeast at the rate of about 40 ft/mi (Lamonds and others, 1969). The Nacatoch Sand consists chiefly of medium-grained glauconitic sand and is as much as 300 ft thick.

Table 4-11.--Outcropping Paleozoic units ground-water quality

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; μg/L = micrograms per liter; μS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (μS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Baxter	No. samples	1	1	1	2	1	1	1	3	3	3
	Minimum	19.0	3	932	7.4	370	40	371	290	56.0	37.0
	Maximum	19.0	3	932	8.7	370	40	371	520	92.0	71.0
	Mean	19.0	3	932	8.1	370	40	371	383	70.3	50.3
Boone	No. samples	118	1	118	118	69	69	115	118	117	117
	Minimum	11.0	5	132	6.2	55	0	45	51	18.0	0.8
	Maximum	24.0	5	790	8.2	410	0	338	390	120.0	50.0
	Mean	15.7	5	417	7.3	200	0	172	197	60.6	10.9
Carroll	No. samples	2	0	2	2	1	1	2	2	2	2
	Minimum	17.0	—	478	7.0	230	0	192	220	58.0	18.0
	Maximum	22.0	—	480	7.5	230	0	202	220	59.0	19.0
	Mean	19.5	—	479	7.3	230	0	197	220	58.5	18.5
Cleburne	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	16.5	5	311	6.3	20	0	16	120	33.0	10.0
	Maximum	16.5	5	311	6.3	20	0	16	120	33.0	10.0
	Mean	16.5	5	311	6.3	20	0	16	120	33.0	10.0
Fulton	No. samples	2	2	2	2	1	1	2	2	2	2
	Minimum	20.0	1	364	6.7	230	0	180	190	39.0	22.0
	Maximum	21.0	3	370	7.8	230	0	185	190	41.0	23.0
	Mean	20.5	2	367	7.3	230	0	183	190	40.0	22.5
Independance	No. samples	14	17	18	18	18	18	18	18	18	18
	Minimum	14.0	0	21	5.4	2	0	2	4	0.5	0.3
	Maximum	17.0	10	3,320	8.5	610	15	502	550	100.0	72.0
	Mean	15.9	4	492	7.2	190	1	158	147	40.0	11.5
Izard	No. samples	0	0	0	1	0	0	0	2	1	1
	Minimum	—	—	—	8.6	—	—	—	190	46.0	24.0
	Maximum	—	—	—	8.6	—	—	—	210	46.0	24.0
	Mean	—	—	—	8.6	—	—	—	200	46.0	24.0
Jackson	No. samples	1	1	1	1	1	1	0	1	1	1
	Minimum	15.5	2	32	5.9	6	0	—	270	110.0	0.3
	Maximum	15.5	2	32	5.9	6	0	—	270	110.0	.3
	Mean	15.5	2	32	5.9	6	0	—	270	110.0	.3
Lawrence	No. samples	4	5	4	4	4	4	4	5	3	5
	Minimum	17.0	0	530	6.9	410	0	335	230	53.0	24.0
	Maximum	21.5	30	700	7.3	500	0	408	420	100.0	40.0
	Mean	20.3	6	614	7.1	450	0	368	350	79.6	36.2
Newton	No. samples	0	1	0	1	0	0	0	2	2	2
	Minimum	—	5	—	8.3	—	—	—	140	48.0	3.9
	Maximum	—	5	—	8.3	—	—	—	150	50.0	7.0
	Mean	—	5	—	8.3	—	—	—	145	49.0	5.5
Randolph	No. samples	8	8	8	8	7	7	8	8	8	8
	Minimum	18.5	0	470	6.9	330	0	272	280	64.0	30.0
	Maximum	23.5	0	780	7.4	470	0	560	500	100.0	59.0
	Mean	20.9	0	580	7.2	414	0	368	371	80.9	41.1
Searcy	No. samples	1	3	3	3	3	3	2	3	3	3
	Minimum	15.0	5	585	7.5	240	0	197	48	9.8	5.7
	Maximum	15.0	7	2,840	8.2	1,720	0	284	400	88.0	43.0
	Mean	15.0	6	1,405	7.8	770	0	241	246	59.9	22.9
Sharp	No. samples	2	1	2	2	2	1	1	2	2	1
	Minimum	9.0	7	419	7.4	200	0	251	190	45.0	11.0
	Maximum	15.0	7	457	7.5	310	0	251	250	82.0	18.0
	Mean	12.0	7	438	7.5	255	0	251	220	63.5	14.5
Van Buren	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	19.0	0	202	6.6	120	0	99	75	15.0	9.1
	Maximum	19.0	0	202	6.6	120	0	99	75	15.0	9.1
	Mean	19.0	0	202	6.6	120	0	99	75	15.0	9.1
White	No. samples	17	1	17	2	1	1	1	2	2	2
	Minimum	17.0	3	62	6.6	86	0	71	54	11.0	6.5
	Maximum	22.0	3	1,260	6.8	86	0	71	120	34.0	9.5
	Mean	18.7	3	500	6.7	86	0	71	87	22.5	8.0

Table 4-11.—Outcropping Paleozoic units ground-water quality—Continued

County		Dissolved iron (μg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Baxter	No. samples	1	2	2	1	3	3	2	1	1	1
	Minimum	150	2.0	0.00	0.90	1.0	9.0	0.20	10.0	612	3.20
	Maximum	150	20.0	0.40	.90	25.0	120.0	.20	10.0	612	3.20
	Mean	150	11.0	0.20	.90	10.3	46.2	.20	10.0	612	3.20
Boone	No. samples	102	117	117	117	118	118	21	20	20	98
	Minimum	1	1.0	0.00	0.05	0.5	1.5	<0.10	8.7	70	<0.04
	Maximum	440	24.0	0.80	9.30	81.0	75.0	.90	14.0	345	11.20
	Mean	[a]21	4.4	0.15	[b]2.33	7.6	[c]14.8	[d].13	10.3	199	[e]1.6
Carroll	No. samples	2	2	2	2	2	2	0	0	0	2
	Minimum	4	6.1	0.20	3.50	6.0	17.0	—	—	—	2.01
	Maximum	8	6.4	0.20	3.90	8.7	17.0	—	—	—	3.24
	Mean	6	6.3	0.20	3.70	7.4	17.0	—	—	—	2.63
Cleburne	No. samples	1	1	1	1	1	2	1	1	1	1
	Minimum	0	4.7	0.20	0.90	2.8	110.0	0.10	10.0	228	0.23
	Maximum	0	4.7	0.20	.90	2.8	110.0	.10	10.0	228	.23
	Mean	0	4.7	0.20	.90	2.8	110.0	.10	10.0	228	.23
Fulton	No. samples	2	2	2	2	2	2	2	2	2	1
	Minimum	4	1.2	0.00	1.4	1.4	0.4	0.10	7.9	181	1.30
	Maximum	1,300	2.0	0.10	1.8	4.1	1.4	.10	11.0	199	1.30
	Mean	652	1.6	0.05	1.6	2.8	.9	.10	9.5	190	1.30
Independence	No. samples	3	17	17	17	17	17	17	17	16	18
	Minimum	20	1.3	0.10	0.20	0.5	0.0	0.00	4.8	24	0.00
	Maximum	200	640.0	21.00	16.00	270.0	1,000.0	.90	24.0	2,480	4.70
	Mean	107	56.1	2.22	3.60	30.0	66.4	.21	11.8	336	1.11
Izard	No. samples	0	1	1	0	2	2	1	0	0	0
	Minimum	—	54.0	2.00	—	5.0	1.0	0.20	—	—	—
	Maximum	—	54.0	2.00	—	9.2	3.0	.20	—	—	—
	Mean	—	54.0	2.00	—	7.1	2.0	.20	—	—	—
Jackson	No. samples	0	1	1	1	1	1	1	1	1	0
	Minimum	—	2.0	0.10	1.10	4.5	1.2	0.00	12.0	27.0	—
	Maximum	—	2.0	.10	1.10	4.5	1.2	.00	12.0	27.0	—
	Mean	—	2.0	.10	1.10	4.5	1.2	.00	12.0	27.0	—
Lawrence	No. samples	0	4	4	4	5	5	5	4	4	5
	Minimum	—	1.3	0.00	1.00	1.4	1.0	0.10	9.1	345	0.00
	Maximum	—	6.7	.10	7.40	20.0	14.0	.30	17.0	433	1.86
	Mean	—	3.5	.08	3.13	6.8	8.7	.20	12.5	386	.63
Newton	No. samples	0	2	2	0	2	2	2	0	0	1
	Minimum	—	7.8	0.30	—	6.5	7.0	0.20	—	—	0.25
	Maximum	—	21.0	.80	—	7.0	10.0	.20	—	—	.25
	Mean	—	14.4	.55	—	6.8	8.5	.20	—	—	.25
Randolph	No. samples	1	8	8	8	8	8	8	8	8	7
	Minimum	200	3.1	0.10	0.90	1.4	1.0	0.10	11.0	324	0.38
	Maximum	200	13.0	.30	3.40	26.0	21.0	.30	20.0	532	4.70
	Mean	200	6.1	.15	1.74	10.4	7.9	.18	13.4	398	2.30
Searcy	No. samples	3	3	3	3	3	3	3	3	3	2
	Minimum	0	11.0	0.20	1.60	17.0	10.0	0.50	2.3	387	0.07
	Maximum	40	700.0	45.00	22.00	100.0	100.0	3.00	9.4	1,770	.09
	Mean	27	241.7	15.20	8.43	45.0	68.7	1.33	5.2	878	.08
Sharp	No. samples	1	2	2	2	2	2	2	2	2	1
	Minimum	0	1.5	0.00	1.00	1.5	4.4	0.10	9.5	238	0.14
	Maximum	0	12.0	.40	1.60	17.0	21.0	.10	9.9	261	.14
	Mean	0	6.8	.20	1.30	9.3	12.7	.10	9.7	250	.14
Van Buren	No. samples	0	1	1	1	1	1	1	1	1	1
	Minimum	—	13.0	0.70	1.00	1.6	4.2	0.20	15.0	121	0.11
	Maximum	—	13.0	.70	1.00	1.6	4.2	.20	15.0	121	.11
	Mean	—	13.0	.70	1.00	1.6	4.2	.20	15.0	121	.11
White	No. samples	2	2	2	1	17	2	1	1	2	1
	Minimum	0	12.0	0.70	1.50	5.0	3.4	0.20	25.0	108	0.43
	Maximum	860	34.0	1.00	1.50	260.0	3.4	.20	25.0	217	.43
	Mean	430	23.0	.85	1.50	56.0	3.4	.20	25.0	163	.43

[a] This mean value includes two <3 values, two <2 values, and two <4 values which were changed to 1.5, 1.0, and 2.0, respectively.
[b] This mean value includes one <1.0 vlaue that was changed to 0.5
[c] This mean value includes 17 values of <3.0 which were changed to 1.5.
[d] This mean value includes 16 values of <0.1 which were changed to 0.05.
[e] This mean value includes 6 values of <0.04 which were changed to 0.02.

Hydrology

The importance of the Nacatoch Sand is in its potential as a source of good quality water. Little is known concerning the hydrologic characteristics of the Nacatoch Sand in the study area, but a study by Boswell and others (1965) indicates that the formation may be a potential source of water in the easternmost counties in the study area. The Nacatoch yields substantial amounts of water in eastern Clay county. Lamonds and others (1969) suggest that a well drilled in Nacatoch downdip from the outcrop area would be artesian and could yield several hundred gallons per minute.

The Nacatoch Sand is not used as a source of ground water in the study area except for domestic wells in its small outcrop area. However, east of the study area, in eastern Clay County, the Nacatoch is used extensively as a source of water for public supply.

Little is known concerning the quality of water in the Nacatoch Sand, but south of the Lawrence-Jackson County line water in the Nacatoch is highly mineralized. Electric logs indicate dissolved-solids concentrations are over 3,000 mg/L in Jackson County (Petersen and others, 1985).

Quaternary Deposits

Geology

The Quaternary deposits in the study area crop out east of the Fall Line and range in thickness from zero at the Fall Line to as much as 155 ft thick at the eastern edge of the basin (Albin and others, 1967). These deposits are chiefly composed of silt and clay to a depth of about 30 ft below land surface, and of sand increasing in coarseness to gravel from the bottom of the clay cap to the base of the unit.

Hydrology

Recharge to Quaternary deposits is principally from precipitation. Wells in Quaternary deposits commonly yield approximately 1,000 gal/min, but yields as high as 2,500 gal/min have been reported.

Water levels in these deposits fluctuate from year to year due to climatic effects, but over a long period of time appear to be relatively constant. Water levels are generally less than 20 ft below land surface. The potentiometric surface in the Quaternary deposits is shown in figure 4-9.

Use of water from the Quaternary deposits in 1985 totaled 278.45 Mgal/d (fig. 4-10). This is over ten times the use in 1965 (25.45 Mgal/d). Almost all of this water was withdrawn for irrigation and rural use. The current withdrawal rate appears to have little long-term effect on water levels in the Quaternary deposits in the study area.

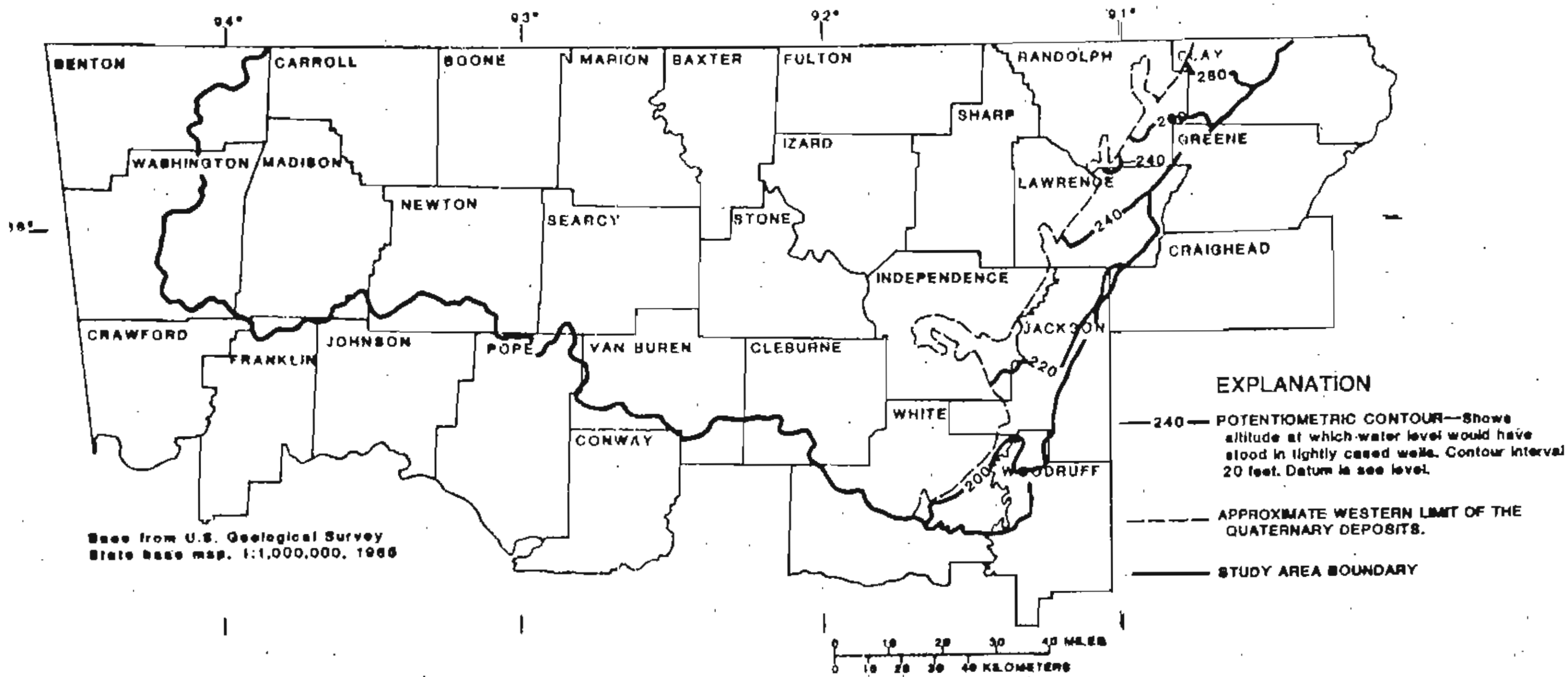

Figure 4-9.--Potentiometric surface in the Quaternary deposits in 1985 (modified from Plafcan and Fugitt, 1987).

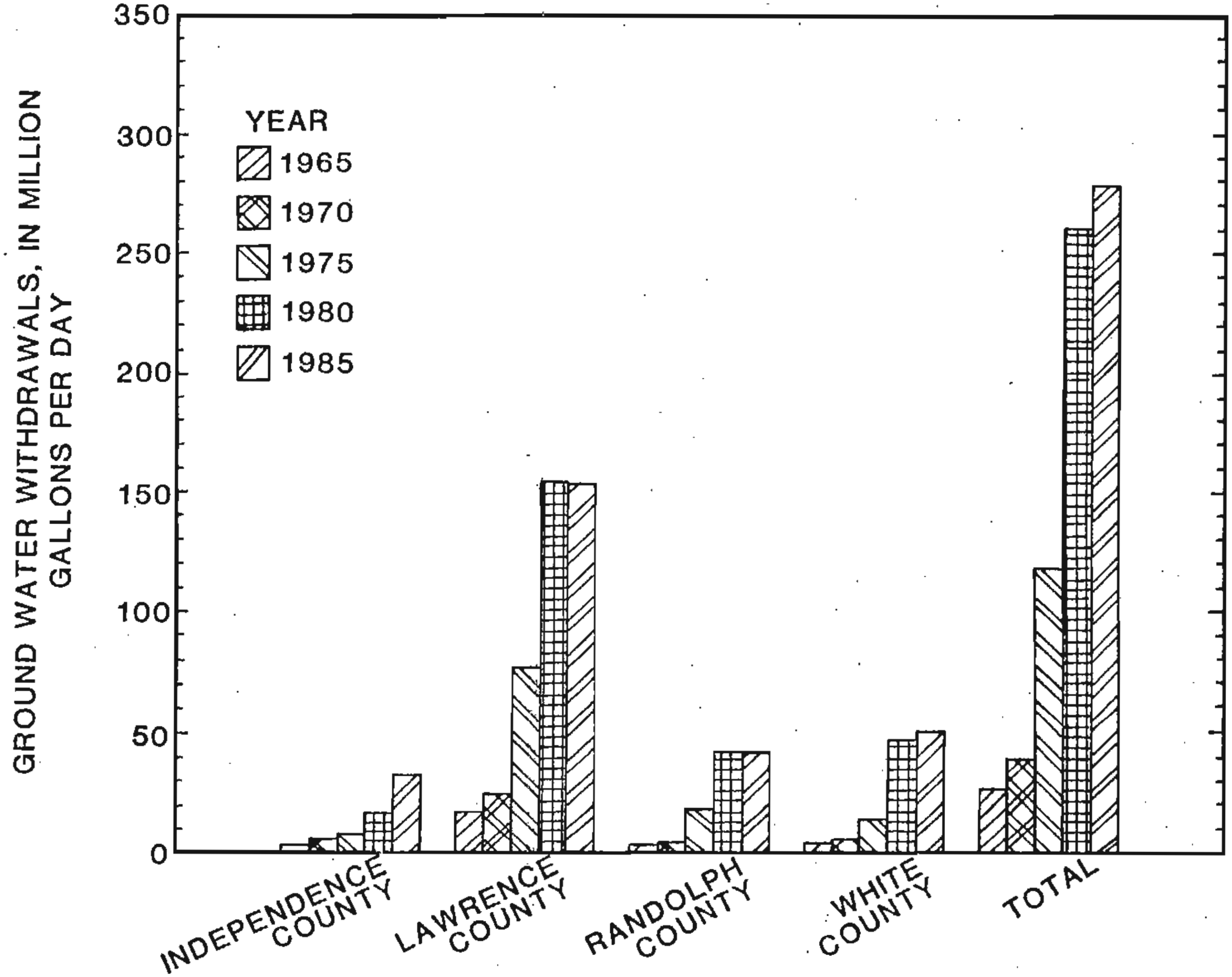

Figure 4-10.--Ground-water withdrawals from Quaternary deposits between 1965 and 1985.

The Quaternary deposits in the study area yield a hard to very hard, calcium magnesium bicarbonate water. Water-quality data for wells tapping Quaternary deposits are summarized in table 4-12. Iron concentrations often exceed the allowable limit, and in some limited areas dissolved solids, nitrate, chloride, and sulfate concentrations may also exceed limits. The water from these deposits is unsuitable for public-supply use without treatment, but it is commonly used without treatment for domestic supply, irrigation, aquaculture, and some industrial purposes (Lamonds and others, 1969).

Table 4-12.—Quaternary deposits ground-water quality

[No. = number; °C = degrees Celsius; pcu = platinum-cobalt units; mg/L = milligrams per liter; µg/L = micrograms per liter; µS = microsiemens per centimeter at 25 degrees Celsius]

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Clay	No. samples	8	7	10	9	9	9	9	8	8	8
	Minimum	15.0	1	146	7.1	66	0	54	56.0	15	4.5
	Maximum	16.5	10	694	7.8	290	0	238	230.0	69	15.0
	Mean	15.6	5	381	7.4	200	0	163	159.5	48	9.7
Greene	No. samples	2	0	2	0	0	0	0	0	0	0
	Minimum	15.5	—	420	—	—	—	—	—	—	—
	Maximum	15.5	—	500	—	—	—	—	—	—	—
	Mean	15.5	—	460	—	—	—	—	—	—	—
Independence	No. samples	15	4	15	5	5	5	4	4	4	4
	Minimum	15.0	0	302	6.8	110	0	87	98.0	25	8.6
	Maximum	18.0	5	2,750	8.0	360	0	292	360.0	89	33.0
	Mean	16.2	2	854	7.4	282	0	224	244.5	65	20.1
Jackson	No. samples	28	16	32	25	24	23	24	22	21	21
	Minimum	15.5	0	128	6.5	28	0	33	55.0	11	6.6
	Maximum	18.5	8	600	8.0	300	0	244	270.0	78	18.0
	Mean	16.5	3	381	7.3	176	0	161	161.9	47	10.9
Lawrence	No. samples	19	16	28	22	20	20	21	20	20	20
	Minimum	15.0	0	263	6.7	120	0	100	130.0	37	7.1
	Maximum	23.5	30	1,030	8.0	450	0	369	530.0	150	45.0
	Mean	17.3	7	472	7.4	252	0	206	231.5	67	15.8
Randolph	No. samples	12	8	11	8	9	9	9	9	9	9
	Minimum	14.5	1	170	6.2	30	0	25	50.0	12	4.8
	Maximum	22.5	7	460	7.9	270	0	221	210.0	64	19.0
	Mean	17.1	3	348	7.1	169	0	138	148.6	40	11.6
White	No. samples	46	10	48	11	11	11	11	11	11	11
	Minimum	16.0	3	66	5.1	6	0	5	17.0	4	0.8
	Maximum	25.0	13	10,200	8.2	450	0	366	600.0	150	53.0
	Mean	18.5	6	1,793	6.9	177	0	145	194.6	51	15.8
Woodruff	No. samples	2	1	3	3	3	3	3	3	3	3
	Minimum	17.0	13	143	6.7	68	0	56	58.0	16	4.5
	Maximum	17.0	13	207	7.7	120	0	97	99.0	29	6.4
	Mean	17.0	13	166	7.3	88	0	72	73.7	21	5.4

Table 4-12.—Quaternary deposits ground-water quality—Continued

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Clay	No. samples	7	8	8	8	8	8	8	8	9	6
	Minimum	30	4.6	0.20	1.40	2.70	0.0	0.00	14.0	114	0.00
	Maximum	5,000	54.0	2.00	3.10	74.00	36.0	.20	40.0	406	.41
	Mean	2,653	19.5	.74	2.36	20.21	12.5	.15	28.9	238	.08
Greene	No. samples	0	0	0	0	0	0	0	0	0	0
	Minimum	—	—	—	—	—	—	—	—	—	—
	Maximum	—	—	—	—	—	—	—	—	—	—
	Mean	—	—	—	—	—	—	—	—	—	—
Independence	No. samples	3	4	4	4	14	4	4	4	4	3
	Minimum	10	5.0	0.10	0.80	5.50	10.0	0.10	15.0	177	0.00
	Maximum	4,700	430.0	10.00	21.00	700.00	31.0	1.10	22.0	1,460	2.10
	Mean	2,170	116.8	2.85	7.83	142.25	16.3	.43	18.5	564	1.02
Jackson	No. samples	20	23	21	21	26	22	21	21	23	18
	Minimum	30	6.0	0.20	1.00	2.50	0.0	0.00	8.7	157	0.00
	Maximum	20,000	29.0	1.00	4.50	35.00	65.0	.30	46.0	362	8.60
	Mean	4,262	13.9	.50	2.11	10.31	20.3	.17	33.6	243	1.06
Lawrence	No. samples	20	23	20	20	23	20	20	20	23	14
	Minimum	20	3.7	0.10	1.10	1.10	1.6	0.00	6.4	178	0.00
	Maximum	13,000	42.0	1.00	21.00	70.00	270.0	.40	42.0	737	10.00
	Mean	2,458	13.5	.38	3.10	14.05	34.3	.16	31.2	311	.78
Randolph	No. samples	9	8	8	8	9	9	8	8	8	8
	Minimum	0	6.9	0.20	1.00	2.50	1.8	0.00	19.0	153	0.00
	Maximum	20,000	27.0	1.00	3.80	28.00	43.0	.20	43.0	316	6.10
	Mean	4,943	12.8	.51	1.74	14.02	14.8	.10	32.9	227	2.08
White	No. samples	11	11	11	3	48	11	3	3	11	11
	Minimum	0	5.1	0.50	2.50	4.80	0.6	0.10	5.6	48	0.00
	Maximum	620	100.0	3.00	3.70	3,000.00	100.0	.20	25.0	1,010	38.00
	Mean	114	42.4	1.46	3.07	492.62	21.9	.13	15.5	376	3.79
Woodruff	No. samples	3	3	3	3	3	3	3	3	3	3
	Minimum	140	4.4	0.20	1.00	2.50	8.2	0.00	21.0	112	0.02
	Maximum	350	7.0	.30	2.40	4.20	12.0	.30	43.0	152	.14
	Mean	280	5.3	.27	1.93	3.07	10.1	.13	30.7	125	.07

Future Ground Water Use (Corps of Engineers)

Ground water use is predicted to increase during the period 1985 to 2030. Overall ground water use is projected to increase 90 percent, from 303.9 million gallons per day to 576.9 million gallons per day. The ground water use category predicted to increase the greatest is irrigation which will increase from 270.6 million gallons per day to 503.1 million gallons per day or an increase of 86 percent. The ground water use category with the greatest percent increase is public supply category which is projected to have a 261 percent increase during the period 1985 to 2030. See Table 4-13 for the ground water use projections in the Upper White River Basin.

Public Supply use of ground water is projected to increase to 22.2 million gallons per day by 2000 and 36.8 million gallons per day by 2030. This is an overall increase of 261 percent. The aquifers providing the increased public supplies will be the Roubidoux Formation-Gasconade Dolomite-Gunter Sandstone aquifer and the Quaternary aquifer to a lesser extent. Due to the expense of drilling deep wells to reach high yield formations in the Interior Highlands, a greater quantity of surface water will be utilized to meet the basin's need.

TABLE 4-13 GROUND WATER USE PROJECTIONS

Use	1985 1/	2000 2/	2030 2/
Public Supply	10.2	22.2	36.8
Self-Supplied			
Industry	1.6	1.5	1.3
Rural Use	21.5	20.3	35.7
Irrigation 3/	270.6	476.7	503.1
Total	303.9	520.2	576.9

1/ Holland, 1987

2/ Adapted from Arkansas Soil and Conservation Commission data

3/ Includes Fish and Minnow Farms and Other Crops irrigation

Self-Supplied Industry use of ground water is predicted to show a 19 percent increase. Use of ground water is expected to show a gradual decline thoughout the period 1985 to 3020.

Ground water use for Rural Use is predicted to increase to 20.3 million gallons per day by 2000 and to 35.7 million gallons per day or an overall increase of 66 percent. The ground water source of Rural Use supplies will be the shallower formations of the Rocks of Paleozoic Age.

Irrigation ground water use is projected to increase from 270.6 million gallons per day in 1985 to 476.7 million gallons per day in 2000 and eventually, to 503.1 million gallons per day in 2030. This is an overall increase of 86 percent. The reason for this increase is the irrigated cropland is projected to increase from 136,964 acres in 1980 to 397,100 acres in 2030. Supplemental irrigation for cotton and soybeans is projected to increase significantly. The source of the additional irrigation water will be the Quaternary alluvial aquifer.

GROUND-WATER PROBLEMS

The most pervasive ground-water problems in the study area are low yields and poor water quality. In many areas there are no viable ground-water sources for public supply, either because insufficient quantities are available or the quality of the available water is too poor for use without treatment.

Quantity

Shallow wells in the Ozark Plateaus commonly yield less than 10 gal/min. Much deeper and more expensive wells can yield up to 500 gal/min in the northernmost counties in the study area. Only these deeper wells can yield adequate amounts of water to public-supply systems. East of the Fall Line in the study area, Quaternary deposits yield up to 2,500 gal/min in some wells.

Quality

The most common water-quality problems in the study area are hardness and iron concentrations, but locally other constituents may also exceed established drinking water standards. Several wells with nitrate concentrations exceeding allowable limits are located within the study area. The contamination of these wells is likely because of poor well construction practices. Wells must have a seal between the well bore and the casing to prevent contaminated water from entering the well.

The occurrence of bacterial contamination in shallow wells and springs has increased as human and animal populations have increased in the study area. Fractures and solution channels in surficial rocks, particularly limestones and dolomites, are highly susceptible to contamination because the fractures allow rapid infiltration of fecal matter from a variety of sources including septic tanks, landfills, poultry and cattle operations and runoff from pastures.

Another water-quality problem in the study area is the occurrence of saline water in the Quaternary deposits. In the eastern part of the study area near Cord and Bald Knob (fig. 4-11) the Quaternary deposits contain saline water.

The Quaternary deposits have also been contaminated from surface sources. Chesney (1979) reports the contamination of water in these deposits at Newport in 1977 when dilute sulfuric acid leaked from holding ponds and affected a nearby water supply. At Augusta, water from industrial monitoring wells in the Quaternary deposits showed lead concentrations exceeding established drinking water standards.

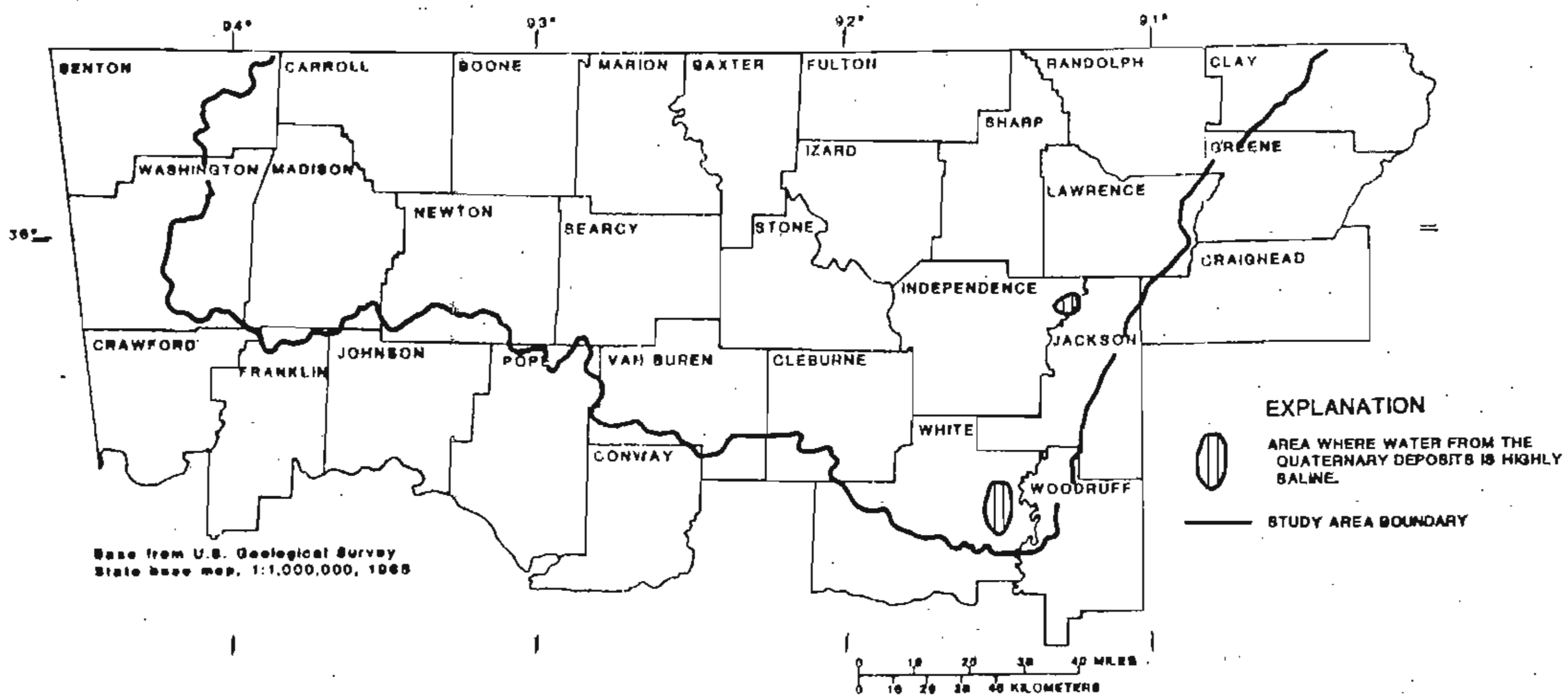

Figure 4-11.--Areas of saline water occurence in the Quaternary deposits (modified from Bryant and others, 1985).

Critical Use Areas

Critical ground-water use areas have been defined by the Arkansas Soil and Water Conservation Commission for both water table and artesian aquifers using the following criteria:

Water table aquifers

1. Less than 50 percent of the thickness of the aquifer is saturated
2. Average annual declines of 1 foot or more have occurred for the preceding 5-year period
3. Ground-water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer

Artesian aquifers

1. The potentiometric surface is below the top of the aquifer
2. Average annual declines of 1 foot or more have occurred for the preceding 5 years
3. Ground-water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer

If even one of these criteria is met by an aquifer in part of the study area, then that part of the study area is considered to be a critical use area for that aquifer.

The aquifers in the subsurface Paleozoic Formations, namely the Eminence-Potosi, Gasconade-Van Buren, and Roubidoux Formations, are all considered to be artesian aquifers in the study area. Water levels in wells tapping these units have shown no long-term declines and most water-quality problems appear to be of a local nature. The ground water from these units is generally extremely hard and iron concentrations commonly exceed secondary drinking water regulations (U.S. Environmental Protection Agency, 1986b). The quantity and quality problems of available ground water are primarily natural constraints. Based on the available data, no areas in these deep Paleozoic formations are critical use areas.

The outcropping Paleozoic units exist under water table conditions. Well yields in these units are low because of natural constraints, and water levels have shown no long-term declines. Water-quality problems are generally of a local nature and are unrelated to pumping rates. Therefore, no critical areas exist in these units in the study area.

The Nacatoch Sand exists under water table conditions in its outcrop area and under artesian conditions downdip. There is no known use in the study area and limited water-quality data are available. Based on the limited data available, no areas in the Nacatoch Sand in the study area are critical use areas.

Quaternary deposits exist under water-table conditions in their outcrop areas in the study area. Iron concentrations are a pervasive problem in these deposits and other isolated water-quality problems exist. Water levels in many areas actually rose in these deposits between 1981 and 1986, while in other areas water levels declined less than 2 ft. No critical use areas exist in the Quaternary deposits in the study area.

In general, the ground-water resources of the study area, with the exception of the Quaternary deposits, are not being used to a large extent. Water use in the Quaternary deposits, while significant, does not appear to be causing water levels to decline at a rate high enough to meet the criteria for a critical use area. Quality problems are generally isolated to individual wells, although some natural problems are more widespread. Therefore, no critical use areas were designated in the study area.

POTENTIAL GROUND-WATER PROBLEMS

The potential for ground-water contamination exists throughout the study area. Potential hazards include landfills, surface impoundments, hazardous waste operations, storage tanks, septic tanks, and saline water intrusion. The probability of contamination of ground water varies from area to area depending largely on the permeability of the surface materials.

Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground-water system. Figure 4-12 shows the recharge potential of the study area in different zones. Zones shown on figure 4-12 as having high recharge potential are outcrop areas of Paleozoic limestones. Zones with medium recharge potential are outcrops of Paleozoic sandstones and shales and low interstream terraces of Quaternary deposits. Zones with low recharge potential are high interstream terraces of Quaternary deposits. The greatest potential for contamination is in zones with high recharge potentials.

At least 64 open landfills and dumps exist in the study area (fig. 4-12). The contents of the majority of these landfills and dumps are essentially unknown. Hazardous materials may be stored in these areas and could be leaking into the shallowest aquifer. Two Resource Conservation and Recovery Act (RCRA) sites and two Superfund sites exist in the study area.

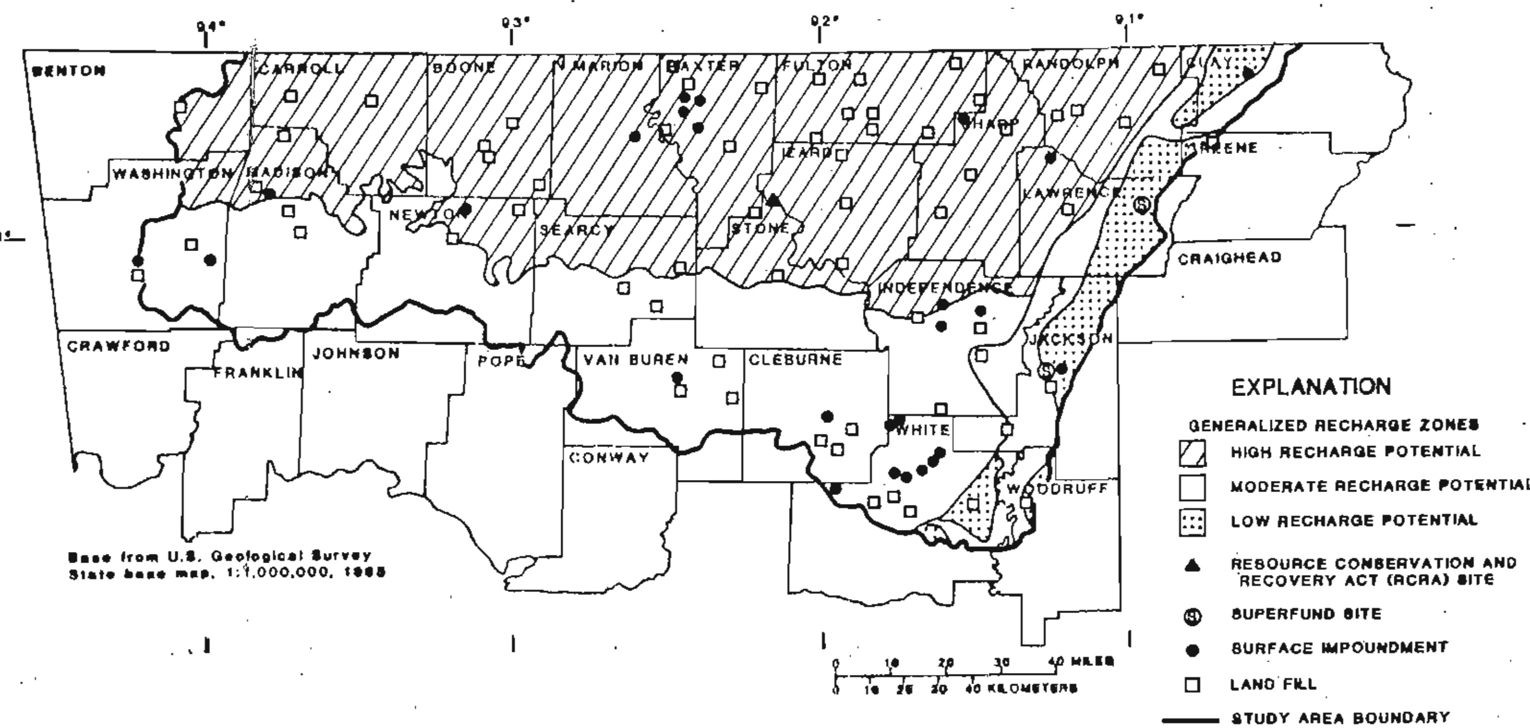

Figure 4-12.--Generalized recharge zones and potential ground-water contamination sources (modified from Bryant and others, 1985).

Surface impoundments may also be considered potential hazards to ground water. Chesney (1979) inventoried 7,640 impoundments at 872 sites. A small number of these impoundments (518) were selected for assessment of contamination potential. The assessment conducted by Chesney included a complete description of the impoundments including size in acres, age, amount and type of wastes present, type of liner, and the presence of monitoring wells. In addition, the geologic formations underlying the impoundments were rated according to the ease with which contaminants could penetrate surface layers. Using these data the impoundments were then assessed for ground-water contamination potential, which is expressed as a numerical rating with a low of 1 and a high of 29. Surface impoundments with a hazard rating of 16 or above are shown in figure 4-12.

Additional sources of potential ground-water contamination include storage tanks, septic tanks, waste-injection wells, mining activities, pipelines, and wastes spilled in transport.

Another potential problem involves the development of ground-water resources to such an extent that water levels decline steadily and ground-water availability is threatened.

Solutions to Ground Water Problems (Corps of Engineers)

Quantity

The low yields of the surface Rocks of Paleozoic age are a natural occurrence which can not be corrected. The solutions are: (1) change to a surface water source; or (2) drill a deep well into one of the deeper high yielding formations.

Quality

The major water quality problems in the Upper White River Basin are hardness and excessive iron concentrations. These problems are due to the geology of the area. The only solution would be to treat the water before it is used. This solution is not practical from an economic standpoint.

Many areas in the study area have marginal water quality and low ground water yields. Two incentives were contained in Act 417 of 1985 to assist ground water users in building impoundments and/or converting to surface water sources. The act was entitled "Water Resource Conservation and Development Incentives Act of 1985". This Act stated that existing water use patterns were depleting underground water supplies at an unacceptable rate because alternative surface water supplies in sufficient quantity and quality were not available at the time of demand. The Act provides ground water conservation incentives in the form of tax credits to encourage construction and restoration of surface water impoundments and conversion from ground water to surface water withdrawal and delivery systems.

A potential source of ground water pollution is the placement of wells too close to septic fields or animal waste disposal areas. The porous geology of the Upper White River Basin provides pollutants with access to ground water supplies. Wells should be placed up hill from waste disposal areas. Also, surface application of waste materials should be well away from ground water wells.

Well construction should be performed properly. If the well casing is not sealed properly to the bore hole, a gap could remain allowing pollutants such as nitrates to enter the ground water.

There is no known solution after saltwater has intruded into an aquifer. The only solution is to seal the well and seek alternate sources of water.

The solution to pollutant leakage into ground water supplies is regulation. Legislation exists to control construction of liquid waste holding impoundments and to require extensive monitoring system at an early stage and prompt action to be taken to prevent further contamination. The Water and Air Pollution Control Act and the Hazardous Waste Management Act contain procedures for enforcement by holding hearings on cases of alleged violations and taking action through civil and criminal courts. These acts provide for immediate action by the Arkansas Department of Pollution Control and Ecology in case of emergency and specifies penalties up to $10,000 for each day of violation or a maximum prison sentence of one year.

The Resource Conservation and Recovery Act (RCRA) provides for the end to open dumps and the conversion to sanitary landfills to avoid ground water pollution. The upgrading of open dumps to sanitary landfills is a step in the right direction to reduce pollution.

The controlling of pollution of ground water is a necessity because many rural residents rely on this water resource as their sole source of potable water.

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U. S. G. S. Streamflow Records.

APPENDIX A

COMMENTS ON THE DRAFT REPORT

Harold K. Grimmett
Director

ARKANSAS NATURAL HERITAGE COMMISSION

THE HERITAGE CENTER, SUITE 200
225 EAST MARKHAM
LITTLE ROCK, ARKANSAS 72201
Phone: (501) 371-1706

Bill Clinton
Governor

Date: October 22, 1986
Subject: Upper White River Basin
ANHC Job #SWCC-5
Dated September 22, 1986
Received October 2, 1986

U.S. Army Corps of Engineers
Little Rock District
P.O. Box 867
Little Rock, Arkansas 72203
ATTN: SWLPL-S

re: State Water Plan, Upper White River Basin

Dear Sirs:

The staff of the Arkansas Natural Heritage Commission has reviewed the draft state water plan for the Upper White River Basin. While several improvements over previous draft plans (of other basins) are apparent, this document suffers from some of the same deficiencies, particularly with regard to potential impacts of plan implementation on fish and wildlife.

First of all, the discussion of minimum streamflow that begins on page 3-19 fails to offer any documentation or clear statement of justification for the conclusions reached concerning fish and wildlife requirements. If the intent was to adopt Tennant's findings in some form, it should be noted that the 10 percent figure he used applied to short-term survival, not maintenance of good survival habitat over the long run. In other words, 10 percent of the mean annual or seasonal flow may suffice as a minimum standard for fish and wildlife for a limited period of time, but it will not insure protection of the resource indefinitely. We note that the draft water plan makes no reference to the length of time a stream might remain at or near minimum discharge. Presumably, this period could be as long as a month or even several months, at which point the question of survival clearly has turned from a short- to a long-term issue.

It is highly likely that many aquatic species will be affected adversely if flows of basin streams should be reduced for extended periods of time to the point that would be permitted by implementation of the proposed standard. Reproduction and growth of fishes and aquatic invertebrates, cleansing of aquatic habitats, and recharge of groundwater tables all depend upon substantial flows of water, flows that exceed the minimum instream flow recommendation.

The alternative method for determining instream flow requirements presented on pages 3-65 through 3-68 is an improvement over methods previously proposed by the authors of this (pages 3-19, 3-20) and other draft water basin plans, and we support the general direction taken. Some of the information presented in Table 3-34, however, is inaccurate. Our records indicate that the North Fork River and the White River harbor populations of Lampsilis orbiculata (pink mucket), which is listed as Endangered by the U.S. Fish and Wildlife Service. In Table 3-34 neither river is shown as supporting endangered species. Furthermore, the Little Red River provides habitat for Simpsonaias ambigua (salamander mussel) and Percina nasuta (longnose darter--also found in several locations on the White River), and War Eagle Creek harbors Ammocrypta asprella (crystal darter). All three species are candidates for federal listing.

If the "alternative" method is pursued, the Arkansas Natural Heritage Commission will be happy to provide specific locational information for endangered species, including not only those on federal lists but those of state concern as well. Whatever method is chosen, it is important to note that the Upper White River Basin provides habitat for no less than 29 aquatic species of federal and/or state concern. These are listed below:

Lampsilis orbiculata	pink mucket	Endangered
Epioblasma florentina curtisi	Curtis' pearly mussel	Endangered
Epioblasma turgidula	turgid-blossum " "	Endangered
Cambarus zophonastes	Hell Creek Cave crayfish	Proposed Endangered
Simpsonaias ambigua	salamander mussel	Federal candidate
Ammocrypta asprella	crystal darter	Federal candidate
Cryptobranchus alleganiensis	Ozark hellbender	Federal candidate
Percina nasuta	longnose darter	Federal candidate
Lampsilis streckeri	speckled pocketbook	Federal candidate, possibly extinct
Notropis camurus	bluntface shiner	
Lampetra appendix	American brook lamprey	
Lampetra aepytera	least brook lamprey	
Etheostoma spectabile fragi	Strawberry River darter	
Notropis sabinae	Sabine shiner	
Somatogyrus crassilabris	thicklipped pebblesnail	
Anodonta suborbiculata	flat floater	
Caecidotea ancyla	isopod	
Caecidotea Steevesi	isopod	

Caecidotea stiladactyla	isopod
Caecidotea dimorpha	isopod
Lirceus bicuspidatus	isopod
Moxostoma anisurum	silver redhorse
Moxostoma macrolepidotum	shorthead redhorse
Hiodon alosoides	goldeye
Epioblasma triquetra	snuffbox
Notropis spilopterus	spotfin shiner
Notropis maculatus	taillight shiner
Etheostoma moorei	yellowcheek darter
Typhlichthys subterraneus	southern cavefish
Ammocrypta clara	western sand darter

If additional information regarding these species or our comments in general is desired, please do not hesitate to contact me.

Sincerely,

Bill Pell

Bill Pell
Stewardship Chief

cc: Craig Uyeda
John Giese

Arkansas **DEPARTMENT OF HEALTH**

4815 WEST MARKHAM STREET • LITTLE ROCK, ARKANSAS 72205-3867
TELEPHONE AC 501 661-2000

BILL CLINTON
GOVERNOR

BEN N. SALTZMAN, M.D.
DIRECTOR

October 22, 1986

U. S. Army Corps of Engineers
Little Rock District
P. O. Box 867
Little Rock, AR 72203

ATTN: SWLPL-S

RE: Draft Upper White River Basin Report

Gentlemen:

We have reviewed the referenced report and we have the following comments:

1. Drinking water quality should be referenced to the National Primary Drinking Water Standards and the National Secondary Drinking Water Standards instead of the 1962 U.S. Public Health Service Standards.
2. What is the reason for the projected decrease in total water use from 1980 to 2000? All ground water uses as well as total uses are projected to increase for this period.
3. There is concern about contamination of shallow aquifers in karst areas by municipal, industrial, and rural domestic sewage discharges.

We are retaining the report for our files.

Sincerely,

T. A. Skinner, P. E.
Chief Engineer
Division of Engineering

LG:JA:lt

STATE OF ARKANSAS
DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY
8001 NATIONAL DRIVE, P.O. BOX 9583
LITTLE ROCK, ARKANSAS 72209

PHONE: (501) 562-7444

October 24, 1986

U.S. Army Corps of Engineers
Little Rock District
Post Office Box 867
Little Rock, Arkansas 72203

Attn: SWLPL-S

Dear Sir(s):

The following comments comprise the input of the staff of the Department of Pollution Control and Ecology concerning the draft copy of the Arkansas State Water Plan - Upper White River Basin. The seriousness with which we view the long term directions set out by the State Water Plan and the potential effects of this plan on the water resources of our state cannot be overstated. It is with these concerns that we make these constructive comments.

The following comments concern the groundwater section: (1) The report attempts to discuss and develop a plan based on surface water drainage basins. It is well documented that groundwater aquifers and recharge areas are not congruent with surface drainages. In its recent publication on groundwater problems, USGS abandoned the surface drainage basins as a vehicle for dividing its report and this resulted in a much more logical, concise and comprehendable document than its first draft which, like the State Water Plan, was based on a surface approach. This basin report fails to note where the Ozark system ends and the Coastal Plain system begins and, hence, fails to discuss the Nacatoch Formation which is a major source of municipal supply in the eastern part of the basin. These kinds of errors would not occur if the groundwater section were not based on surface basins. (2) While it is true that aquifer recharge requirements are not known for each aquifer, elaborate models are not needed for entire aquifers to figure recharge requirements as they relate to minimum stream flows. Recharge as a percentage of streamflow can be figured by either physical or chemical means using methods and formulas available in basic hydrology texts. The applicable principle is that to maintain base flow in a stream, the water table in the adjoining aquifer has to be sufficiently high to allow for lateral movement into the stream bed. That depth can be readily ascertained and pumping limits established so that sufficient recharge is maintained. To allow the water table to fall below the streambed has the result of eliminating the flow entirely when runoff is absent, thus making minimum streamflow questions academic.

(3) It should be made clear to all readers of this document that there is a significant paucity of data on the quantity and quality of groundwater in Arkansas and that much of the available data is self supplied by the users and may be heavily biased by their preconception of the uses of the data. (4) An additional source of data which is available concerning groundwater quality is the CERCLA industrial monitoring data available through STORET. Specifically, monitor-well data is available from the Boone County area in conjunction with a commercial wood-treatment plant.

We are very concerned about the methodology used in the draft document to establish minimum streamflows for surface waters and the negative impact these will have on the biotic uses of the streams. These minimum streamflows are proposed to be only 10 percent of the historical flows for 3 specified seasons of the year; and the proposal, hereafter referred to as SWC plan, is proposed to supply all instream flow needs, including fish and wildlife, during all seasons of the year. In our view, such an approach will drastically alter the designated beneficial uses of the streams in contravention of federal and state statutes and regulations. By definition, minimum streamflows are the point at which "all diversions should cease"; however, there is no effective mechanism to control diversions above the minimum streamflow level. Without such controls, diversions will cause the minimum streamflows to become the average streamflow and with the SWC plan, "worst case" conditions for instream aquatic life will become the standard.

The Clean Water Act was a mandate from Congress to reverse the trends of degradation of the nation's waters and to restore and maintain the chemical, physical and biological integrity of these waters. Such a mandate is not limited to water quality control and is so recognized in the Act. The biological integrity of an aquatic ecosystem is limited by its energy source, habitat structure, water quality and flow regime. In the goal of the Clean Water Act "...that provides for the protection and propagation of fish, shellfish and wildlife and recreation in and on the water," it further recognizes and mandates the protection of all life stages of the aquatic biota, specifically including the propagation stage. It is intimately clear that maintaining the "biological integrity of the nation's waters" must include maintenance of a flow regime that will be fully protective of the biotic designated beneficial uses of these waters during all life stages.

It should be recognized that the proposed "Arkansas Plan" for establishing minimum streamflows for fish and wildlife represents acceptable streamflow conditions which may become average or standard conditions without significant damage to the aquatic resources. Although, it is realized that there will be both natural and artificial flow conditions above and below these "target" flows, we feel that an acceptable allocation plan must be a part of the State Water Plan if minimum streamflows are established lower than those proposed by the "Arkansas Plan." If a rigid and effective allocation plan is developed and implemented which is automatically initiated before streamflows reach a minimum level, then minimum streamflows could be set at relatively low levels. Without an active allocation plan, minimum streamflows must be set high enough to ensure protection of the aquatic resources and waste assimilation capacity in the streams.

There have been recent discussions concerning the development of a stream classification system. The intent of such a system would be to establish minimum flows reflecting a stream's historic flow pattern and recognizing the variation in uses of the state's surface waters. We feel that development of such a system could be a valuable asset to the State Water Plan and to numerous other water resource management activities. Therefore, to establish minimum streamflows before this option is thoroughly investigated would be inappropriate. A segment in the Upper White River Basin Plan discusses a methodology which might be used for such a classification system. However, the report is unclear as to the status or use of such an approach. Obviously, this approach needs considerable review and refinement.

It is imperative that minimum streamflows be established on a seasonal scale since the instream flow needs for fish and wildlife are drastically different in the spring of the year than during the late summer. The needs are more critical during the reproductive season of the fish than at any other time. To assume that there will always be sufficient water for fish reproduction in the springtime and that removal of water from the streams during this period could not be of significant magnitude to affect the fishery is erroneous. Our studies have shown that higher water quality standards requiring more sophisticated treatment procedures and/or higher background flows are necessary during the springtime when the most sensitive life stages of various aquatic organisms are present. Therefore, allocation level flows and/or minimum streamflows should mimic the general hydrological pattern of the stream.

The modification of the SWC plan in the Upper White River Basin segment to establish minimum streamflows as 10 percent of the seasonal flows--i.e., November-March, April-June, and July-October--is insufficient to provide seasonally variable flows that will protect the instream aquatic uses. We fail to find rationale or justification for the modified SWC plan; therefore, they appear arbitrary and without basis in fact or ecological expertise. We are convinced that these suggested levels will have severe negative impacts on the stream biota.

Since there appears to be several factors which may influence the establishment of minimum streamflows--e.g., allocation procedures and stream classification--we suggest the establishment of minimum streamflows be delayed until all of the basin plans can be thoroughly reviewed and the factors mentioned above resolved.

We also note several important omissions from the Upper White River Basin Report. These include: (1) Karst terrain areas of this basin and their influence on surface water streamflows and groundwater aquifers, including their contamination susceptibility; (2) the impact of the numerous, large reservoirs in the basin on streamflows and their potential for streamflow augmentation; (3) water level management plans for these reservoirs, particularly in light of potential uses of reservoir waters for irrigation, navigation and public water supply; and (4) the use of state-of-the-art instream flow incremental methodology data which has been developed for several of the major streams in the basin. Although such data was developed for the major trout production areas, the data could be used as an aid in assessing other suggested methods of establishing minimum instream flows for fish and wildlife.

Sincerely,

Phyllis Garnett

Phyllis Garnett, Ph.D.
Director

PG/WEK/sy

cc: J. Randy Young, Director
Soil & Water Conservation Commission

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
Arkansas District
2301 Federal Office Building
Little Rock, Arkansas 72201

October 27, 1986

U.S. Army Corps of Engineers
Little Rock District
P.O. Box 867
Little Rock, Arkansas 72203
Attn: SWLPL-S

Enclosed are two copies of the report, "Arkansas State Water Plan, Upper White River Basin." A review of this portion of the State Water Plan was requested by the Director of the Arkansas Soil and Water Conservation Commission. Specific comments are shown in the margins of the text. Surface-water comments by Braxtel Neely are in the report labeled surface water and ground-water comments by Gus Ludwig and Dave Freiwald are in the report labeled ground water.

The following general suggestions are offered for your consideration: A summary would be helpful for the surface-water chapter. The ground-water chapter does very little to focus in on the study area, as nearly all of the figures and much of the text pertain to the State of Arkansas as a whole. Much attention is given to the ground water used for irrigation but only 9.3 percent of the study area is cropland. Nothing is mentioned as to the source of the irrigation water (alluvial aquifer). The Roubidoux and Gasconade Formations, which are the only aquifers mentioned are not used as a source of irrigation water. This clarification along with a discussion of the source of water and potential contamination of shallow domestic wells would add to the report.

Please contact us if we can be of additional assistance.

Sincerely,

E. E. Gann

E. E. Gann
District Chief

Enclosures

cc: J. Randy Young

Arkansas 150
DEPARTMENT OF PARKS AND TOURISM
Years of Statehood

October 31, 1986

Mr. Manuel Barnes
U.S. Army Corps of Engineers
Little Rock District
Planning SWLPL-A
P.O.Box 867
Little Rock, Arkansas 72203

Dear Mr. Barnes:

This letter is written in response to your request for our specific comments concerning recreation in the Draft Arkansas State Water Plan for the Upper White River Basin. I appreciate your interest in water-based recreation for this area of our state and I am glad that you have spent time discussing several aspects of the plan with our staff members.

As I understand the planning process, this draft for the Upper White River Basin is a part of an overall State Water Plan for Arkansas. We have reviewed two earlier basin reports, and were pleased to note that this draft is the first one to address the recreational water uses and needs in any detail. If each of the basin plans prepared to date are to become part of a larger plan for the state, it would seem that some continuity in preparation and format would be helpful. We would encourage a format similar to the one for the Upper White River Basin, with information included on water recreation requirements.

We were very pleased to see that recreation use as well as special stream designation were factors in determining instream flow requirements for the basin. However, we do have some concerns about the priority matrix as shown in table 3-34. The term "recreation use", with a ranking of high, medium, or low, was not clearly defined and seems subject to question if it is based only upon "common knowledge", as indicated in the narrative. I am very hesitant to see an absolute numerical value attributed to this recreation use which will in turn effect the stream's score in a protection level ranking. We have several streams in the Upper White River Basin which receive heavy use and the recreation patterns in that area are changing because of this. People are choosing to recreate on the lesser-used streams to enjoy the solitude and isolation which is an important value in outdoor recreation. Therefore those high use streams are not the only ones worthy of protection.

The priority matrix is a good beginning and as stated earlier, we heartily support the inclusion of recreation values in consideration of stream flow protection levels. Additional information on water-based recreation in the area is needed. We support your recommendation for additional studies and computer models as outlined in Chapter III.

Thank you for the opportunity to comment on this draft plan. We hope this information will prove helpful. If you have any questions, please do not hesitate to contact our office.

Sincerely,

Jo Luck Wilson

Jo Luck Wilson

cc: J. Randy Young, Director
Arkansas Soil and Water Conservation Commission

Arkansas
Soil and Water
Conservation Commission

J. Randy Young
Director

ONE CAPITOL MALL
SUITE 2D
LITTLE ROCK, ARKANSAS 72201

PHONE 501-371-1611

Spec Studies

November 6, 1986

David Burrough, Chief
Planning and Reports Engineering Division
U.S. Army Corps of Engineers
Little Rock District
P. O. Box 867
Little Rock, Arkansas 72203

Dear Mr. Burrough:

Our review of the Upper White River Basin Report has been completed. Our comments are as follows:

CHAPTER 2

Irrigated cropland (present and projected) needs to be evaluated, discussed, and presented in Chapter 2.

CHAPTER 3

1. When determining excess streamflow, interstate compact requirements should not be quantified at this time as no compact exists between Arkansas and Missouri. Should a compact take effect in the future, then determination of excess streamflow can be modified.

2. The need for an interstate compact between Arkansas and Missouri for the White River Basin needs to be emphasized in the Problems and Recommendations section. The effects of an interstate compact needs to be addressed in the following sections of the report: Instream Flow Requirements, Minimum Streamflows, Safe Yield, and Excess Streamflow.

3. The critical surface water areas delineated in the report are not mentioned in the Problems or Recommendations section of the report. No data are included in the report to justify the designation of these critical areas. This information needs to be defendable.

4. There needs to be a more detailed discussion of the large reservoirs. This discussion should include operations, water quality, storage allocations, water use, effects on streamflow characteristics, and effects on minimum streamflows. A discussion including necessary procedures to obtain a reallocation of storage in Corps reservoirs would be appropriate.

5. Water use projections for the Upper White Basin need to be evaluated and discussed in the text. If the projections are not reasonable, then they should be adjusted.

6. Minimum streamflows established at gaging station locations in this basin need to be compared with daily discharge hydrographs for a more representative analysis of the data than the comparison with mean monthly discharges.

7. Our definition of Safe Yield is 95% of the annual exceedance flow minus the minimum streamflow during the low flow season, (July-October). The volume of water that would be available if suitable impoundment locations existed should be computed in the Safe Yield section.

8. The priority matrix classification system should be expanded to include cell instream needs and consider historic riparian uses of the stream.

9. Problems identified should be specifically addressed in the Solutions section. Additionally, solutions suggested must be appropriate for this basin.

10. Effects of the geology of the basin on streamflow characteristics should be discussed.

11. Although erosion is addressed in the water quality section, areas of excessive erosion should be identified.

12. This draft consists mainly of very general statements about water quality and quantity that could apply to many areas of the state. This report should include detailed information regarding the water resources of the Upper White River Basin. Figures need to be limited to the study area.

13. Statements taken from either sources need to be referenced.

14. It appears that a wealth of information available from the Corps has not been utilized. Examples include White River Authorization Study (January, 1986), Flood Reduction Studies (Clinton), Benefits derived by flood control projects, etc.

CHAPTER 4

1. If you keep this outline, subhead each aquifer under your headings of Geology, Hydrology, Quality. Otherwise, have major aquifers as headings with Geology, Hydrology and Quality subheadings under each aquifer.

2. Subheadings under Geology, Hydrology could be; outcrop zone, elevation of the top and bottom, thickness, % sand, recharge, yield, potentiometric map, movement, level change, saturated thickness, quality and others such as transmissivity and specific capacity when available.

3. The stratigraphic column needs to be shown.

4. Water use needs to be illustrated by aquifer by county for 1965, 1970, 1975, 1980.

5. Identify major aquifers in the basin by analysis of use data.

6. While the Roubidoux - Gasconade are an important source of groundwater for public supplies across the northern two tiers of counties, there are several formations used for a water source in the basin. The Roubidoux - Gasconade account for only a small percentage of total basin use, yet they are the only aquifers that you discuss. The Quaternary Aquifer is the major aquifer based on use. The Roubidoux - Gasconade are important as public supply sources but there are several aquifers used in the basin, and they have to be inventoried along with the Roubidoux - Gasconade.

7. Once use data is compiled and major aquifers are identified, scope of report can be outlined.

8. Figures and verbage need to concentrate on the study area instead of statewide or regional emphasis.

9. Level data for major aquifers needs to be included.

10. Report on major uses of water from each aquifer and the spatial distribution of use.

11. Show the spatial distribution of public supply systems relying on each major aquifer.

12. Too much reference to material in other publications with no information about the data contained therein.

13. Move all general information to the introductory section.

14. The projected use data is very questionable.

15. Quality section needs considerable work. Show data by aquifer in each county. Include those areas or wells exceeding standards in problems section by aquifer.

16. Compare level data with critical use area criteria to evaluate significance of stress on aquifers.

17. Reorganize your solutions into aquifers or categories, such as conservation, research, education, alternate supplies, legal and institutional, quality management etc., to correlate with the problems identified.

Enclosed are copies of the Draft Report giving specific comments.

Sincerely,

J. Randy Young, P.E.
Director

JRY:lls
Enclosure

Arkansas Game & Fish Commission

2 Natural Resources Drive   Little Rock, Arkansas 72205

December 17, 1986

U.S. Army Corps of Engineers
Little Rock District
P.O. Box 867
Little Rock, AR 72203

Attention: SWLPL-S

Dear Sir:

The appropriate staff of the Arkansas Game and Fish Commission has reviewed your agency's draft report on the Upper White River Basin as part of the Arkansas Water Plan. The following comments are directed towards specific statements in this draft report.

On page 3-19 under "Recreation Requirements", while recreation may be classified as a "non-consumptive" use as far as actual removal of water from a stream is concerned, minimum and optimal flow levels are necessary for canoeists, boaters etc. An excellent example of using Instream Flow Incremental Methodology (IFIM) to determine recreational flows as well as fishery flow below a hydropower facility maybe found in the publication by Nestler et al (1985), which included personnel from the U.S. Corps of Engineers.

On page 3-19, under "Minimum Streamflow", the proponents of the Arkansas Method realize that at certain times during many water years, fish and wildlife minimum flows will be greater than USGS measured low flows. These are periods of critically low flows when protection of the aquatic environment is even greater than normal. Except in extreme situations, it is at these times that water users must either supplement their surface water use with groundwater or utilize water stored during periods of excess streamflow. In extreme droughts when substantial hardship is experienced by basin water users, a contingency plan allowing use of surface water below minimum flows may be followed.

The Corps' method of determining minimum flows on page 3-20 by taking 10% of the mean monthly flows during three periods of the year, while at least factoring in some seasonality (as opposed to ASWCC's mono-level recommendation) is not acceptable from a fish and wildlife viewpoint as a standard minimum flow. As stated earlier in this report Tennant (1975) demonstrated that 10% of the average annual flow was an acceptable minimum only for short-term survival. Minimum flows recommended by the Little Rock District Corps of Engineers overextended periods of time and/or at regular intervals would decimate fish and wildlife populations associated with the stream in question causing significant economic loss to Arkansas. This is especially true in the Upper White River Basin which contains many of the state's prime fishing and floating streams.

In reference to the section where flow duration curves are mentioned (pages 3-20 to 3-27), it is notable that the lowest flow recommendation as determined by the Arkansas Method of instream flow quantification for the various gaging stations in the Upper White River was still exceeded the majority of the time as seen below:

Station	Lowest Flow Recommendation Arkansas Method (cfs)	Exceedence (exceeded "x" % of time)
Buffalo River @ St. Joe	82	70-80%
Black River @ Corning	348	90-95%
Spring River @ Imboden	284	95-98%
White River @ Calico Rock	2,474	85-90%
Eleven Pt. River @ Ravenden	285	98-99%
Strawberry River @ Poughkeepsie	63	80-90%
White River @ Newport	5,250	95-98%
Middle Fork Little Red @ Shirley	35	70%

These levels of exceedence are not unreasonable when considering other uses of streams in the Upper White River Basin. Part of the idea behind a statewide water plan is to regulate surface water usage so that there is enough for all interests, or in times of shortage, an equitable apportioning of available water. Inherent in any regulation process is the understanding that there is or will be need to regulate a resource before it is depleted. In other words, everyone does not have free rein to divert unlimited water from a stream during periods of low flow. We are seeing in ASWCC's minimum flow recommendations (and, therefore, SCS and USCOE) is the picking of such a low value that it will always be naturally exceeded and diversion will always be possible i.e, until the stream is virtually dry.

On page 3-28, the report states that projected use of water in the basin will gradually increase from year 1980 to year 2030. While use of surface water will decline, the report states that use of groundwater will almost double. If so, extreme use of the surface water resource during low flow summer-fall months will short change groundwater recharge. A more logical time period for heavy withdrawals from streams is during high flow winter and spring months. This obviously would have to be stored in reservoirs (on-farm and larger) for use during peak demand times of the growing season (summer). As mentioned on page 3-36, there presently exists abundant stored water for irrigation, industrial, and domestic uses in the Upper White River Basin with combined storage of ~~10.56 million acre feet of water.~~

On page 3-37, hydropower is a "non-consumptive" use of water in the strict sense of the definition, but timing of river flows below hydro-facilities can and does impact fish and wildlife resources. Periods of zero generation below Bull Shoals Dam (leakage only) for long periods of time between peaking power demand has resulted in substantial fish kills (trout) in the White River tailwater. Relative to regulated streams within the Upper White River Basin, the AGFC has concerns for the deletion of the Little Red River near Heber Springs as a station to monitor instream flows. This station was on the original list requested by ASWCC and AGFC would like to know the status of this station as one of the monitoring stations. We know that USGS is scaling down their stream gaging system due to lack of funds but feel that particular station is important enough at least to monitor gage heights and therefore have some index to flows.

On page 3-49, it is reported correctly that spills/accidents have caused fish kills in the Upper White and Kings Rivers due to the heavy oxygen demand of the waste released. Potential diversion of water to the extent recommended by the Corps in this report will only aggrevate this situation, especially in low flow periods.

Under "Diversion Reporting", it is stated that although diversion registration is a necessary tool in the water planning process, there is no penalty for non-compliance of this requirement. While self-regulation is always the ideal situation, it rarely is practical. Non-compliance of diversion reporting needs to carry with it some type penalty or conversely an incentive for compliance is a must.

On page 3-52, the Arkansas Method is based on the Montana Method of instream flow reservation, which has been tested on 100's of streams. Being formulated from a widely tested and accepted technique, it is not strictly theoretical. The Arkansas Method goes beyond a prior modification of the Montana Method made by Orth and Maughan (1981) for Oklahoma streams. Instream flow recommendations, as determined by the Arkansas Method, are applicable for use in the Upper White River Basin for the the above reasons. It has been incorrectly stated by the report that recommendations computed using the Arkansas Method represent flow requirements for excellent fisheries habitat. This is not the case, as the flow required for excellent and improving fisheries would be 100% of historical flow. The Arkansas Method is a maintenance flow recommendation. Therefore, excellent fisheries, such as the Buffalo River, are maintained as fairly excellent fisheries. Impacted streams, such as Bayou Bartholomew, are maintained as fair fisheries (Filipek et al 1985).

The AGFC agrees with the Corps that the White River from Beaver Dam to Sylamore is a critical water area. We would like to include the Norfork and Little Red Rivers tailwaters under this classification also. Combined they account for a near $80 million dollar annual trout fishing industry that Arkansas (and especially the Upper White River Basin) benefits from. The Arkansas Method would protect this significant economic base in our state. Recommendation by the Corps in this report would degrade this valuable resource to the point where its potential cannot be reached. In this same section, the statement that permits granted for water withdrawal have exceeded the dependable flow of the Little Red River downstream of Searcy underline the problem Arkansas is currently facing and support active regulation of surface waters.

The AGFC agrees with the Corps on the need for and use of water conservation techniques and methods as stated on pages 3-53 and 54, as well as BMP's (Best Management Practices) for agriculture, forestry, construction, etc. We also support the Corps' statement that more stream gaging stations are needed, especially on smaller streams (page 3-63). AGFC has utilized this information in the past and is now cooperatively funding several of these stations with the USGS.

On page 3-65, under "Determining Instream Flow Requirements", it is agreed that more work needs to be done in this area. However, recent work by AGFC, USGS, and the ASWCC on the L'Anguille River using IFIM lends more credence to the Arkansas Method than the ASWCC's or COE's "method" (10% of monthly means).

While determining instream flows for fisheries on the White River at Calico Rock, proponents of the Arkansas Method reviewed work by the U.S. Fish and Wildlife Service using IFIM (Aggus et al 1981). These data were weighed when developing the Arkansas Method, which is why their instream flow recommendations using IFIM are similar to the recommendations of the Arkansas Method for that site if adjustments are made for the difference in watershed area above each site.

The priority matrix suggested on page 3-65 shows some potential when trade-offs need to be made between various water users. This approach seems better suited for use in critical water areas of the state. In other words, the Arkansas Method, based on historic discharge data and fish and wildlife cycles, better approximates flows which determined present fish and wildlife populations in the Upper White River Basin. As discussed in the WELUT publication by Armour et al (1984), use of methods based on flow records may be the most useful as guidance to planners when initial maintenance flows are needed.

There is one other aspect of instream flows that has not been well addressed in this draft. The impact of reduced flows on threatened and endangered species in the Upper White Basin needs more evaluation and study. While we will not address this matter in depth in this correspondence, it is quite notable that at least 29 aquatic species of federal and/or state concern inhabit the Upper White River Basin. We concur with the concern for these species indicated in the correspondence from the Arkansas Natural Heritage Commission to your agency of October 22, 1986.

We appreciate the opportunity to comment on this draft report before changes are incorporated into it. If you have any questions on the content of this correspondence, please feel free to contact me on the matter.

Cordially,

Steve N. Wilson
Director

SNW:SF:jmc

Attachment

Literature Cited

Aggus, L. R., W. M. Bivin, and T. O. Duncan. 1981. Evaluation of instream flow needs for fisheries in the tailwaters of Bull Shoals, Norfork and Greers Ferry Lake, Arkansas. Report to U.S. Corps of Engineers, Little Rock District. 23pp.

Armour, C. L., R. J. Fisher, and J. W. Terrell. 1984. Comparison of the use of the Habitat Evaluation Procedure (HEPL) and the Instream Flow Incremental Methodology (IFIM) in aquatic analysis. U.S. Fish and Wildl. Service. FWS/OBS-84/11. 30pp.

Filipek, S., W. E. Keith and J. Giese. 1985. Instream flow requirements for fisheries: Arkansas - Lower Ouachita River Basin. Report to Arkansas Soil and Water Conserv. Comm. by Arkansas Game and Fish Comm. Little Rock. 20pp.

Nestler, J. M., R. T. Milhous, J. Troxel and J. Fritschen. 1985. Effects of flow alterations on trout, angling, and recreation in the Chattahoochee River between Buford Dam and Peachtree Creek. U.S. Army Corps of Engineers Waterways Experiment Station. Vicksburg, MS. 300pp.

Orth, D. J. and O. E. Maughan. 1980. Instream flow methodology evaluation and flow quantification for Oklahoma streams. Okla. Coop. Fish Res. Unit, Phase II Proj. Complete Report. Stillwater, OK.

Tennant, D. L. 1975. Instream flow regimens for fish, wildlife, recreation and related environmental resources. U.S. Fish and Wildl. Service. Billings, MT. 30pp.

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

REFERENCE OR OFFICE SYMBOL	SUBJECT		
SWLPL-A	COMTS TO ASWCC STATE WATER PLAN- UPPER WHITE RIVER		
TO	**FROM**	**DATE**	**CMT 1**
CH, SPECIAL STUDIES BR	CH, ENV ANAL BR	1-6-87 MANUEL BARNES	

Comment 4. No storage in Corps reservoirs has been allocated for fish and wildlife minimum stream flows. Reallocation thru Congressional authorization would be required to provide such reservoir storage. Presently fish and wildlife minimum flow benefits are incidental to storage for hydropower and flood control. The reallocation procedure would necessitate cost sharing by a non-federal entity according to the reallocated purpose. There is an ameliorative operation outlined in an interagency agreement between the Southwest Power Administration and the Corps of Engineers. The agreement is that during critically hot periods such as the three-day memorial weekend, Fourth of July weekend, or Labor Day weekend emergency releases to minimize trout kills on the White River below Bull Shoals Dam and Norfork Dam are made. Table 1. describes the relationship between air temperature and releases below Bull Shoals Dam and Beaver Dam.

Table 1.

Interagency Agreement between the South West Power Administration and the U.S. Army Corps of Engineers for making water temperature related emergency releases to minimize trout kills on the White River below Bull Shoals Dam and Norfork Dam.

WATER RELEASE REQUIREMENTS
FOR NON-POWER PURPOSES

Project	Period of Time in Effect	Forecast Air Temperature							
		90° or Below		91° - 95°		96° - 104°		105° and Above	
		Generation (MWH)	Discharge (MWH)	Generation (MWH)	Discharge (MWH)	Generation (MWH)	Discharge (MWH)	Generation (MWH)	Discharge (MWH)
Bull Shoals 1/	May 1 - Oct. 15	80	250	120	375	160	500	240	750
Norfork 1/	May 1 - Oct. 15	40	145	60	218	80	290	100	360

1/ The minimum combined operation at Bull Shoals and Norfork shall not be less than a 3-day summation of 4,000 Day Second Feet (DSF). Any 3-day average shall not be less than 2,000 DSF. This applies for all air temperature conditions above 85°.

Comment 6. The minimum stream flows have been based on seasonal flows in order to have a simple and manageable means to establish minimum flows. The seasonal approach establishes three different minimum flow targets rather than 365 individual minimum flows. This very detailed approach could be done, but it would be very cumbersome and difficult to implement as a standard.

Comment 8. In our discussion of the priority matrix classification system on page 3-66, the first paragraph add the following statement: "The matrix could also be refined by including cell instream needs. This would necessitate the development of hydrologic information that is not presently available."

Morris D. Leggett
MORRIS D LEGGETT
CHIEF, ENVIRONMENTAL ANALYSIS BRANCH

Memorandum

To: To the Record

From: Liz Cole

DATE: January 19, 1987

SUBJECT: Comments on the Upper White River Basin Report by Arkansas Game & Fish

==

The planning staff of the Arkansas Soil and Water Conservation Commission has reviewed the comments on the Upper White River Basin report by the Arkansas Game and Fish Commission. It is obvious from their letter of December 17, 1986, as well as from review comments on previous basin reports of the State Water Plan, that the staffs of the Game and Fish Commission and the Soil and Water Commission have significantly different approaches for addressing Act 1051 requirements in the State Water Plan. The purpose of this memo is to address the comments made by the Game and Fish Commission. Selected sections of the letter, which have been numbered, correspond to the following comments from the staff of the Soil and Water Commission.

1 On page 3-19 under "<u>Recreation Requirements</u>", while recreation may be classified as a "non-consumptive" use as far as actual removal of water from a stream is concerned, minimum and optimal flow levels are necessary for canoeists, boaters etc. An excellent example of using Instream Flow Incremental Methodology (IFIM) to determine recreational flows as well as fishery flow below a hydropower facility maybe found in the publication by Nestler et al (1985), which included personnel from the U.S. Corps of Engineers.

<u>Section 1</u>

The following statement in the Upper White River Basin report should be revised: "since recreation is a nonconsumptive use of water, there is not a need to quantify needs for this reason" Recreation is a nonconsumptive use of water in the basin. however, Act 1051 requires that all instream needs (consumptive and nonconsumptive) be quantified. Therefore, instream needs for recreation should be determined. The IFIM study by Nestler et al (1985) on the effects of flow alterations on trout, angling and recreation in the Chattahoochee River between Buford Dam and Peachtree Creek would probably not be of significant help in determining instream needs for recreation in the Upper White River Basin. The Instream Flow Incremental Methodology (IFIM) does provide excellent results for determining instream needs and is a very versatile method that can be used in water management. However, results of IFIM studies are site and/or stream reach specific. Therefore, although the methodology is transferable to other streams, the results of IFIM studies probably should not be transferred. Since it is not feasible to undertake detailed IFIM studies on the streams in Arkansas, some other method of determining instream needs for recreation and fish and wildlife must be used.

Instream needs for canoeing must also be considered in this basin. It should also be stated, however, that other recreational activities such as swimming and boating are not authorized purposes of the Corps' reservoirs. Therefore, the Corps is not required to operate the reservoirs in a manner which would support these recreational purposes to the detriment of authorized uses. Since instream flow needs are not additive.other instream needs may supply sufficient flow for recreation. If this is the case, a statement to that effect should be made.

2 On page 3-19, under "Minimum Streamflow", the proponents of the Arkansas Method realize that at certain times during many water years, fish and wildlife minimum flows will be greater than USGS measured low flows. These are periods of critically low flows when protection of the aquatic environment is even greater than normal. Except in extreme situations, it is at these times that water users must either supplement their surface water use with groundwater or utilize water stored during periods of excess streamflow. In extreme droughts when substantial hardship is experienced by basin water users, a contingency plan allowing use of surface water below minimum flows may be followed.

Section 2

Comments in this section of the letter from the Game and Fish Commission pertain to the following statement in the Upper White River Basin report: "When comparing the various requirement recommendations, it was noted that the fish and wildlife recommendations were greater than some of the USGS measured low flows." Although true, this statement in the Basin report does not adequately explain the reasoning for the necessary adjustment of instream needs of fish and wildlife for determination of minimum streamflows. Since the instream flow requirements, as determined using the Arkansas Method, represent a maintenance flow level for fisheries, the instream flow requirements for fish and wildlife were reevaluated to determine instream needs that represent minimum conditions.

The statement by the Game and Fish Commission that "In extreme droughts when substantial hardship is experienced by basin water users, a contingency plan allowing use of surface water below minimum flows may be followed" is not consistent with the definition of minimum streamflow. The minimum streamflow represents the discharge at which all withdrawals from the stream will cease.

3 The Corps' method of determining minimum flows on page 3-20 by taking 10% of the mean monthly flows during three periods of the year, while at least factoring in some seasonality (as opposed to ASWCC's mono-level recommendation) is not acceptable from a fish and wildlife viewpoint as a standard minimum flow. As stated earlier in this report Tennant (1975) demonstrated that 10% of the average annual flow was an acceptable minimum only for short-term survival. Minimum flows recommended by the Little Rock District Corps of Engineers overextended periods of time and/or at regular intervals would decimate fish and wildlife populations associated with the stream in question causing significant economic loss to Arkansas. This is especially true in the Upper White River Basin which contains many of the state's prime fishing and floating streams.

Section 3

The Game and Fish Commission has stated their concern that the "Minimum flows recommended by the Little Rock District Corps of Engineers over extended periods of time and/or at regular intervals would decimate fish and wildlife populations associated with the stream in question causing significant economic loss to Arkansas." Statements are contained in the Basin report which emphasize the fact that the minimum flow is not a flow that can be maintained for extended periods of time without serious environmental problems. Before the flow in a stream reaches the minimum discharge, allocation of water based on the establishment of water use priorities should be in effect which should maintain streamflow at or above the established minimum discharge. However, due to natural streamflow variability, streamflow levels would be less than any established minimum flow at regular intervals unless the minimum discharge was established as the lowest discharge measured for the period of record. Also, we would not oppose utilizing economic considerations as a factor in the determination of minimum streamflow.

It is recommended that the Corps analyze the method for determining minimum streamflows with regard to streamflow conditions in the Upper White River Basin. Since the streamflow characteristics and stream usage are significantly different in the Lower Ouachita Basin and the Upper White River Basin, methodologes for determination of minimum streamflows should be carefully evaluated in order to determine if a modification of the method used to determine minimum streamflows in the Lower Ouachita Basin (10 percent of the mean monthly flow for each of the three seasons) is warranted.

4 In reference to the section where flow duration curves are mentioned (pages 3-20 to 3-27), it is notable that the lowest flow recommendation as determined by the Arkansas Method of instream flow quantification for the various gaging stations in the Upper White River was still exceeded the majority of the time as seen below:

Station	Lowest Flow Recommendation Arkansas Method (cfs)	Exceedence (exceeded "x" % of time)
Buffalo River @ St. Joe	82	70-80%
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Strawberry River @ Poughkeepsie	63	80-90%
White River @ Newport	5,250	95-98%
Middle Fork Little Red @ Shirley	35	70%

These levels of exceedence are not unreasonable when considering other uses of streams in the Upper White River Basin. Part of the idea behind a statewide water plan is to regulate surface water usage so that there is enough for all interests, or in times of shortage, an equitable apportioning of available water. Inherent in any regulation process is the understanding that there is or will be need to regulate a resource before it is depleted. In other words, everyone does not have free rein to divert unlimited water from a stream during periods of low flow. We are seeing in ASWCC's minimum flow recommendations (and, therefore, SCS and USCOE) is the picking of such a low value that it will always be naturally exceeded and diversion will always be possible i.e, until the stream is virtually dry.

Section 4

It is inappropriate and misleading to compare the lowest flow recommendation determined by the Arkansas Method which is a monthly discharge with exceedance probabilities that have been computed on an annual basis. Since the minimum discharge is computed on a seasonal basis, the minimum discharge for each season should be compared with exceedance probabilities based on the same seasons.

The Game and Fish Commission has stated that the minimum flow recommendations of ASWCC, SCS, and the Corps are so low that they "...will always be naturally exceeded and diversion will always be possible, i.e., until the stream is virtually dry." The minimum flow recommendations do not represent a discharge that will always be naturally exceeded. If this were the case, the minimum discharge computed in the State Water Plan would be the lowest discharge for the period of record at each station. In the Upper White River Basin, seasonal minimum discharges were compared with the seasonal exceedance probabilities. The seasonal minimum discharges ranged from approximately 58 percent exceedance to 99 percent exceedance. It should be noted, however, that for the eight stations that were analyzed, the minimum discharges were generally exceeded greater than 95 percent of the time. Therefore, as previously stated, an evaluation of the methodology for determining minimum streamflow in the Upper White River Basin is probably warranted.

The statement by the Game and Fish Commission that the recommended minimum streamflow would allow diversion of water until the stream is virtually dry is not true. For example, minimum discharges for the period of July through October for the eight streams analyzed in the Upper White River Basin ranged from 10 cfs for the Middle Fork Little Red River at Shirley to 1260 cfs for the White River at Newport.

5 On page 3-29, the report states that projected use of water in the basin will gradually increase from year 1980 to year 2030. While use of surface water will decline, the report states that use of groundwater will almost double. If so, extreme use of the surface water resource during low flow summer-fall months will short change groundwater recharge. A more logical time period for heavy withdrawals from streams is during high flow winter and spring months. This obviously would have to be stored in reservoirs (on-farm and larger) for use during peak demand times of the growing season (summer). As mentioned on page 3-36, there presently exists abundant stored water for irrigation, industrial, and domestic uses in the Upper White River Basin with combined storage of 10.56 million acre-feet of water.

Section 5

The Game and fish Commission is concerned that groundwater recharge would be reduced through extreme use of surface water during low-flow periods. This concern would seem to be unwarranted since the baseflow of these streams is sustained by rejected groundwater that is naturally discharged from the formations as seeps and streams. Streams that exhibit sustained baseflow during dry-weather conditions are evidence that formations in these drainage basins are recharged above capacity and are discharging to streams to maintain equillibrum with annual recharge.

The statement made by the Game and Fish Commission that "there presently exists abundant stored water for irrigation, industrial and domestic uses in the Upper White River Basin with combined storage of 10.56 million acre-feet of water" is misleading. According to the Upper White River Basin report, there does presently exist abundant stored water in reservoirs of this basin (combined storage of 10.56 million acre-feet). However, the major impoundments that contain this water are Beaver, Table Rock, Bull Shoals, Norfork, Greers Ferry, and Clearwater Lakes. These reservoirs are owned and operated by the Corps of Engineers with authorized purposes such as flood control, hydropower generation, and water supply. Water in these reservoirs is not available for other uses such as irrigation or industrial purposes.

6 On page 3-37, hydropower is a "non-consumptive" use of water in the strict sense of the definition, but timing of river flows below hydro-facilities can and does impact fish and wildlife resources. Periods of zero generation below Bull Shoals Dam (leakage only) for long periods of time between peaking power demand has resulted in substantial fish kills (trout) in the White River tailwater. Relative to regulated streams within the Upper White River Basin, the AGFC has concerns for the deletion of the Little Red River near Heber Springs as a station to monitor instream flows. This station was on the original list requested by ASWCC and AGFC would like to know the status of this station as one of the monitoring stations. We know that USGS is scaling down their stream gaging system due to lack of funds but feel that particular station is important enough at least to monitor gage heights and therefore have some index to flows.

Section 6

It is agreed that the extreme variability in release of water from reservoirs operated for hydropower generation impacts the fish and wildlife resources downstream of these facilities. However, since hydropower generation is an authorized purpose of these reservoirs, the Corps cannot under law, adjust reservoir releases to support an unauthorized purpose to an extent which hars authorized uses.

7 On page 3-49, it is reported correctly that spills/accidents have caused fish kills in the Upper White and Kings Rivers due to the heavy oxygen demand of the waste released. Potential diversion of water to the extent recommended by the Corps in this report will only aggrevate this situation, especially in low flow periods.

Section 7

A major purpose of the State Water Plan is to determine the amount of water available for other uses in the basin. Potential diversion of water from streams in the Upper White River Basin should not be restricted due to spills or accidents which have caused fish kills. Rather, the source of the spills and/or accidents should be addressed to prevent future fish kills due to these problems.

8 Under "Diversion Reporting", it is stated that although diversion registration is a necessary tool in the water planning process, there is no penalty for non-compliance of this requirement. While self-regulation is always the ideal situation, it rarely is practical. Non-compliance of diversion reporting needs to carry with it some type penalty or conversely an incentive for compliance is a must.

Section 8

A solution addressing the problems with diversion reporting is identified in the Solutions and Recommendations for Diversion Reporting section of the Upper White River Basin report. The following statement on page 3-64 of the Basin report states that "One solution to the reporting problems of non-reporting, over reporting, or one-time-only reporting is to amend the current law to include a penalty, other than nonpreference in allocation proceedings." It should be noted that reporting is just one variable in allocation and past litigation negated the significance of reporting.

9 On page 3-52, the Arkansas Method is based on the Montana Method of instream flow reservation, which has been tested on 100's of streams. Being formulated from a widely tested and accepted technique, it is not strictly theoretical. The Arkansas Method goes beyond a prior modification of the Montana Method made by Orth and Maughan (1981) for Oklahoma streams. Instream flow recommendations, as determined by the Arkansas Method, are applicable for use in the Upper White River Basin for the the above reasons. It has been incorrectly stated by the report that recommendations computed using the Arkansas Method represent flow requirements for excellent fisheries habitat. This is not the case, as the flow required for excellent and improving fisheries would be 100% of historical flow. The Arkansas Method is a maintenance flow recommendation. Therefore, excellent fisheries, such as the Buffalo River, are maintained as fairly excellent fisheries. Impacted streams, such as Bayou Bartholomew, are maintained as fair fisheries (Filipek et al 1985).

Section 9

The Arkansas Method does represent a modification of the Montana Method. However, the Arkansas Method remains a theoretical until the modifications are verified with by field data. The statement that "the Arkansas Method is a maintenance flow recommendation" must be substantiated with data.

Instream flow recommendations, as determined by the Arkansas Method, are applicable for use in the Upper White River Basin for determining excess streamflow and the amount of water available for interbasin transfer. However, instream flow requirements determined by the Arkansas Method are not applicable for use in determining minimum streamflows in the basin. The maintenance flow recommendations from the Arkansas Method are not consistent with the definition of minimum streamflow as the lowest daily mean discharge that will satisfy minimum instream flow requirements. The minimum streamflow represents a critical low-flow condition that can not be maintained for an extended period of time without serious environmental consequences. Therefore, since minimum streamflow and maintenance flow are significantly different streamflow conditions, instream flow recommendations as determined by the Arkansas Method are not applicable for use in determining minimum streamflows in the basin.

There is a difference of opinion between the Game and Fish Commission and the Soil and Water Commission as to whether the instream flow recommendations from the Arkansas Method represent excellent fisheries habitat. This difference of opinion does not pose a problem in the determination of minimum streamflow, however, since maintenance level instream flow recommendations from the Arkansas Method do not represent minimum instream flow requirements for fish and wildlife.

10 The AGFC agrees with the Corps that the White River from Beaver Dam to Sylamore is a critical water area. We would like to include the Norfork and Little Red Rivers tailwaters under this classification also. Combined they account for a near $80 million dollar annual trout fishing industry that Arkansas (and especially the Upper White River Basin) benefits from. The Arkansas Method would protect this significant economic base in our state. Recommendation by the Corps in this report would degrade this valuable resource to the point where its potential cannot be reached. In this same section, the statement that permits granted for water withdrawal have exceeded the dependable flow of the Little Red River downstream of Searcy underline the problem Arkansas is currently facing and support active regulation of surface waters.

The AGFC agrees with the Corps on the need for and use of water conservation techniques and methods as stated on pages 3-53 and 54, as well as BMP's (Best Management Practices) for agriculture, forestry, construction, etc. We also support the Corps' statement that more stream gaging stations are needed, especially on smaller streams (page 3-63). AGFC has utilized this information in the past and is now cooperatively funding several of these stations with the USGS.

Section 10
Arkansas Soil and Water Conservation Commission regarding the critical surface water area section of the Upper White River Basin report included the necessity for documentation to support the identification of certain areas in the basin as critical surface water areas. If the Norfork and Little Red River tailwaters were also identified as critical surface water areas in this basin, as the Game and Fish Commission has suggested, adequate justification needs to be provided for such a designation. If it can be shown that projected water use and/or quality degradation will cause a shortage of useful water so as to cause prolonged problems for the fisheries and fishing industry, then these two areas may need to be designated as critical surface water areas. It should be noted also that the mere exxistance of a use or resource does not automatically carry the disirrgation as a critical surface water area. The definition of a critical surface water area does not assess potential of an underutilized resource.

It is stated in the Upper White River Basin report that "permits for water withdrawals have been granted which exceed the dependable flow" of the Little Red River from Searcy downstream to the mouth. The U.S. Geological Survey, in cooperation with ASWCC, is in the process of analyzing this potential problem. However, since results of this study are not available at the present time, the identification of this area as a critical surface water area is not now warranted. It should be noted that "permits" for water use do not exist. We register diversions, the Corps of Engineers grants permits for water conduits across Corps Easements.

11 On page 3-65, under "Determining Instream Flow Requirements", it is agreed that more work needs to be done in this area. However, recent work by AGFC, USGS, and the ASWCC on the L'Anguille River using IFIM lends more credence to the Arkansas Method than the ASWCC's or COE's "method" (10% of monthly means).

Section 11
It should be noted that the IFIM study on the L'Anguille River was not done in cooperation with USGS. A USGS hydrologist, currently participating in an interagency personnel agreement with ASWCC, was involved with the IFIM study. However, the purpose of the interagency personnel agreement is to provide technical assistance to be provided to ASWCC and does not constitute endorsement or involvement by the U.S. Geological Survey for the IFIM on the L'Angville River.

The Game and Fish Commission has stated that the IFIM study on the L'Anguille River "...lends more credence to the Arkansas Method than the ASWCC's or COE's "method" ... "for determining instream flow requirements. Analysis of the IFIM study by the ASWCC staff showed that the results of the study should be considered inconclusive, at best, for the following reasons:

1. An optimization technique for data analysis described by Bovee (1982) was used to analyze the results of the IFIM study on the L'Anguille River. This technique involves the development of monthly flow-duration curves which are used to select discharges which range from 50 percent exceedance to 90 percent exceedance for each month. The habitat-discharge curves for each appropriate life stage of the species present in the stream for each month are then used to determine the usable habitat at the specified exceedance flows. However, since the habitat-discharge curves did not provide information below 50 cfs, the optimization technique could not be used during several months of the year when the exceedance flows were below 50 cfs.

2. The habitat-discharge curves for overbank flow conditions were developed from theoretical data and were not based on any actual flow and velocity data representative of overbank conditions.

For the above reasons, the results of the IFIM study on the L'Anguille River are inconclusive. Therefore, the study does not support either ASWCC's method or the "Arkansas Method" of determining instream flow requirements for fish and wildlife.

12 While determining instream flows for fisheries on the White River at Calico Rock, proponents of the Arkansas Method reviewed work by the U.S. Fish and Wildlife Service using IFIM (Aggus et al 1981). These data were weighed when developing the Arkansas Method, which is why their instream flow recommendations using IFIM are similar to the recommendations of the Arkansas Method for that site if adjustments are made for the difference in watershed area above each site.

Section 12

The IFIM study on the tailwaters of Bull Shoals, Norfork, and Greers Ferry Lakes by Aggus et al (1981) should be evaluated. The results of this study may be applicable in determining instream flow requirements for fisheries in the areas that were investigated in the IFIM study. In the evaluation of the IFIM study, it is important to identify the objectives of the study and the flow conditions (minimum or maintenance) for which the instream flow requirements are applicable.

13 The priority matrix suggested on page 3-65 shows some potential when trade-offs need to be made between various water users. This approach seems better suited for use in critical water areas of the state. In other words, the Arkansas Method, based on historic discharge data and fish and wildlife cycles, better approximates flows which determined present fish and wildlife populations in the Upper White River Basin. As discussed in the WELUT publication by Armour et al (1984), use of methods based on flow records may be the most useful as guidance to planners when initial maintenance flows are needed.

Section 13

The priority matrix, as presented in the Upper White River Basin report, may be an excellent approach for determining instream flow requirements and minimum streamflows provided the method is modified to address all water needs such as water quality, fish and wildlife, municipal and industrial water supply, agriculture, navigation, etc. The effort required to modify the priority matrix to consider the relative importance of all uses of water from the streams, however, will preclude the use of this method on a statewide basis in the near future.

The comment by the Game and Fish Commission regarding the priority matrix and the necessity of using methods based on flow records to determine instream flow requirements is unclear. As shown on pages 3-67 and 3-68 of the Upper White River Basin report, the priority matrix methodology involves the determination of streamflow protection levels which are then correlated with an appropriate percent of the seasonal flow for each stream which is based on historic streamflow records.

14 There is one other aspect of instream flows that has not been well addressed in this draft. The impact of reduced flows on threatened and endangered species in the Upper White Basin needs more evaluation and study. While we will not address this matter in depth in this correspondence, it is quite notable that at least 29 aquatic species of federal and/or state concern inhabit the Upper White River Basin. We concur with the concern for these species indicated in the correspondence from the Arkansas Natural Heritage Commission to your agency of October 22, 1986.

Section 14

The presence of aquatic species of federal and/or state concern in the Upper White River Basin and the need for additional study on the impact of reduced flows on threatened and endangered species should probably be noted in the Basin report.

References Cited

Aggus, L.R., W.M. Bivin, and T.O. Duncan, 1981, Evaluation of instream flow needs for fisheries in the tailwaters of Bull Shoals, Norfork, and Greers Ferry Lake, Arkansas, Report to U.S. Corps of Engineers, Little Rock District, 23 p.

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Nestler, J.M., R.T. Milhous, J. Troxel, and J. Fritschen, 1985, Effects of flow alterations on trout, angling, and recreation in the Chattahoochee River between Buford Dam and Peachtree Creek: U.S. Army Corps of Engineers Waterways Experiment Station, 300 p.

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