ARKANSAS STATE WATER PLAN

RED RIVER BASIN

ABOVE FULTON

Prepared for
Arkansas Soil and Water Conservation Commission
by
U.S.D.A. and Soil Conservation Service

APRIL, 1987

ACKNOWLEDGEMENT

This report was prepared by the USDA, Soil Conservation Service for the Arkansas Soil and Water Conservation Commission. Assistance and cooperation extended by individuals from many state and federal agencies and from private and local organizations were instrumental in the development of this document.

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 has 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. Periodic revisions to the State Water Plan are necessary for the document to remain valid.

This report covers the revision of Basin Number 11 (Red River Basin above Fulton) component of the Arkansas State Water Plan. The objectives are:

(1) to incorporate into the report newly developed and compiled data available;

(2) to address new and existing problems;

(3) to present current solutions and recommendations; and

(4) to satisfy the requirements of Act 1051 of 1985 for the Red River Basin above Fulton.

ABSTRACT

The Red River Basin above Fulton, Arkansas consists of nearly 1.5 million acres of gently rolling to steep mountainous areas in the southwest part of the state. Forest land accounts for about 65 percent and cropland covers about 5 percent of the total land use in the basin. Water is available from both surface water and ground water sources. The Red River, Little River, Rolling Fork, Saline River and the Cossatot are the principal streams, and the Quaternary the source of 50 percent of the ground water withdrawn in the basin.

Streams in the Red River Basin above Fulton have a combined yield of approximately 12.4 million acre-feet of water on an average annual basis of which 1.1 million acre-feet is excess surface water and is available for other uses such as interbasin transfer. Runoff varies seasonally as well as annually, with the area subject to extremes of both flood and drought. Seasonal variability is characterized by low flows which usually occur from August through October. This period of lowest streamflow parallels the season of greatest water needs. In response to Act 1051 of 1985 the following actions were taken:

(1) instream flow requirements were identified for riparian needs, water quality, fish and wildlife, navigation, and interstate compacts;

(2) minimum streamflows were defined and established for selected streams for the purpose of protection of all instream flow needs during low-flow conditions; and

(3) safe yield of streams was quantified for selected streams.

Water quality problems associated with the Red River originate principally outside the Red River Basin above Fulton and more specifically in the area above Denison Dam. The pollution problems consist mostly of high chloride concentration and turbidity. Also, non-point source pollution from agriculture and silviculture often deteriorate the water quality in some of the basin streams. Point source pollution from M & I uses frequently contaminate streams for short periods of time.

Recommendations for surface water quality problems include closer monitoring of basin streams for detecting and controlling stream contamination. Best Management Practices (BMP's) installed within and above the basin could reduce the water quality problems especially in the Red River. Watershed protection projects are excellent programs to help implement BMP's in agriculture areas. Also, water conservation, if practiced continually throughout the basin, can result in more water of higher quality.

Recommendations for surface water quantity problems include on-farm water storage reservoirs and interbasin transfer of water to areas of need utilizing facilities constructed, operated, and maintained by various types of water districts.

The Quaternary, Cretaceous, and Paleozoic Age aquifers in the Red River Basin above Fulton contain freshwater. Ground water withdrawals in 1980 from the Quaternary aquifer was 5.62 million gallons per day which represents 50 percent of the total ground water withdrawn in the basin and was used primarily for irrigation of crops in Little River County. Withdrawals from the Paleozoic was 2.61 mgd or 23 percent of the basin total with the use being mainly for rural and domestic purposes in Polk County.

The remaining ground water withdrawals in the basin during 1980 were:

Tokio formation - 1.46 mgd (13 percent)
Trinity Group - 1.24 mgd (11 percent)
Nacatoch Sand - 0.3 mgd (3 percent)

The major ground water problem in the basin is the limited supply of the ground water resource. Although ground water supplies are extremely limited, no areas were determined as critical ground water areas. The primary reason for not determining some areas critical is that ground water withdrawals are self-limiting due to natural geologic constraints, a fact well known by most basin users. In addition, all of the basin aquifers exceed the conditions defined as critical ground water areas.

Most basin aquifers yield water that requires some treatment for most uses other than for irrigation. Hardness and/or iron concentrations are problematic in the Quaternary, Paleozoic, and Tokio aquifers. In the Tokio, Nacatoch, and Trinity aquifers, excessive chloride concentrations are abruptly encountered from a few miles up to 20 miles downdip from the outcrops. Very limited yields (less than 10 gpm) are characteristic of the Paleozoic.

Potential exists over much of the basin for contamination of the aquifers especially from the outcrop areas. These potential hazards include landfills, hazardous waste, and surface impoundments (waste holding). Some programs now exist for monitoring and controlling these sites; however, these programs are yet inadequate to properly protect the basin ground water resources.

The primary recommendation for meeting the limited ground water supply problem is the greater utilization of the more abundant surface water resources of the basin. Many larger towns and communities and M & I facilities are turning to surface water to satisfy their needs.

TABLE OF CONTENTS

PAGE

PAGE

PAGE

LIST OF FIGURES

PAGE

Chapter I

Chapter II

Chapter III

Chapter IV

LIST OF TABLES

Page

CHAPTER I

CHAPTER II

CHAPTER III

PAGE

CHAPTER IV

CHAPTER I

GENERAL DESCRIPTION

LOCATION AND SIZE

The Red River Basin above Fulton, Arkansas (herein referred to as the Red River Basin above Fulton) consists of about 2,276 square miles, or 1,456,572 acres and is located in the southwestern part of Arkansas. <38> (Numbers in angle brackets refer to the reference numbers cited in the bibliography) The basin is bounded on the west by Oklahoma and on the south by Texas. (See Figure 1-1) <52>

In order to comply with the requirements of Arkansas Act 1051 (1985), basic data in this report was compiled and presented according to surface drainage or watershed boundaries established on the Arkansas Hydrologic Unit Map (U.S. Water Resources Council) rather than on sub-surface divisions such as geologic formations or aquifers. Figure 1-1 shows the Red River Basin above Fulton boundary and contains information from the Arkansas Hydrologic Unit Map. <52> The heaviest weighted line on Figure 1-1 corresponds to the Regional Boundary and the lightest weighted line corresponds to the Cataloging Boundary. The units delineated by these lines are utilized by the U.S. Geological Survey in their management of the National Water Data Network. (See Figure 1-1 Legend) The Red River Basin above Fulton area is bounded by the Regional Boundary Line on the east, by Texas on the south and by Oklahoma on the west.

All of two counties and parts of four other counties are within the basin. The counties with corresponding total acreages and percentages of each county in the basin are: Hempstead - 41,755 acres (8.8 percent); Howard - 334,611 acres (87.1 percent); Little River - 359,040 acres (100.0 percent); Miller - 12,298 acres (3.0 percent); Polk - 334,468 acres (60.8 percent); and Sevier - 374,400 acres (100.0 percent). (See Table 2-1) <38>

The basin has an overall length of about 70 miles in a north-south direction and averages about 35 miles in width. The main watercourse is a 50-mile reach of the Red River that makes up the basin's southern boundary. In addition to the Red River, other major streams located in the basin are the Saline River, Cossatot River, Rolling Fork River, Walnut Bayou, and Little River. <53>

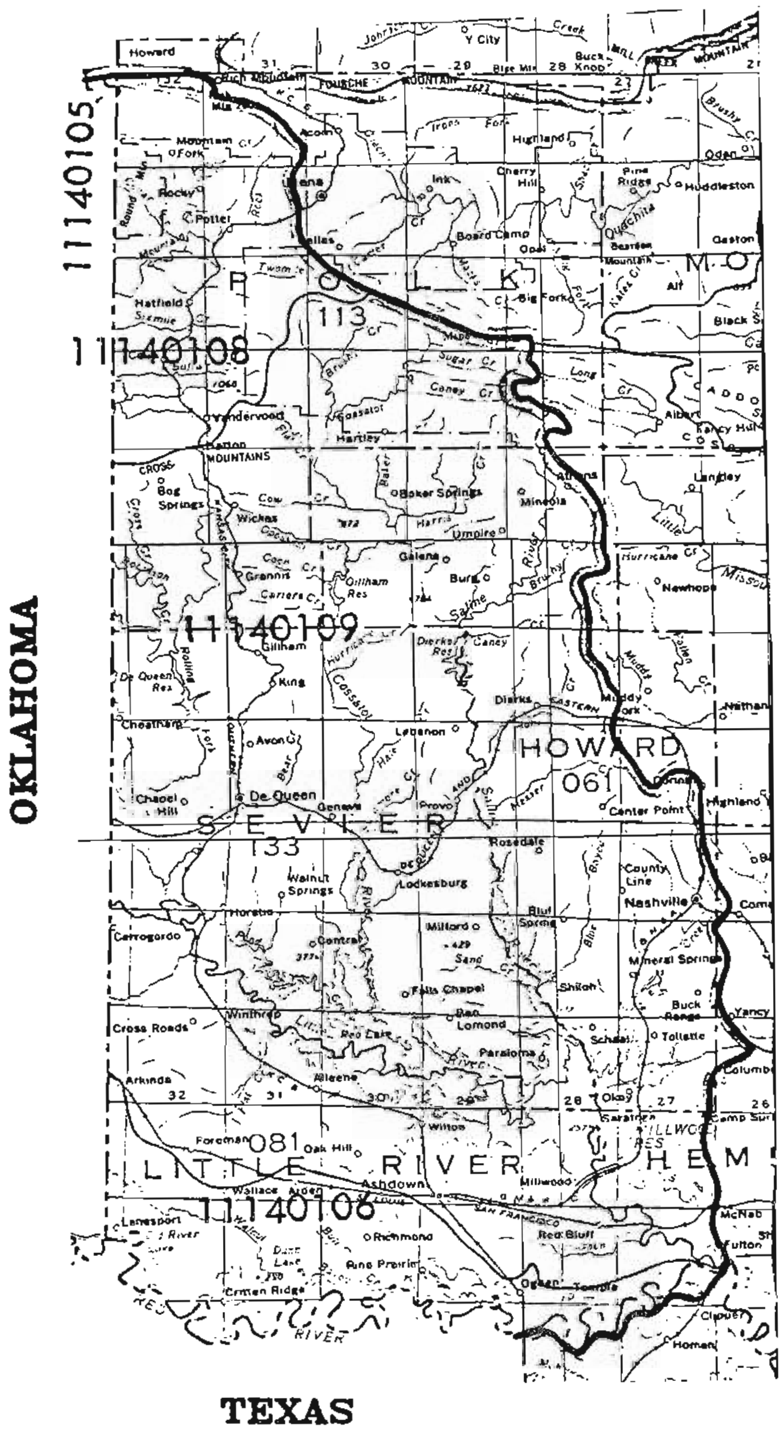
Four major impoundments, all Corps of Engineers projects, are located in the basin. These impoundments are DeQueen Lake on Rolling Fork River, Gillham Lake on the Cossatot River, Dierks Reservoir on the Saline River, and Millwood Lake on Little River.

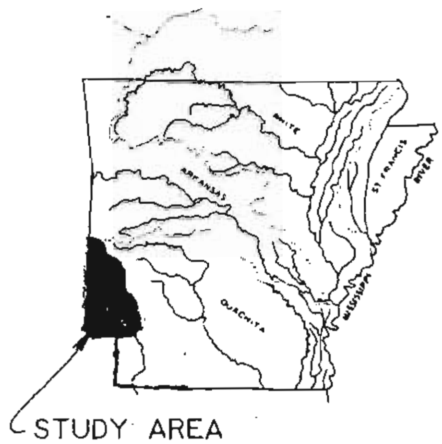
TOPOGRAPHY

Elevations in the basin range from a high of about 2,700 feet National Vertical Geodetic Datum (NVGD) in the Poteau Mountains in the northern part of the basin to about 250 feet NVGD along the bottomlands of the Red River. Relief of the basin ranges from the steep mountainous areas of the Ouachita Mountains to the gently rolling areas of the Western Coastal Plain.

Figure 1-1

RED RIVER BASIN ABOVE FULTON HYDROLOGIC UNIT MAP





N

EXPLANATION

REGIONAL (BASIN) BOUNDARY

CATALOGING UNIT BOUNDARY

11140106 CATALOGING UNIT NUMBER

Scale : 1" = Approx. 13 Miles

POPULATION

Census data for four of the six basin counties (Howard, Little River, Polk, and Sevier) was used to profile the study area's population. Hempstead and Miller Counties combined account for less than 12 percent of the total basin area. It was determined that incorporation of census data from these two counties in the development of population trends and projections could cause the results to be misleading.

The total 1980 population of the four counties in the study area was 58,478, an increase of about 11,300 people from the 1970 census. <66> Each of these counties showed an increase in population. Table 1-1 shows the population trend in the four counties since 1900. <41> <66>

Arkansas Department of Pollution Control and Ecology projections show a population increase from 58,478 to 76,720 by the year 2000, an increase of about 31 percent. (Table 1-2) The Arkansas Soil and Water Conservation Commission extended a straight line projection to the year 2030, and projections indicate the population will be about 104,250, an increase over the year 2000 by almost 36 percent. The above figures amount to an overall increase from 1980 to the year 2030 of about 78 percent.

TABLE 1-1: POPULATION BY COUNTY

County	Years 1900	1910	1920	1930	1940	1950	1960	1970	1980
Howard	14,076	16,898	18,565	17,489	16,621	13,342	10,878	11,412	13,459
Little River	13,731	13,597	16,301	15,515	15,932	11,690	9,211	11,194	13,952
Polk	18,352	17,216	16,412	14,857	15,832	14,182	11,981	13,297	17,007
Sevier	16,339	16,616	18,301	16,364	15,248	12,293	10,156	11,272	14,060
Total	62,498	64,327	69,579	64,225	63,633	51,507	42,226	47,175	58,478

Sources: Research and Public Services <66>
U. S. Department of Commerce <41>

TABLE 1-2: POPULATION PROJECTIONS

County	Years 1980	2000 1/	2030 2/
Howard	13,459	16,930	22,190
Polk	17,007	24,540	35,740
Little River	13,952	18,420	25,010
Sevier	14,060	16,830	21,310
Total	58,478	76,720	104,250
Percent Change		+ 31.2	+35.9

1/ Arkansas Department of Pollution Control & Ecology

2/ Arkansas Soil and Water Conservation Commission

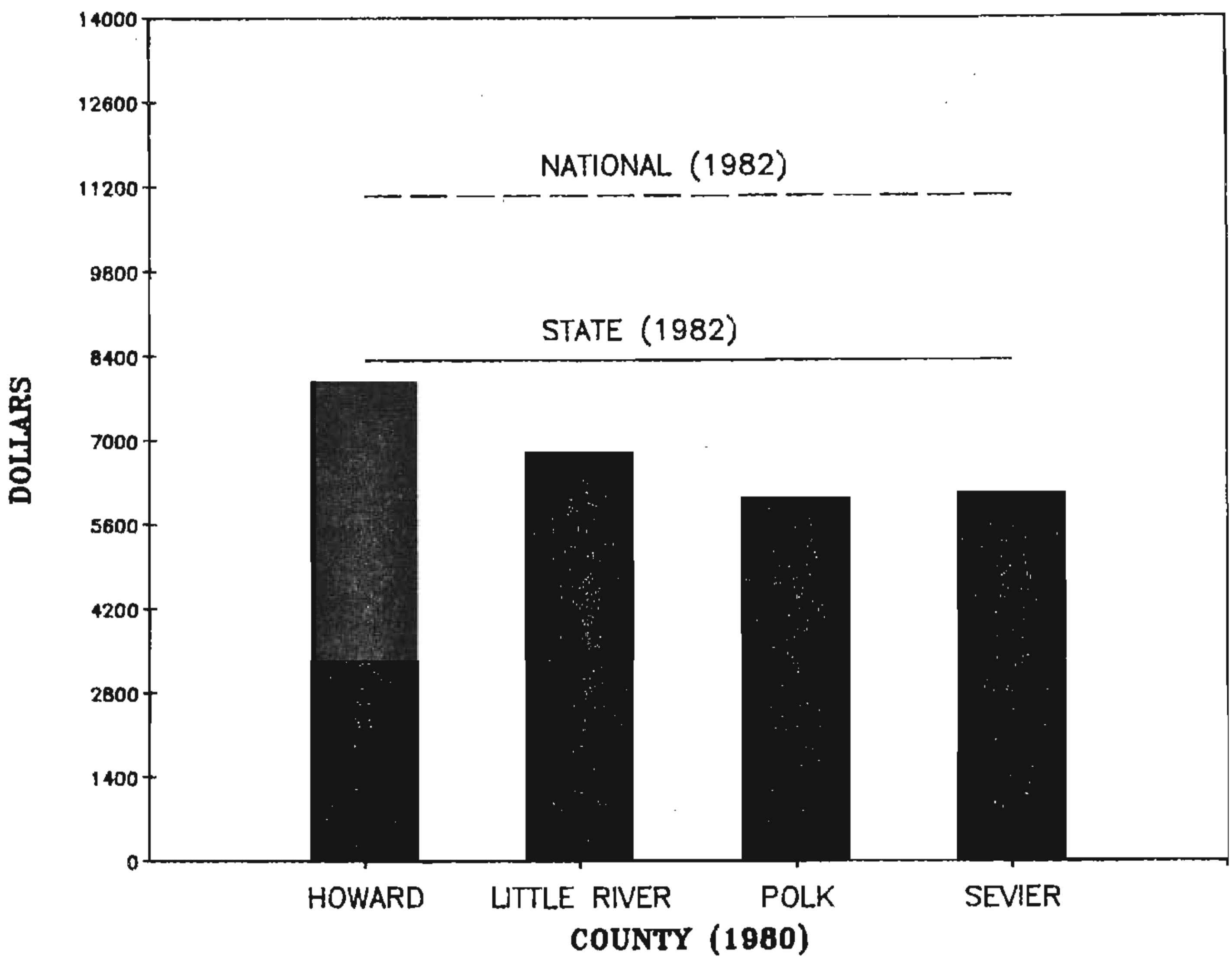
Source: U.S. Department of Commerce <41>

ECONOMY

The 1980 average per capita personal incomes for the four counties ranged from a low of $6,021 in Polk County to a high of $7,980 in Howard County. Howard County's per capita income ranks as the fifth highest per capita personal income in the state. The 1980 per capita income for Arkansas was $7,185. <42> In 1982, average per capita incomes of $8,332 and $11,056 were reported for Arkansas and the United States, respectively. (See Figure 1-2) <6>

Figure 1-2

PER CAPITA INCOME

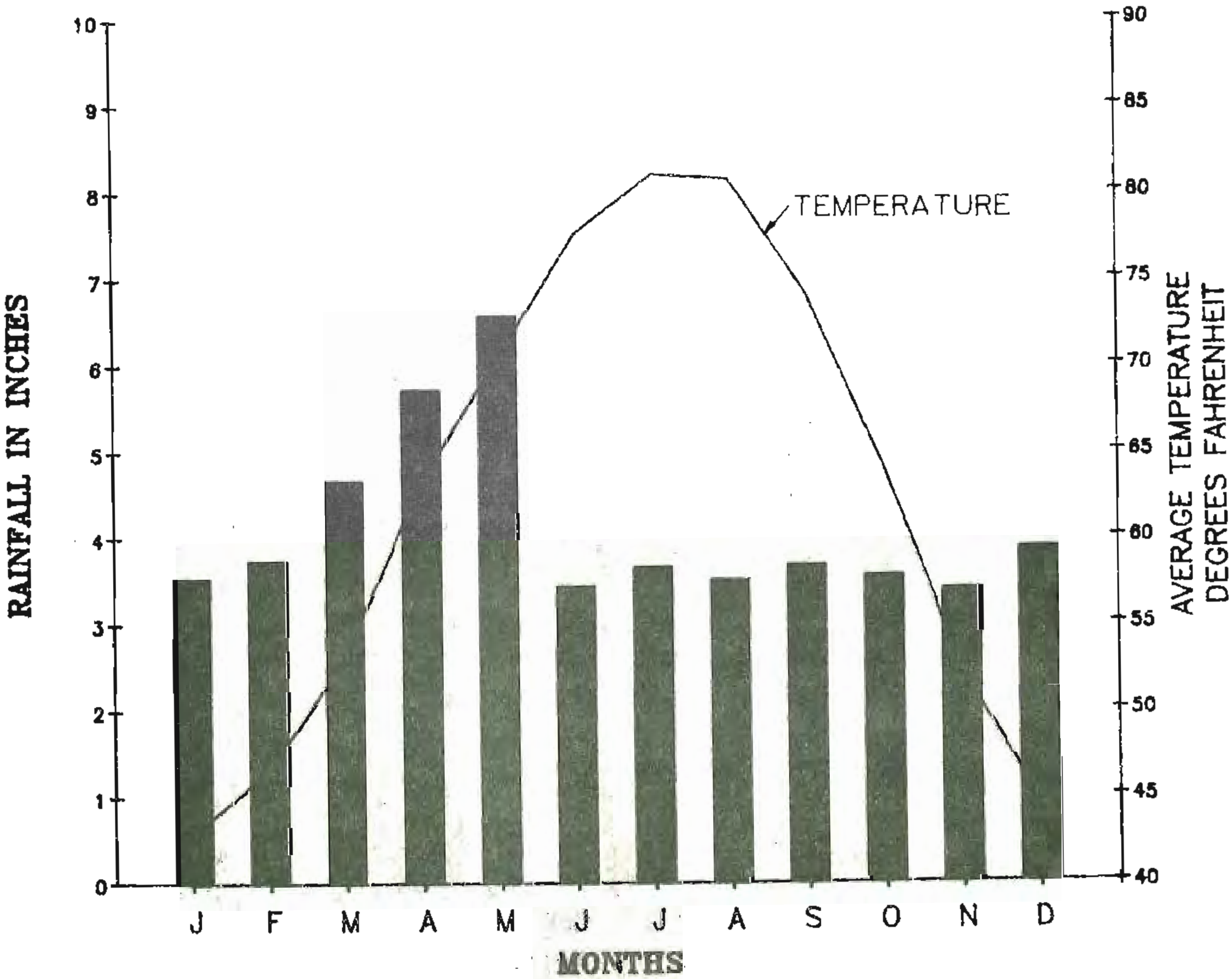


Source: Ark. Employment Security Division & U.S. Dept. of Commerce <6,42>.

CLIMATE

The climate in the basin is humid with warm summers. Mean temperatures range from 81.0 degrees Fahrenheit in July to 42.9 degrees Fahrenheit in January. The average annual temperature is 62.5 degrees Fahrenheit. Recorded temperature extremes are 114.0 degrees Fahrenheit and minus 14.0 degrees Fahrenheit. The average annual rainfall in the basin is about 49 inches. (See Figure 1-3 for the average monthly rainfall and temperature from the DeQueen gage) <44> Climatic data were selected from a 30-year (1941-1970) weather bureau record at DeQueen, Arkansas, located in the central part of the basin. (See Figure 1-4) <43>

Figure 1-3
AVERAGE MONTHLY RAINFALL AND TEMPERATURE
DEQUEEN GAGE



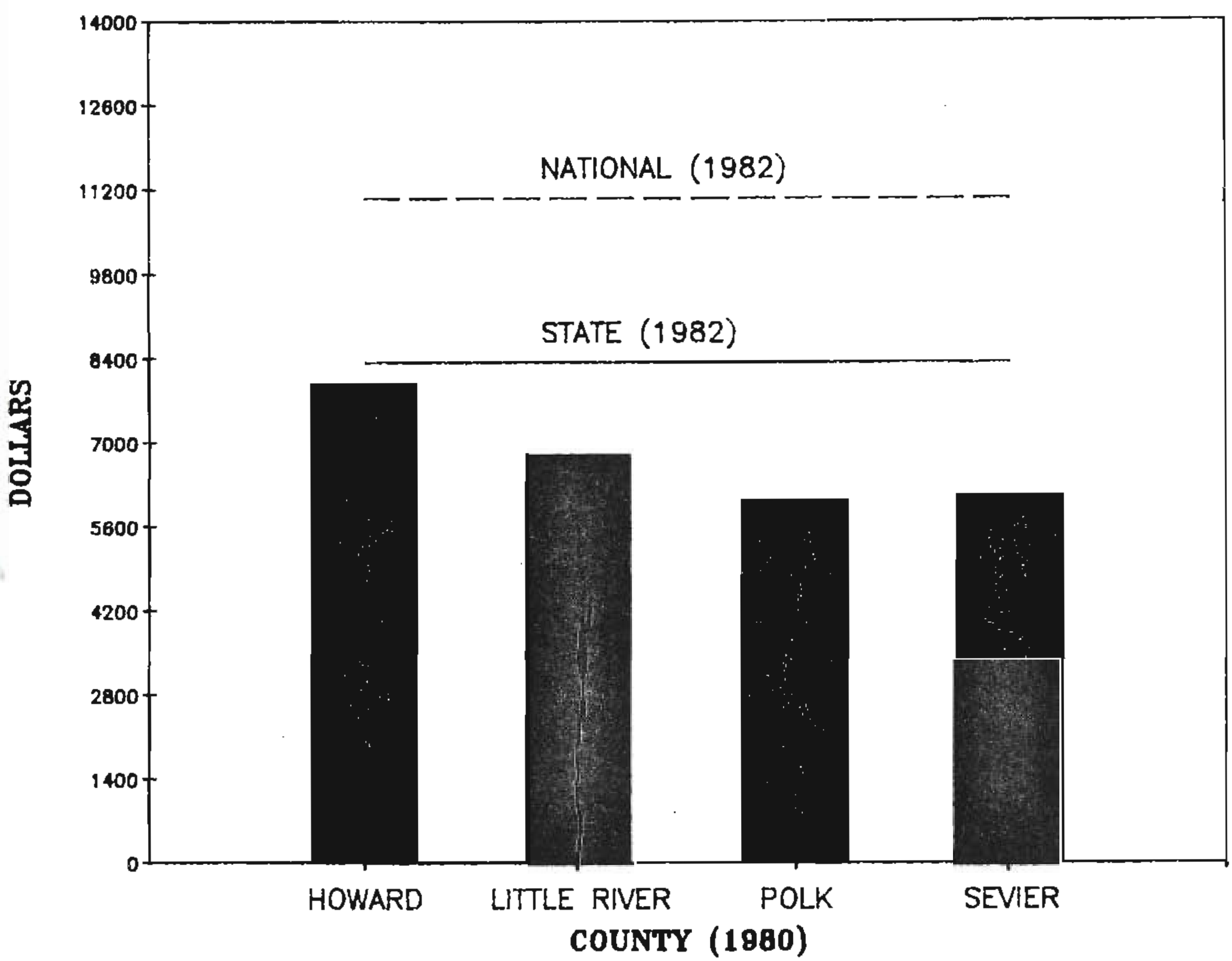
Source: U.S. Department of Commerce <44>.

ECONOMY

The 1980 average per capita personal incomes for the four counties ranged from a low of $6,021 in Polk County to a high of $7,980 in Howard County. Howard County's per capita income ranks as the fifth highest per capita personal income in the state. The 1980 per capita income for Arkansas was $7,185. <42> In 1982, average per capita incomes of $8,332 and $11,056 were reported for Arkansas and the United States, respectively. (See Figure 1-2) <6>

Figure 1-2

PER CAPITA INCOME

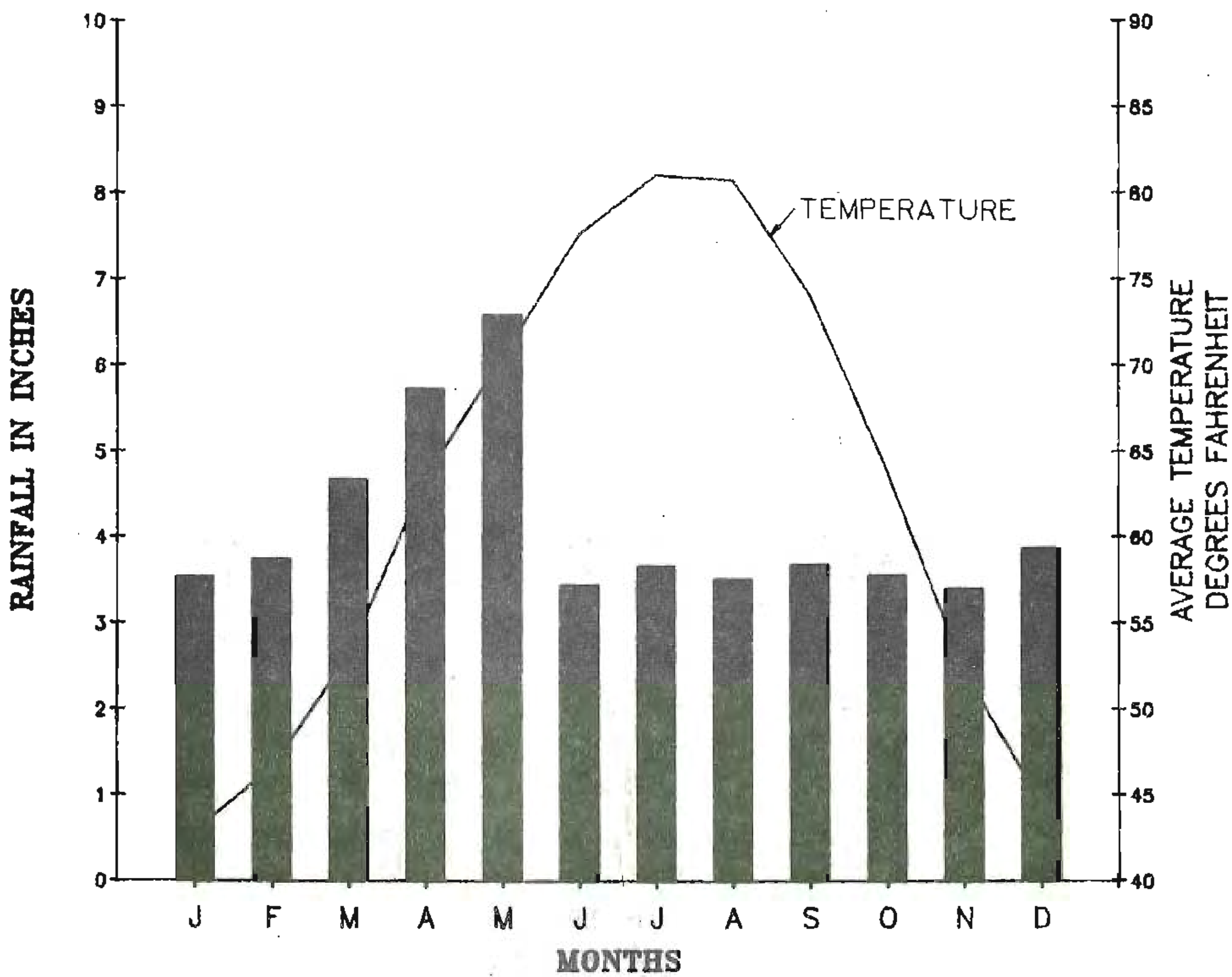


Source: Ark. Employment Security Division & U.S. Dept. of Commerce <6,42>.

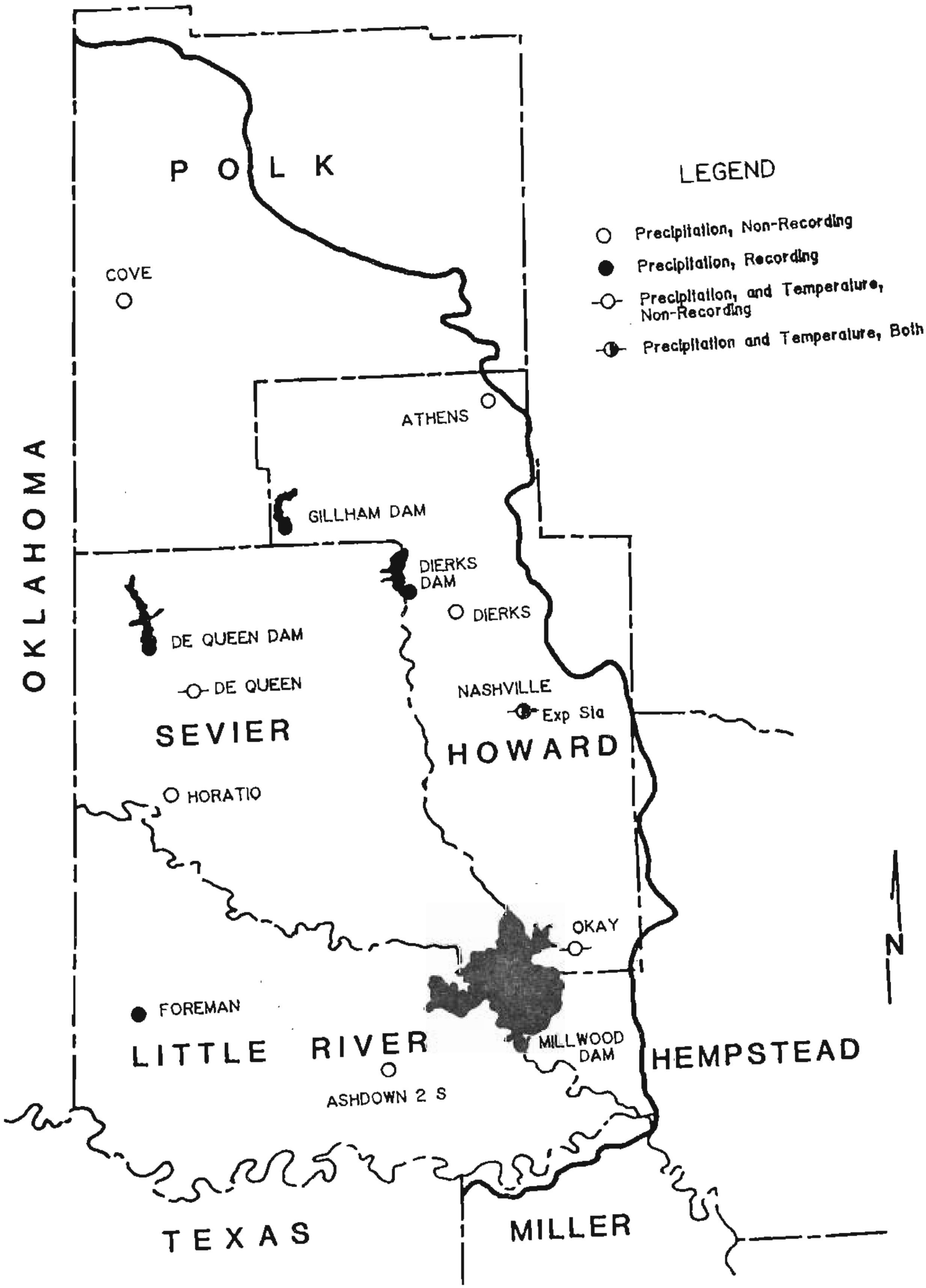
CLIMATE

The climate in the basin is humid with warm summers. Mean temperatures range from 81.0 degrees Fahrenheit in July to 42.9 degrees Fahrenheit in January. The average annual temperature is 62.5 degrees Fahrenheit. Recorded temperature extremes are 114.0 degrees Fahrenheit and minus 14.0 degrees Fahrenheit. The average annual rainfall in the basin is about 49 inches. (See Figure 1-3 for the average monthly rainfall and temperature from the DeQueen gage) <44> Climatic data were selected from a 30-year (1941-1970) weather bureau record at DeQueen, Arkansas, located in the central part of the basin. (See Figure 1-4) <43>

Figure 1-3
AVERAGE MONTHLY RAINFALL AND TEMPERATURE
DEQUEEN GAGE



Source: U.S. Department of Commerce <44>.



SOURCE : U.S. DEPARTMENT OF COMMERCE <43>

CHAPTER II

LAND RESOURCES INVENTORY

LAND USE

Of the total 1,456,572 acres in the basin, forest land accounts for 944,448 acres or 64.9 percent. Grassland occupies 390,670 acres or 26.8 percent of the basin and is used for pasture or hay for beef and dairy cattle production. Cropland covers 66,923 acres or 4.6 percent of the basin. About 89 percent of the cropland is in soybeans, 3 percent in rice, and the remaining 8 percent in a variety of other crops such as sorghum and corn. The remaining 54,531 acres or 3.7 percent is used for other purposes such as urban development, impoundments, or farmsteads. (See Table 2-1 and Figure 2-1) <38> Figure 2-2 shows cropland trends. <26>

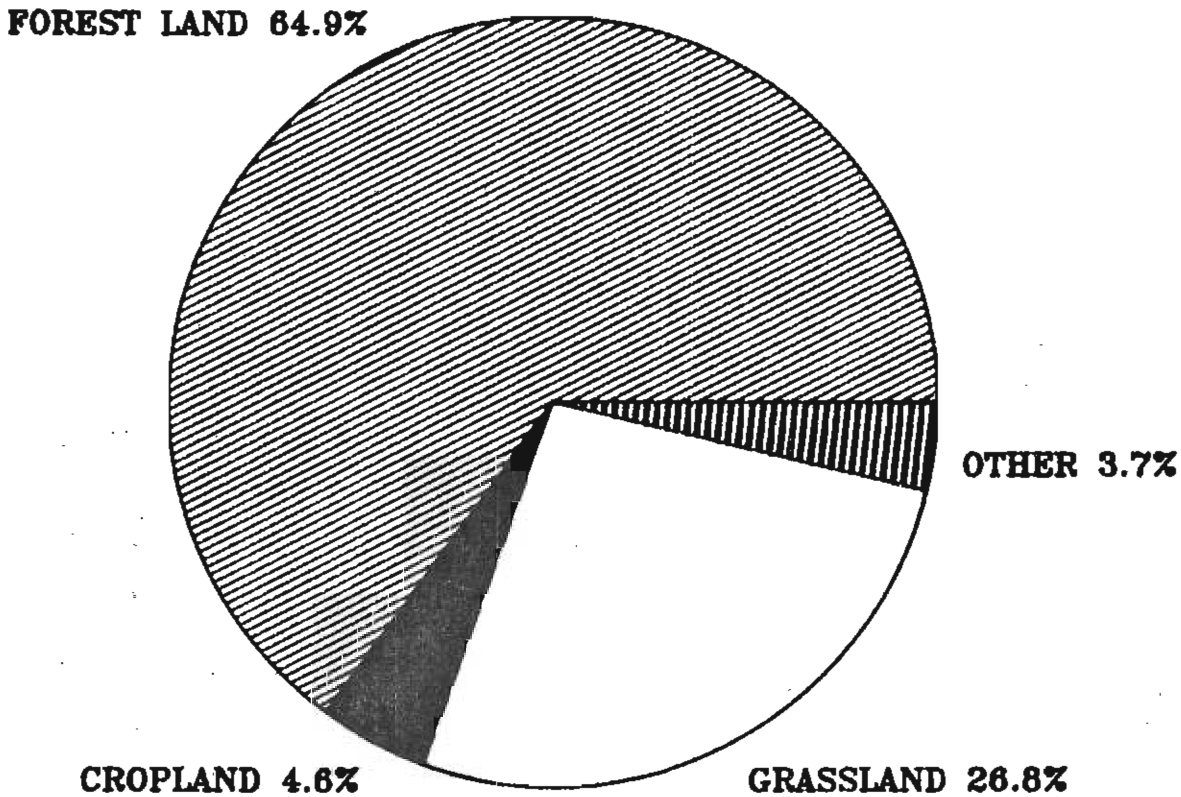
TABLE 2-1: LAND USE BY COUNTY

County	Cropland	Grassland	Forest Land	Urban & Builtup	Other	Total Acres in Basin	Total Acres in County	Percent of County in Basin
Hempstead	2,428	15,522	19,645	2,080	2,080	41,755	474,880	8.8
Howard	2,415	105,287	224,494	-	2,415	334,611	384,000	87.1
Little River	51,772	102,294	172,546	-	32,428	359,040	359,040	100.0
Miller	5,521	1,936	2,761	-	2,080	12,298	410,880	3.0
Polk	2,359	45,809	281,684	-	4,616	334,468	550,400	60.8
Sevier	2,428	119,822	243,318	-	8,832	374,400	374,400	100.0
Total	66,923	390,670	944,448	2,080	52,451	1,456,572	-	-
Percent	4.6	26.8	64.9	0.1	3.6		-	-

Source: USDA, Soil Conservation Service <38>

Figure 2-1

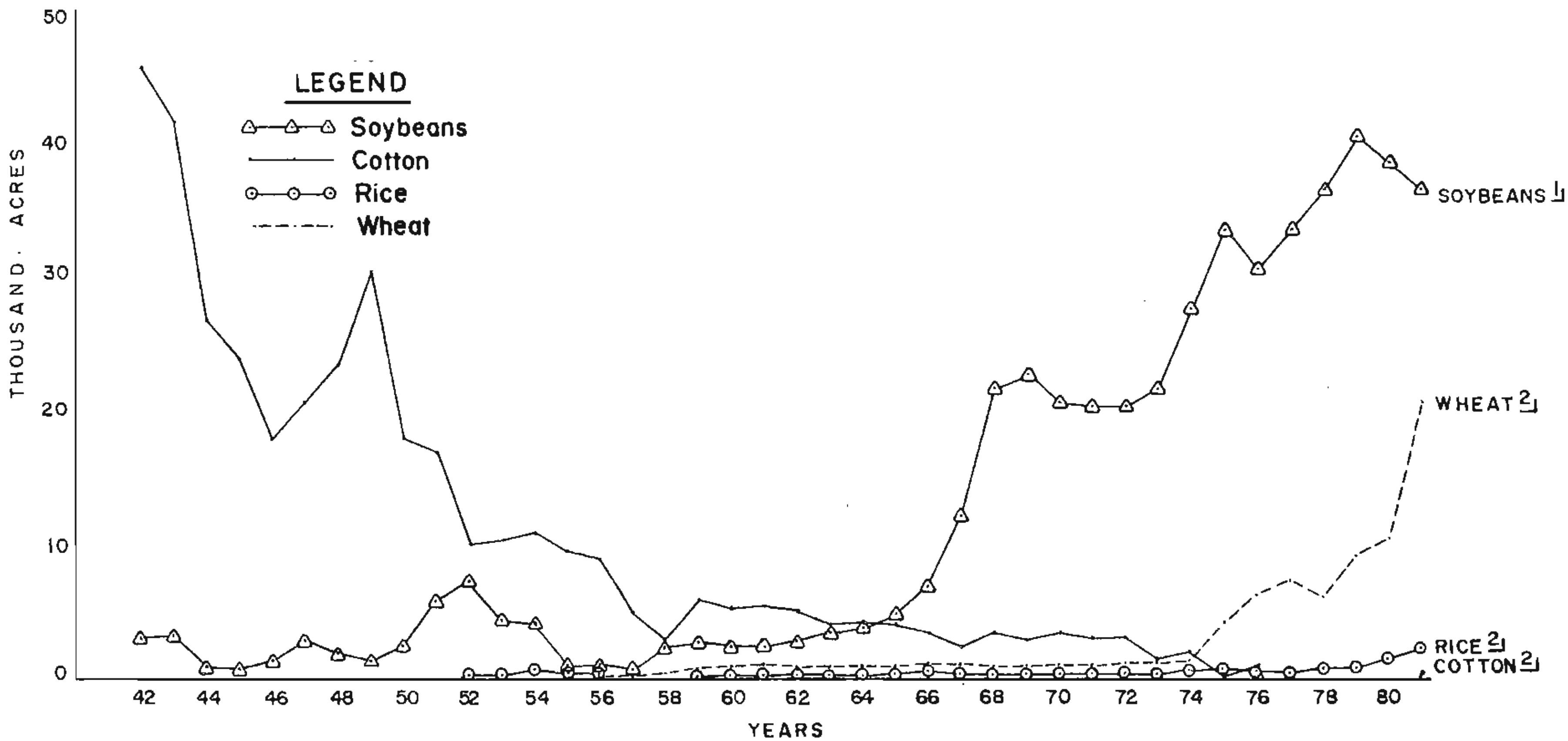
LAND USE IN THE BASIN



SOURCE: USDA, SOIL CONSERVATION SERVICE <38>.

Figure 2-2

TREND IN ACREAGE OF MAJOR CROPS GROWN IN STUDY AREA



1/ ACRES HARVESTED
2/ ACRES PLANTED

Forest Land

Forest land in the basin is defined as land with a 10 percent or more tree canopy cover of any size forest trees or land formerly having had such tree cover, and not currently developed for non-forest use.

Of the present land use in the basin, 64.9 percent (944,448 acres) is forest land. (See Table 2.1) <38> About 12 percent (115,223 acres) of this forest land is located in the Ouachita National Forest and is owned by the Federal government. Forest industries own about 52 percent of the forest land and the remaining 36 percent is privately owned. <38> There is no state-owned or city-owned forest lands in the basin.

Table 2-2 shows forest land percentages by type and ownership. Nearly all (99.7 percent) of the forest land in the study area is commercially managed.

TABLE 2-2: FOREST LAND BY TYPE
(Percent)

Loblolly - Shortleaf Pine	43.8
Oak - Pine	40.8
Oak - Hickory	7.1
Oak - Gum - Cypress	6.5
Elm - Ash - Cottonwood	1.8
	100.0

FOREST LAND BY OWNERSHIP
(Percent)

Federal	12.2
Forest Industry	51.7
Private	36.1
	100.0

Source: USDA, Soil Conservation Service <38>

Prime Farmland

Prime farmland is land having the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. Prime farmland can be cropland, pastureland, rangeland, forest land, or other land, but not urban or built-up land, or water.

Prime farmland soils must meet all the following criteria: (1) have adequate and dependable water supply from precipitation or irrigation, (2) have a favorable temperature and growing season, (3) have acceptable acidity or alkalinity, (4) are not saturated with water during the growing season, (5) have low salt and sodium content, (6) are not flooded during the growing season, (7) are not highly erodible, (8) are permeable to air and water, and (9) contain few or no coarse fragments. More detailed criteria for prime farmland are given in the Federal Register, Vol. 43, No. 21, Tuesday, January 31, 1978.

The study area has 421,000 acres of prime farmland, 3.6 percent of the state total. Of this total, 53,200 acres (12.6 percent) are cropland, 140,000 acres (33.3 percent) are pastureland, 223,400 acres (53.1 percent) are forest land and 4,400 acres (1.0 percent) are minor land uses. <38><35> Figure 2-3 shows the range of percentages of prime farmland in the basin.

Irrigated Cropland

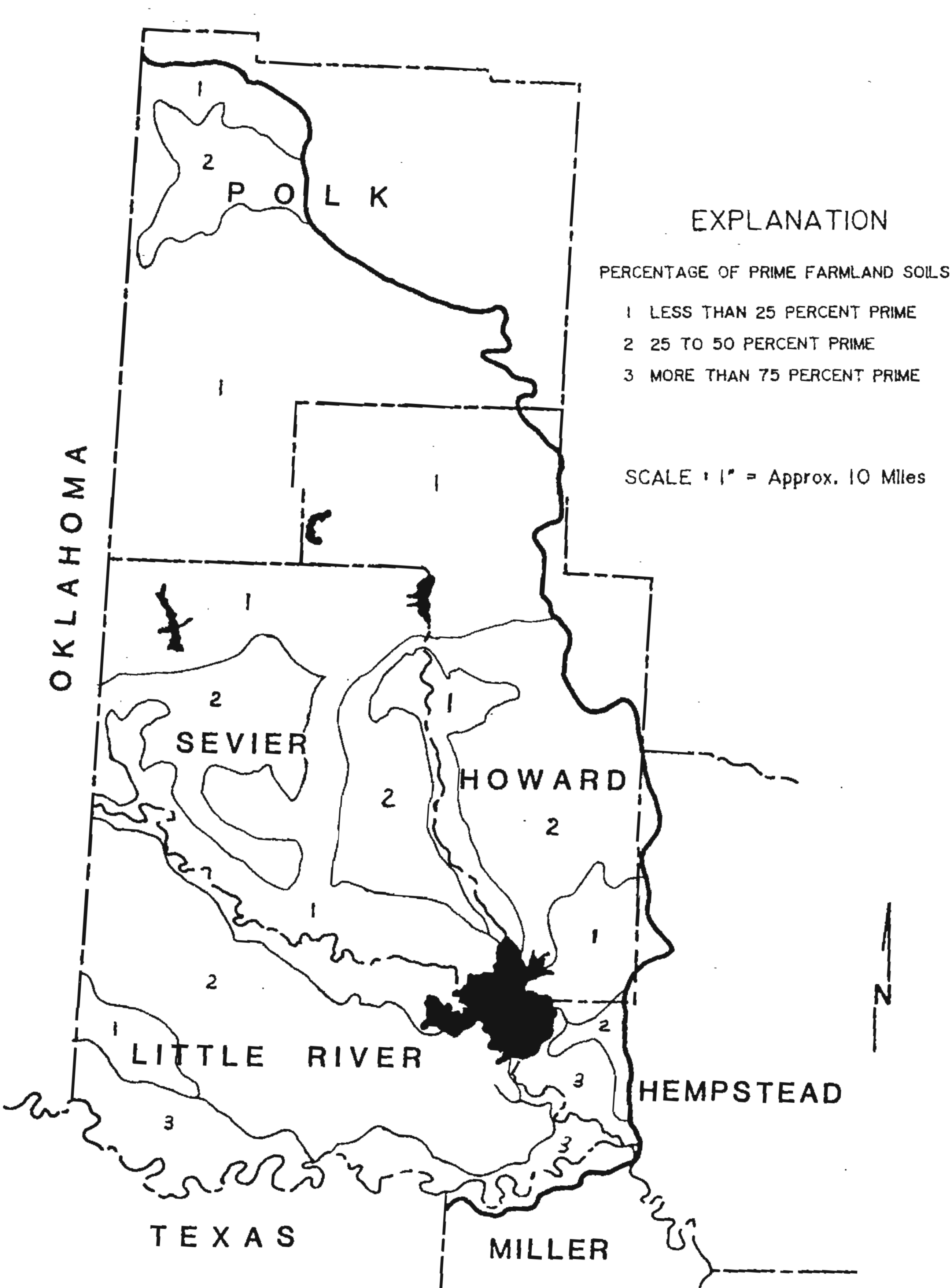
Data compiled for the United States Department of Agriculture (USDA), Agriculture Water Use Study shows a total of 5,497 irrigated acres in the study area in 1980 <31>. Irrigated acres represent 8 percent of the total cropland in the basin. Soybeans is the major irrigated crop with 3,588 acres (65 percent) followed by rice with 1,756 acres (32 percent).

Potential for Irrigated Cropland

To preserve a sufficient amount of water for future agriculture uses in this basin and quantify the excess water for possible interbasin transfer, the determination of maximum agriculture water needs is essential. Projection techniques were used by the USDA Economic Research Service to estimate the maximum potential acreage of irrigated cropland in the combined, above Fulton and below Fulton, Red River Basins. These projections were made in conjunction with the Arkansas Statewide Study, Phase V. <29> The projections were based on 1980 irrigated acreage data and expanded to the years 2000 and 2030. (See Table 2-3) A profit maximization linear programming model was used as an aid in estimating irrigated acres for the year 2030. Institutional and physical restraints were included but water availability and cost of converting prime farmland to cropland was not considered.

Figure 2-3

PRIME FARMLAND



SOURCE: USDA, SOIL CONSERVATION SERVICE < 37 >

As previously stated, projections of maximum potential irrigated acreage were established for the entire Red River Basin area of Arkansas (above and below Fulton combined). To determine the projected acreage of maximum potential irrigated cropland in each of the above and below Fulton basins, the percentage of total cropland in each basin for 1977 was applied to the maximum potential acreage of each crop.

For example, the combined basin had 221,010 acres of cropland in 1977. <38> The Red River Basin above Fulton had 66,923 acres of cropland or about 30 percent of the total. (See Table 2-3) The result of 30 percent times the projected total basin irrigated acreage of each crop for the year 2030 is shown in Table 2-3. The year 2000 was then determined from a straight line projection.

Table 2-3 projects a maximum 100,710 acres of irrigated cropland by the year 2030. Table 2-3 does not include acreage for orchards and vineyards, vegetables, surface water areas for recreation, and other miscellaneous uses. The total basin cropland (irrigated and non-irrigated) is 66,923 acres. (See Table 2-1). If the estimated 100,710 acres are actually irrigated by 2030, an additional 33,787 acres must be converted from some other land use assuming all the current 66,923 acres of irrigated and non-irrigated cropland is irrigated. The conversion would likely come from the 421,000 acres of prime farmland in the study area of which 140,000 acres are pastureland.

TABLE 2-3: IRRIGATED CROP ACREAGE PROJECTIONS

Year	Soybeans	Sorghum	Rice	Corn	Cotton	Total
	(Acres)					
1980 1/	3,588	71	1,756	82	0	5,497
2000 2/	33,257	115	7,030	289	3,012	43,414
2030 3/	77,760	180	14,940	300	7,530	100,710

Sources: 1/ USDA, Soil Conservation Service <31>
2/ Straight line projection
3/ USDA, Soil Conservation Service <29>

Wetlands

Wetlands are areas inundated or saturated by surface water or ground water at a frequency and duration sufficient to support a prevalence of plants which are adapted for life in saturated soil conditions. Such areas in Arkansas are commonly referred to as swamps, sloughs, shallow lakes, ponds, and river-overflow lands.

As part of an inventory of the Nation's resources, the SCS collected information about wetlands in 1982. <35> Inventory sample areas were classified with respect to types of wetlands as described in Wetlands of the United States, Circular 39. <50> Within the Red River Basin above Fulton, a total of 46,800 acres of wetlands, including river-overflow lands and permanently flooded sloughs and swamps, were estimated to occur. <35>

SOIL RESOURCES

Major Land Resource Areas

The four major land resource areas (MLRA) in the basin are the Ouachita Mountains, Western Coastal Plain, Southern Mississippi Alluvium, and Blackland Prairie. These major land resource areas are illustrated in Figure 2-4. A general description of each area is provided in the following paragraphs.

Ouachita Mountains (MLRA)

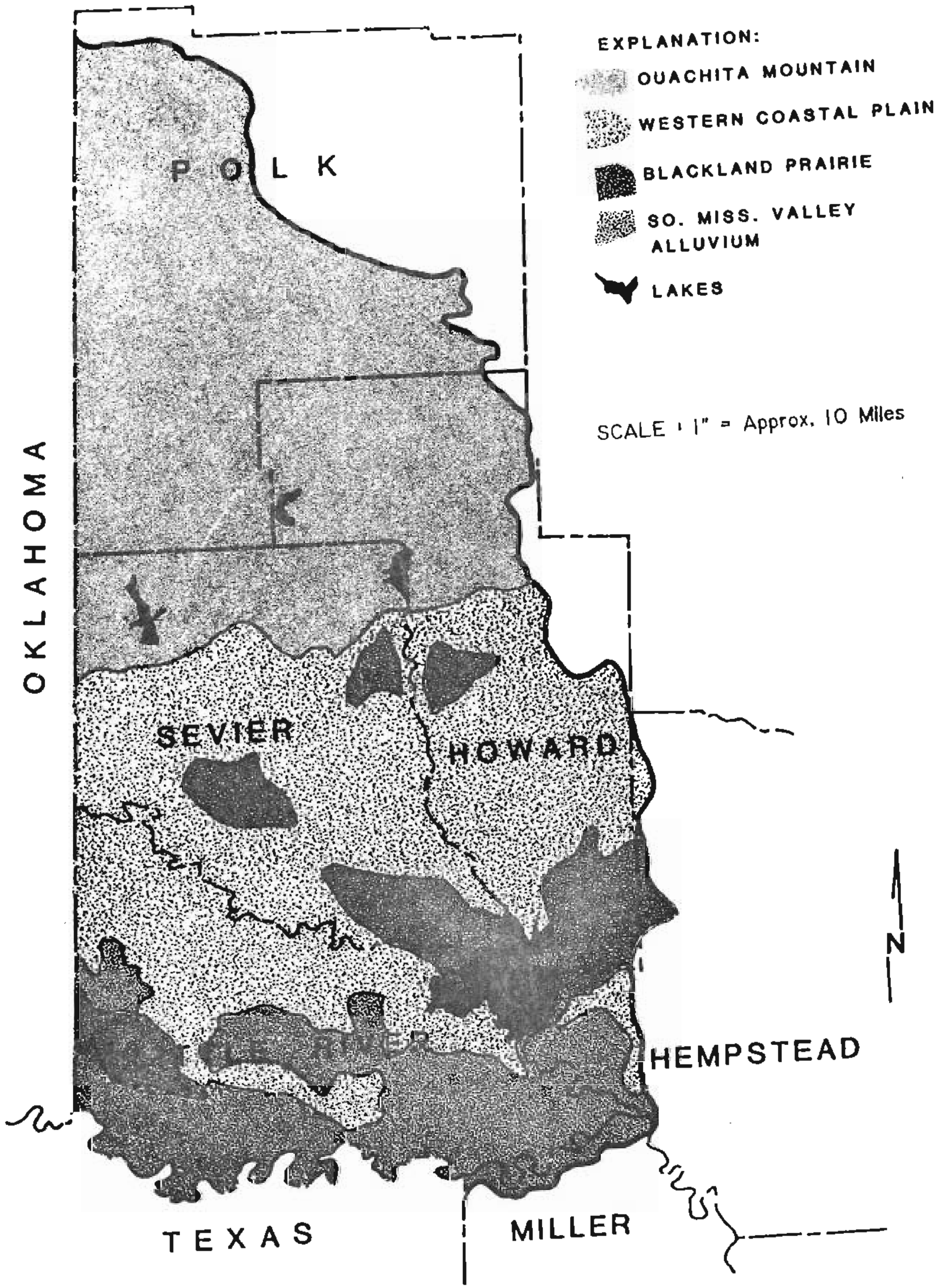
The Ouachita Mountains consist of a series of east-west ridges and valleys in the west-central part of the state. Common bedrock is shale, slate, quartzite, novaculite and sandstone. The rocks are generally steeply inclined and fractured and folded. Elevations range from about 500 feet to 2,700 feet NVGD. Soils are deep to shallow and moderately permeable to slowly permeable. Surface textures are mainly sandy loam, loam, silt loam or their gravelly, very gravelly, cobbly, very cobbly, or stony analogues. Slopes range from level to gently sloping in the valleys to moderately sloping to very steep on the mountain sides. Most of the area is used for timber production, however, some narrow valleys have been cleared and are used for pasture production. The Ouachita Mountain MLRA accounts for 561,300 acres or about 39 percent of the basin area. <28> <33>

Western Coastal Plain (MLRA)

The Coastal Plain consists of rolling terrain broken by stream valleys. Elevations range from about 100 feet to 500 feet NVGD. The deep soils developed from marine sediments and are rapidly to slowly permeable. The surface textures are mainly sandy loam or silt loam. Slopes are level to nearly level on flood plains and terraces and nearly level to moderately sloping on uplands. This area is used extensively for timber production and pasture. The Coastal Plain accounts for about 38 percent or 559,300 acres of the study area. <28> <33>

Southern Mississippi Valley Alluvium (MLRA)

Southern Mississippi Valley Alluvium consists of broad alluvial plains in the extreme eastern part of the basin. Elevations range from about 100 feet to 400 feet NVGD. Soils are developed from deep alluvial 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 undulating. Most of the area is used for production of cultivated crops. Some areas remain forested and are important for hardwood production and wildlife habitat. The MLRA makes up approximately 15 percent or 213,000 acres of the basin area. <28>, <33>



SOURCE : USDA, Soil Conservation Service.<33>

Blackland Prairie (MLRA)

The Blackland Prairie consists of gently rolling areas in the southwestern part of the state. Elevations range from 300 feet to 700 feet NVGD. Much of the area is in farms and about 10 percent is in urban or minor land uses. Soils are formed mainly from calcareous marls and chalk. Soils are shallow to deep and slowly permeable to very slowly permeable. Surface textures are mainly silt loam or clay. Slopes are dominantly nearly level to moderately steep. Blackland Prairie accounts for about 8 percent or 122,972 acres of this basin. <28> <33>

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, Agriculture Extension Service, U. S. Forest Service, Arkansas Highway Department, the 76 soil and water conservation districts, and other state and federal agencies. Complete soil surveys for four of the six counties in the basin have been published. The counties and corresponding date of publication are: Little River (1984), Hempstead (1979), Miller (1984), and Howard (1975). Soil surveys for Sevier and Polk Counties are presently in progress.

General Soil Units

In the Red River Basin above Fulton, there are four soil units of the Western Coastal Plain MLRA, three soil units of the Southern Mississippi Valley Alluvium, one soil unit of the Blackland Prairie, and four soil units of the Ouachita Mountains MLRA. Additional information for these soil units can be found in published county soil surveys and the General Soil Map of Arkansas.

These soil units are shown by resource area in Table 2-4 and their locations are shown on Figure 2-5.

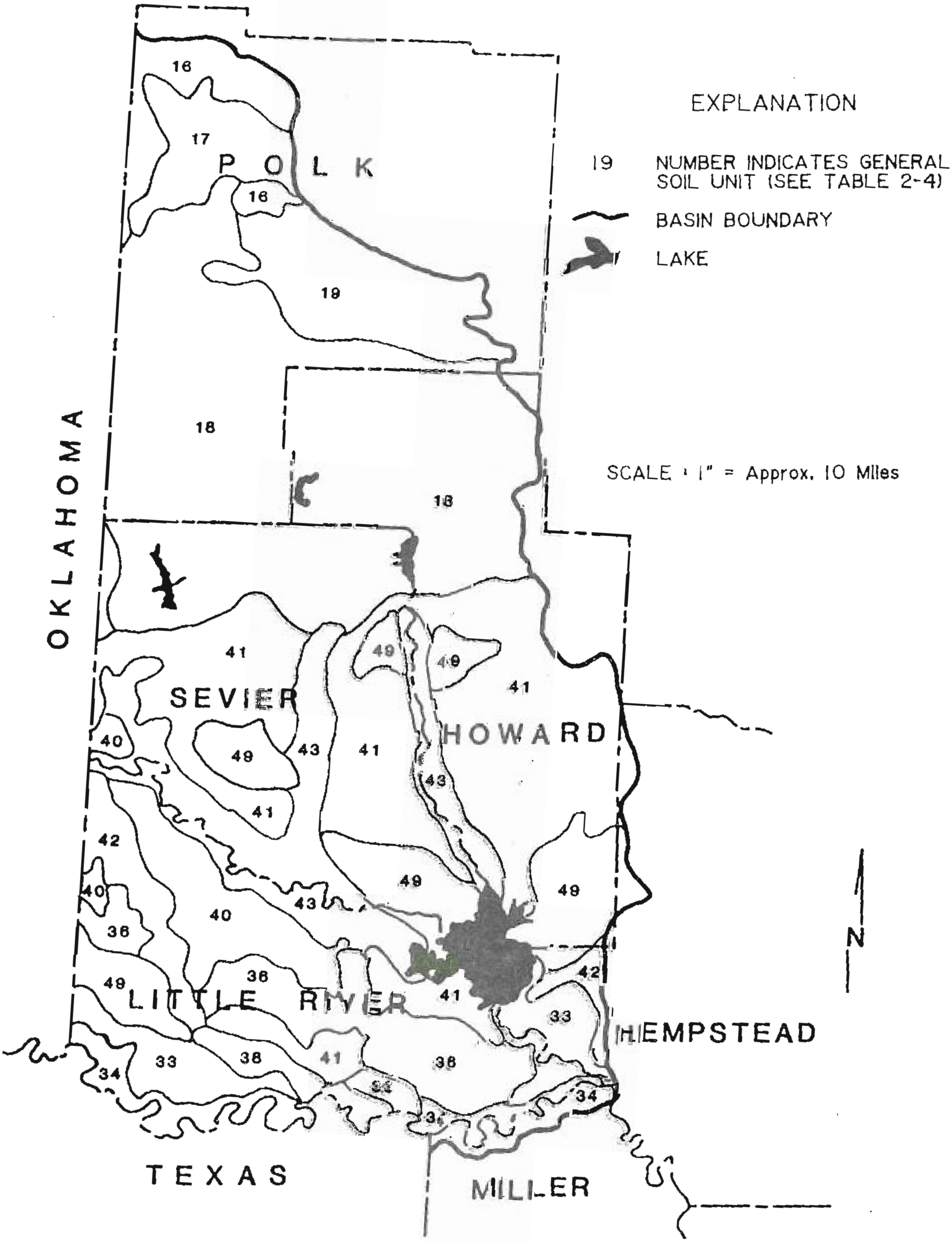
TABLE 2-4: GENERAL SOIL UNITS BY MAJOR LAND RESOURCE AREA

Major Land Resource Area (MLRA)	General Soil Unit
Ouachita Mountains	16 Carnasaw-Pirum-Clebit
	17 Kenn-Ceda-Avilla
	18 Carnasaw-Sherwood-Bismarck
	19 Carnasaw-Bismarck
Blackland Prairie	49 Oktibbeha-Sumter
Western Coastal Plain	40 Pheba-Amy-Savannah
	41 Smithdale-Sacul-Savannah-Saffell
	42 Sacul-Smithdale-Sawyer
	43 Guyton-Ouachita-Sardis
Southern Mississippi Valley Alluvium	33 Billyhaw-Perry
	34 Severn-Oklared
	36 Wrightsville-Louin-Acadia

Sources: USDA, Soil Conservation Service, Arkansas General Soil Map <33>

Figure 2-5

GENERAL SOILS MAP



SOURCE : USDA, SOIL CONSERVATION SERVICE <33>

CHAPTER III

SURFACE WATER

INTRODUCTION

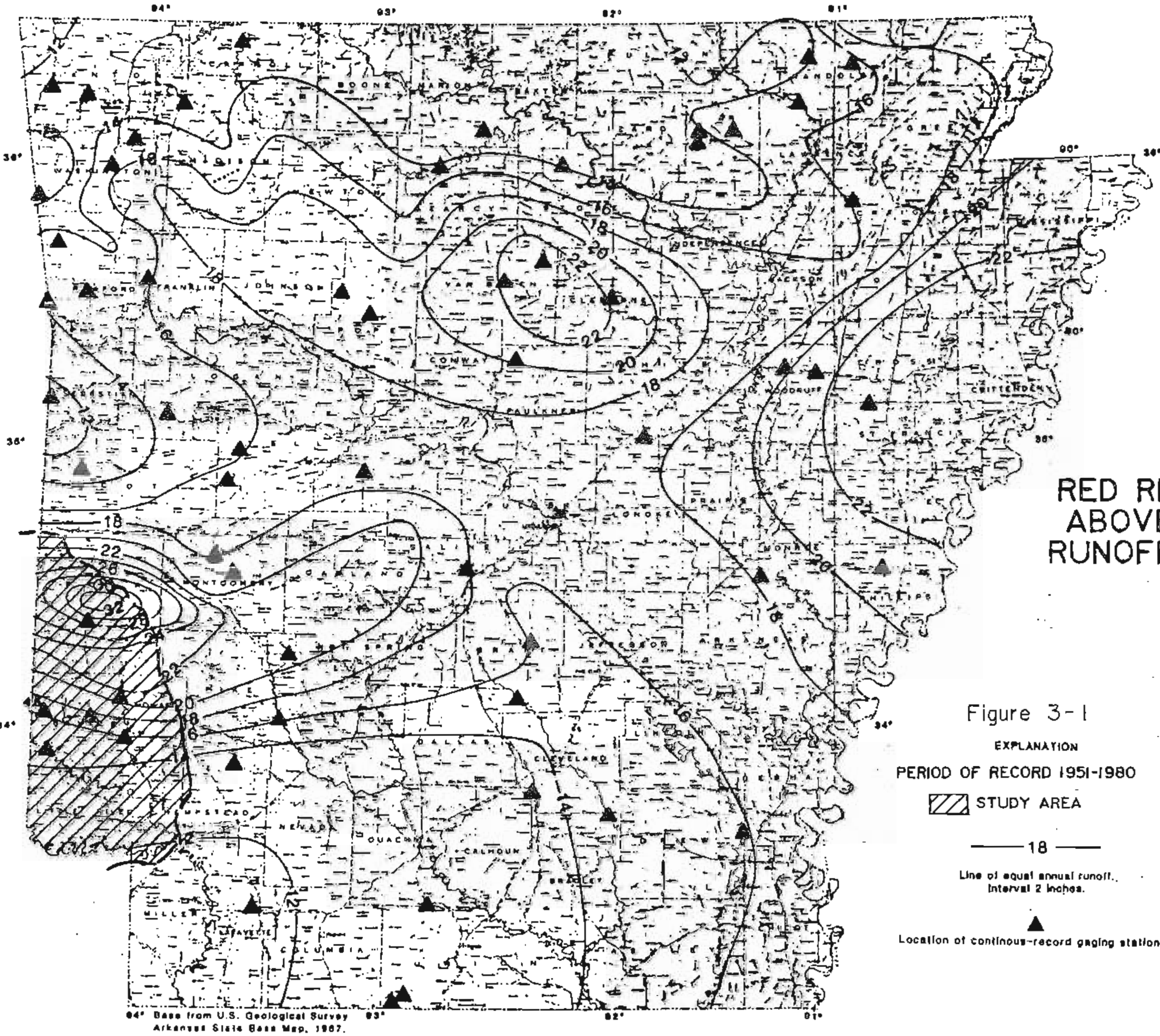
This section of the report presents an inventory of the surface water resources of the Red River Basin above Fulton. Present water use and estimated future needs are quantified. Current water resource problems are indentified and possible solutions are presented, if appropriate. The information in this section is intended to serve as a guide for the proper use, management, and development of basin water resources.

The Red River Basin above Fulton has 66 impoundments exceeding 5 acres in size, and approximately 5,900 impoundments smaller than 5 acres. <17> <53> The primary stream in the basin is the Red River which enters the basin at the southwest corner of Little River County. The total drainage area for the Red River as it enters the basin is 47,518 square miles. The average discharge of the Red River at DeKalb, Texas (drainage area - 47,348 square miles) is 11,300 cubic feet per second (cfs) and 11,620 cfs at Index, Arkansas (drainage area - 48,030 square miles). The Red River flows in an easterly direction throughout its course within the basin. The Red River forms the Arkansas/Texas boundary to the Index stream gaging station and is the common boundary for Little River and Miller Counties to Fulton, Arkansas, where it exits the basin. The Red River is partially regulated by Denison Dam (1943) on the main stem and by numerous other contributing land and water resource developments in Oklahoma, Texas, and Arkansas. However, flow of the Red River is still subject to periodic fluctuations.

The second largest stream in the basin is Little River which has a drainage area of 2,269 square miles at the Oklahoma/Arkansas state line and a drainage area of 4,239 square miles at its confluence with the Red River near Fulton, Arkansas. Other major streams in the basin include the Rolling Fork River, Cossatot River, Saline River, and Walnut Bayou.

Considerable surface water storage exists in the basin. A total of 34,259 acres of surface storage is provided by six artificial reservoirs constructed and operated by state or federal agencies. Over 3,000 acres of surface water storage is available from 60 private lakes exceeding 5 acres in size. Numerous natural impoundments of varying sizes are located throughout the basin but most are ox-bow lakes along either side of the Red River. Primary uses of the large state and federal reservoirs are flood control and recreation while the small private impoundments are used for recreation and livestock.

The average annual runoff in the Red River Basin above Fulton, based on data for the record period 1951-1980, ranges from about 32 inches in the northeast part of the basin to about 12 inches in the extreme southern part (see Figure 3-1). Runoff within the basin varies according to topography, land use, normal precipitation, and with the occurrences of extreme precipitation or droughts. Normally, low flows occur from June through November which includes the peak agricultural growing season.



RED RIVER BASIN ABOVE FULTON RUNOFF IN INCHES

Figure 3-1

EXPLANATION

PERIOD OF RECORD 1951-1980

STUDY AREA

—— 18 ——

Line of equal annual runoff. Interval 2 inches.

▲

Location of continous-record gaging station.

SCALE: 1"=APPROX. 40 MILES
MODIFIED FROM FREIWALD, 1985 <69>

SURFACE WATER INVENTORY

Surface Water Data Collection Network

Gage height, streamflow, and water quality data are collected at various stream sites in the Red River Basin above Fulton primarily by the U.S. Geological Survey, the Arkansas Department of Pollution Control and Ecology, and the U.S. Army Corps of Engineers. Only streamflow data collection sites providing relatively long-term records were used as a data base for computations in this report.

The ten stations selected for study are summarized in Table 3-1. Figure 3-2 shows the location of the ten stations (nine in Arkansas and one in Texas).

TABLE 3-1: SUMMARY OF SELECTED STREAMFLOW DATA COLLECTION SITES
(DATA COLLECTED BY USGS UNLESS OTHERWISE NOTED;
SITE NUMBERS CORRESPOND TO THOSE IN FIGURE 3 2)

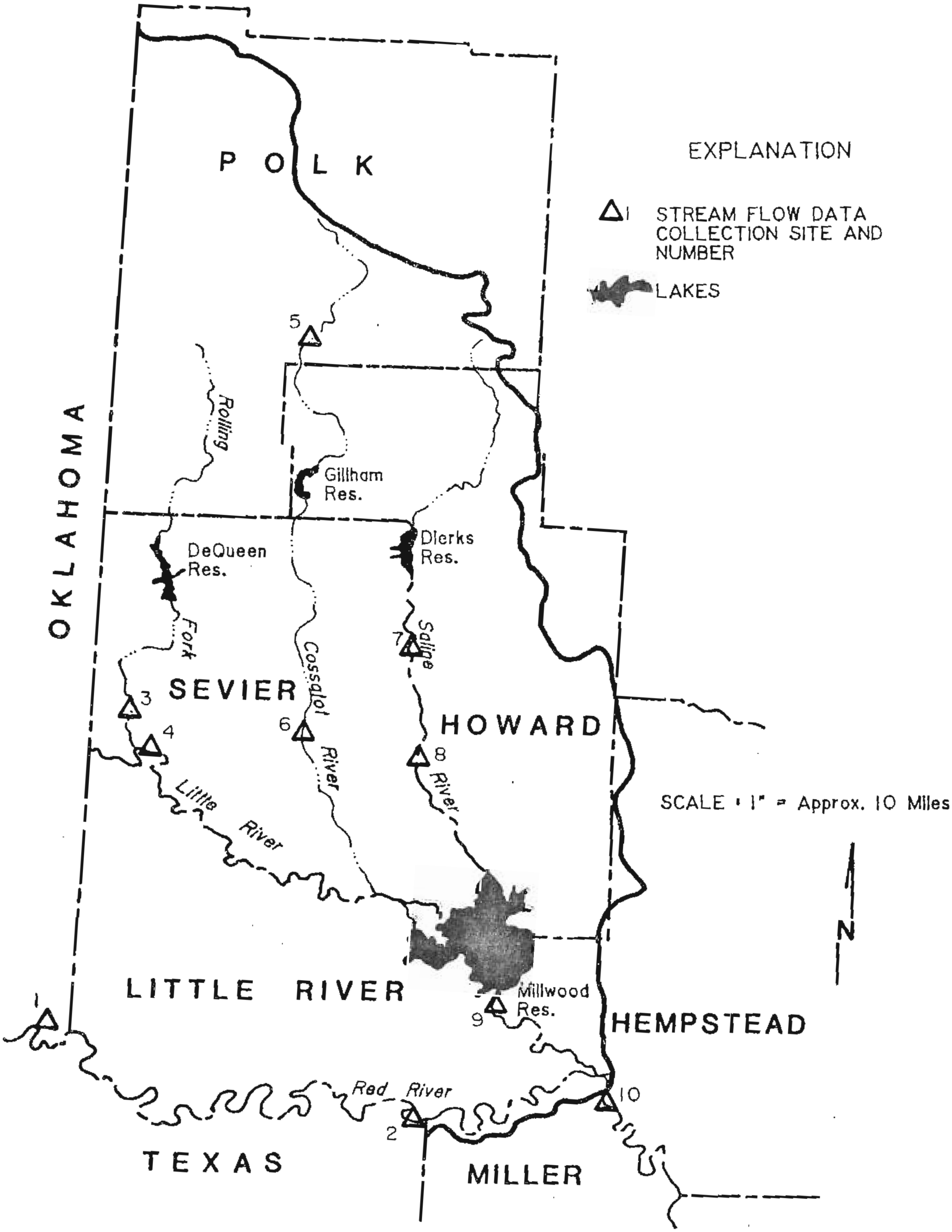
Site Number	USGS Station Number	Name	Drainage Area (Sq. Mi.)	Period of Record	Maximum Discharge and Date (CFS)	Minimum Discharge and Date (CFS)	Average Discharge for Period of Record 3/ (CFS)
1	07336820	Red River near DeKalb, TX	47,348 1/	1967-1984 (1943-1984 REGULATED PERIOD)	189,000 12/11/71	213 11/30/79	1969-1984 11,300
2	07337000	Red River at Index, AR	48,030 1/	1936-1984 (1943-1984 REGULATED PERIOD)	297,000 2/23/38	378 11/28/56	11,620
3	07339500	Rolling Fork near DeQueen, AR	182	1948-1980 (1977-1980 REGULATED PERIOD)	71,000 12/10/71	NO FLOW AT TIMES - 1954, 1948, 1956	292
4	07340000	Little River near Horatio, AR	2,662	1930-1984 (1968-1984 REGULATED PERIOD)	120,000 3/30/45	1 8/18/30 9/1/34	3,750
5	07340300	Cossatot River near Vandervoort, AR	89.6	1967-1984	32,000 12/2/82	7.2 8/28, 29, 30, 31,/1972	193
6	07340500	Cossatot River near DeQueen, AR	360	1938-1980 (1975-1980 REGULATED PERIOD)	122,000 5/13/68	1.1 9/2, 3/1972	618
7	07341000	Saline River near Dierks, AR	121	1938-1980 (1975-1980 REGULATED PERIOD)	59,200 5/13/68	NO FLOW AT TIMES	193
8	07341200	Saline River at Lockesburg, AR	256	1963-1984 (1975-1984 REGULATED PERIOD)	64,700 5/14/68	0.2 11/6/63 10/29/69	397
9	07341301 2/	Little River at Millwood Dam near Ashdown, AR	4,119	(1966-1980 REGULATED DISCHARGE)	67,300 5/13/73	NO FLOW AT TIMES MOST YEARS	6,388
10	07341500	Red River at Fulton, AR	52,336 1/	1927-1981 (1943-1984 REGULATED PERIOD)	338,000 2/24/38	390 10/26/56	17,190

1/ 5,936 square miles probably non-contributing.
2/ Data furnished by U.S. Army Corps of Engineers.
3/ Based on total period of record unless otherwise noted.

Source: U.S. Geological Survey <54>

Figure 3-2

GENERAL LOCATIONS OF WATER RECORDING STATIONS



SOURCE : U. S. GEOLOGICAL SURVEY

Streamflow Characteristics

Distribution of streamflow is generally dependent upon climate, physiography, geology, and land use in the basin. Basins where these conditions are similar may have similar streamflow characteristics. The distribution of high flows is governed largely by the climate, the physiography, and the plant cover of the basin while the distribution of low flows is controlled mainly by the basin geology. Streamflow variability is the result of variability in precipitation as modified by the basin characteristics previously mentioned. The variability is reduced by storage, either on the surface or in the ground. <61> Streamflow in the basin is normally highest during December through May because of the large amount of precipitation during this period. Similarly, streamflow is lowest during June through November due to a decrease in precipitation and an increase in evapotranspiration that occurs during the growing season. Mean monthly discharges at selected gaging stations are shown in Table 3-2. Also peak flow frequency analysis for two selected sites are shown in Figure 3-3 and Figure 3-4. The values in the Figures were determined according to guidelines found in WRC Bulletin 17-B. <61>

As seen in Figure 3-1, the northern part of the Red River Basin above Fulton, which is dominated by the steeper Ouachita Highland topography, produces a much higher average annual runoff (up to 32 inches) than the flatter slopes of the lower basin dominated by the Gulf Coastal Plains.

Management and development of surface water supplies depend on the rate of sustained streamflow during dry periods. The index generally used to define the low flow characteristics of a stream is defined as the lowest mean discharge for seven consecutive days at recurrence intervals of 2 and 10 years. It is referred to as the 7-day $Q_2(7Q_2)$ and 7-day $Q_{10}(7Q_{10})$ discharge, respectively. 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 3-3. The $7Q_2$ and $7Q_{10}$ discharges per square mile are also shown in Table 3-3 for comparison purposes.

The $7Q_2$ and $7Q_{10}$ values were determined using U. S. Geological Survey streamflow data and the Log Pearson Type III probability distribution program. <62> The program mathematically fits a frequency curve to the discharge data and $7Q_2$ and $7Q_{10}$ values are 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. Extrapolation of the $7Q_2$ and $7Q_{10}$ indices in Table 3-3 to other reaches on the streams or to other streams in the basin without knowledge of the basin characteristics and without knowledge of the effects of man-made practices can produce erroneous results. Low flow characteristics of basin streams may be affected by such conditions as frequent irrigation diversions, municipal or industrial effluent discharged into the streams, heavy pumping of ground water near the streams <62> or stream channel work such as dredging. The only stream appreciably affected in the basin is the Red River which periodically undergoes bank stabilization, revetment and stream training.

TABLE 3-2: MEAN MONTHLY DISCHARGES AT SELECTED GAGING STATIONS

Station Number	Station Name	Drainage Area (Sq. Mi.)	Years Used for Computation	Mean Monthly Discharge (cubic feet per second) OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
07336820	Red River near DeKalb, TX	47,348 1/	1969-1984	9,856	13,280	12,540	6,801	11,810	14,880	14,180	20,300	20,480	6,776	4 ,203	4,842
07337000	Red River at Index, AR	48,030 1/	1974-1984 Regulated Period	8,972	13,580	9,606	5,874	10,110	12,100	12,010	17,060	23,470	8,266	4,611	4,715
07341500	Red River at Fulton, AR	52,336 1/	1946-1981 Regulated Period	9,837	13,310	15,410	15,060	21,260	20,990	23,660	33,390	23,510	9,462	6,239	7,844
07339500	Rolling Fork near DeQueen, AR	182	1949-1976 Unregulated Period	109	245	352	392	438	495	566	504	193	73.8	40.4	112
07340300	Cossatot River near Vandervoort, AR	89.6	1968-1984	84.5	185	316	196	234	390	299	278	174	70.4	29.7	66.2
07340500	Cossatot River near DeQueen, AR	360	1939-1974 Unregulated Period	215	462	732	807	1,007	1,120	1,172	1,055	378	182	122	239
07341000	Saline River near Dierks, AR	121	1939-1974 Unregulated Period	60.1	148	227	254	319	355	368	353	115	55.8	19.2	62.1
07341200	Saline River near Lockesburg, AR	256	1975-1984 Regulated Period	98.9	377	613	364	624	766	564	650	541	270	48.2	59.4
07340000	Little River near Horatio, AR	2,662	1971-1984 Regulated Period	1,763	3,755	5,300	3,485	4,411	6,134	5,646	6,013	5,037	1,772	1,028	1,493
07341301	Little River at Millwood Dam near Ashdown, AR	4,119	1967-1980	1,868	6,263	7,840	6,772	8,966	10,500	10,680	11,540	7,742	1,402	1,080	2,276

1/ 5,936 square miles probably non-contributing.

Source: U.S. Geological Survey <54>

TABLE 3-3: SUMMARY OF LOW FLOW CHARACTERISTICS OF SELECTED STREAMS 1/

Name	Period of Record Used	$7Q_2$ (CFS) 2/	$7Q_2$/Sq. Mi. (CSM) 3/	$7Q_{10}$ (CFS) 2/	$7Q_{10}$/Sq. Mi. (CSM) 3/
Red River near DeKalb, TX 1/	1969-1984	1,100	0.027	637	0.015
Red River at Index, AR 1/	1974-1984	1,610	0.038	1,290	0.031
Red River at Fulton, AR 1/	1946-1981	2,390	0.052	1,110	0.024
Rolling Fork near DeQueen, AR	1949-1976	1.9	0.010	0.2	0.001
Little River near Horatio, AR 1/	1971-1984	281	0.106	194	0.073
Cossatot River near Vandervoort, AR	1968-1984	11	0.123	8.4	0.094
Cossatot River near DeQueen, AR	1939-1974	8.6	0.024	2.6	0.007
Saline River near Dierks, AR	1939-1974	0.3	0.002	0	0
Little River at Millwood Dam near Ashdown, AR 1/	1967-1980	180	0.044	132	0.032

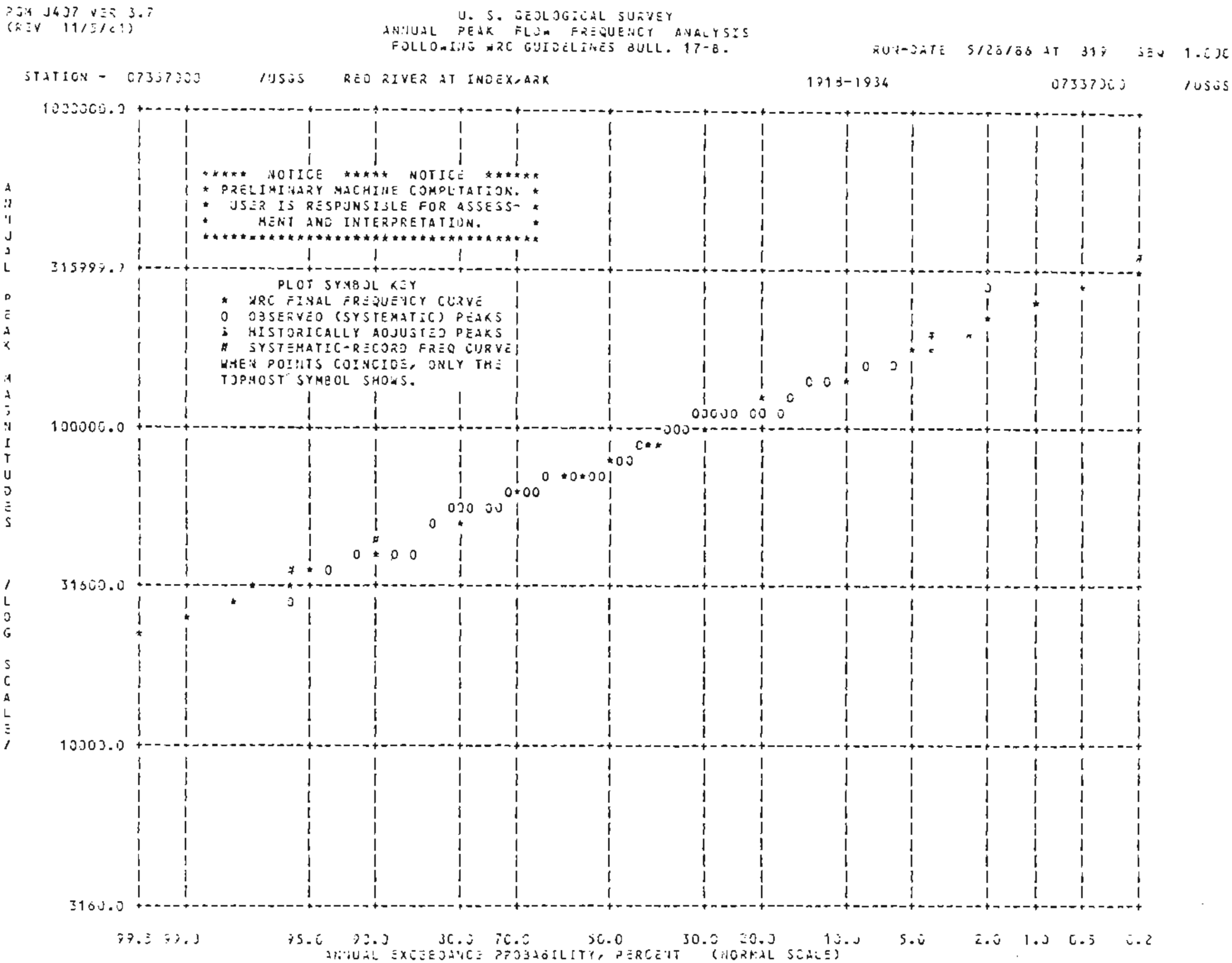
1/ Lowflow characteristics are applicable only as long as the existing pattern of regulation and/or diversion exists.

2/ CFS - Cubic feet per second

3/ CSM - Cubic feet per second per square mile

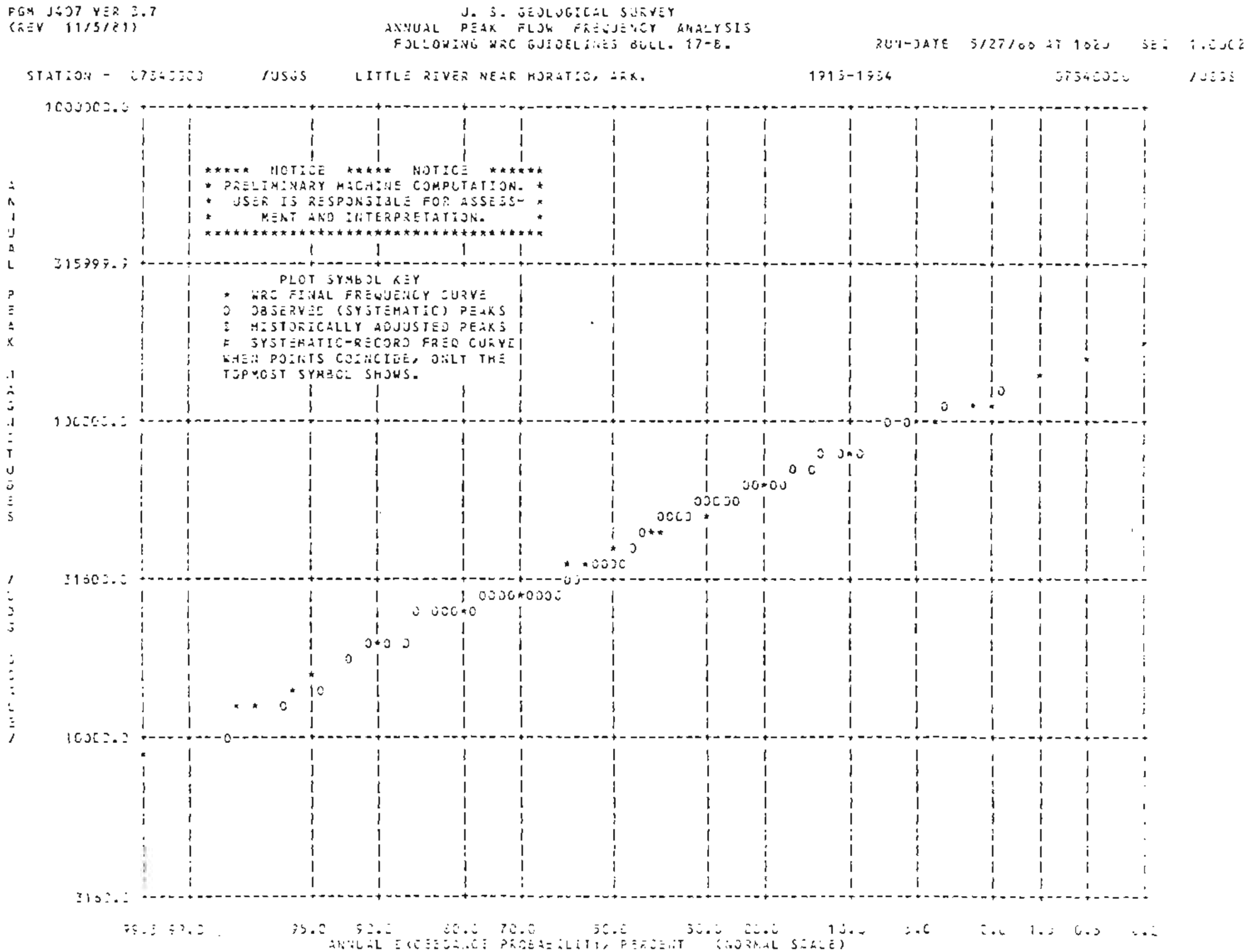
Source: U.S. Geological Survey and Lee <54><68>

Figure 3-3



SOURCE: U.S. GEOLOGICAL SURVEY

Figure 3-4



SOURCE: U.S. GEOLOGICAL SURVEY

Since seasonal and annual variability of streamflow affect the dependability of water available for development, flow duration curves were developed to analyze the variability of streamflow in the Red River Basin above Fulton. 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 <61> was used to develop the flow duration curves and selected points from the curves are summarized in Table 3-4. Figure 3-5 shows the flow duration curve of the Little River near Horatio, Arkansas from which corresponding values shown in Table 3-4 were obtained.

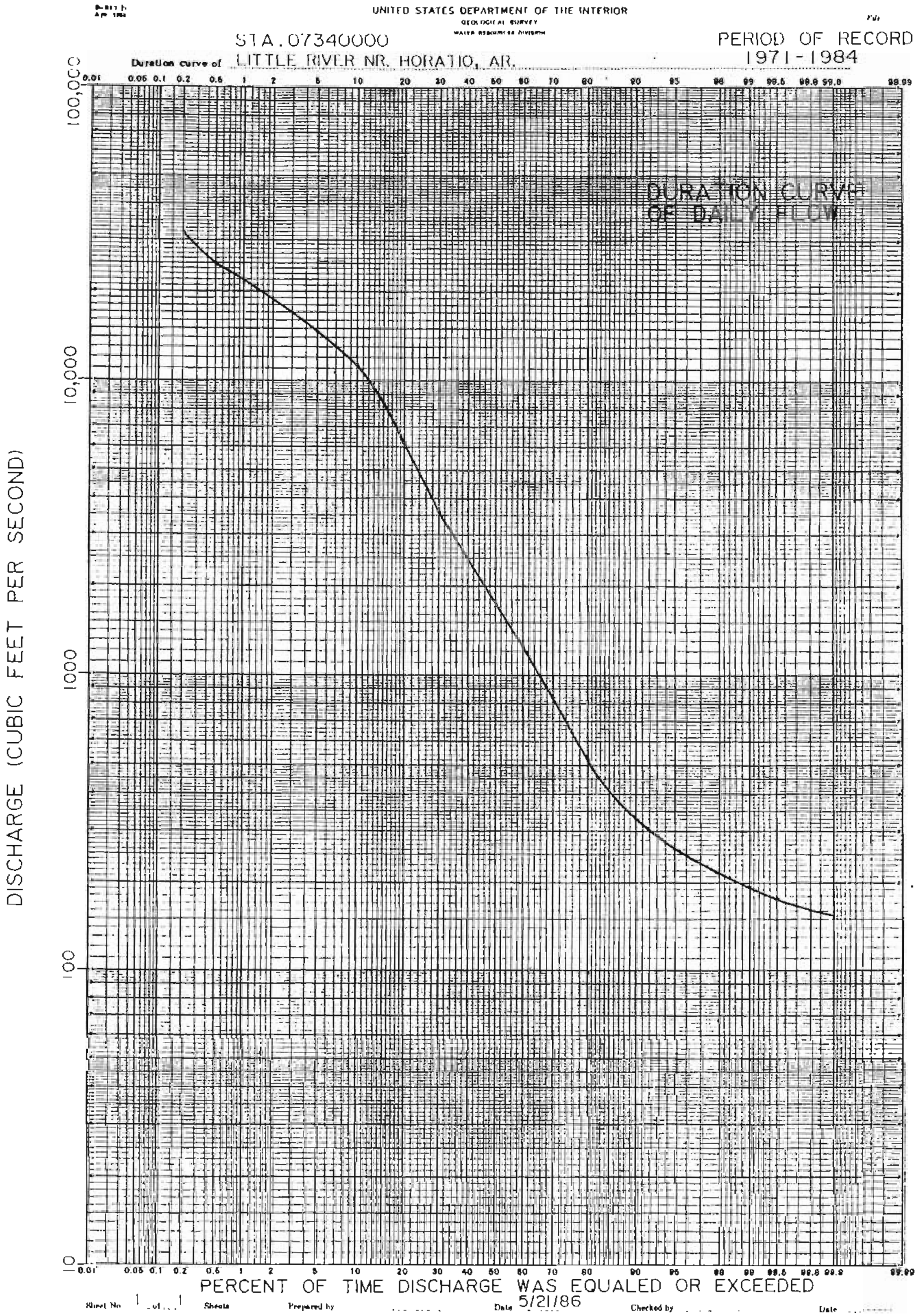
TABLE 3 - 4: FLOW DURATION OF STREAMS AT SELECTED CONTINUOUS-RECORD GAGING STATIONS

Station Number and Name	Drainage Area (Sq. Mi.)	Records Used (Wtr. Yrs.)	Flow in Cubic Feet per Second, Which Was Equaled or Exceeded for Percentages of Time Indicated																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
07336820 Red River near DeKalb, TX	47,348 1/	1969–1984	425	630	780	980	1,400	1,880	2,710	3,460	4,300	5,430	7,100	10,000	15,900	30,500	47,300	66,000	75,500	86,500
07337000 Red River at Index, AR	48,030 1/	1974–1984	1,220	1,360	1,440	1,560	1,830	2,170	2,740	3,380	4,180	5,220	6,800	9,700	15,800	27,700	40,200	56,500	67,000	77,500
07341500 Red River at Fulton, AR	52,336 1/	1946–1981	510	920	1,190	1,550	2,200	2,860	3,720	4,560	5,680	7,380	10,200	15,700	25,300	44,000	63,500	88,000	105,000	126,000
07339500 Rolling Fork near DeQueen, AR	182	1949–1976	0	0	0.13	0.34	1.0	2.7	7.4	18	36	64	103	166	282	620	1,300	2,640	3,800	5,600
07340000 Little River near Horatio, AR	2,662	1971–1984	154	178	194	215	260	330	520	840	1,240	1,750	2,420	3,600	6,450	11,300	14,700	18,200	21,200	25,000
07340300 Cossatot River near Vandervoort, AR	89.6	1968–1984	7.8	8.8	9.4	10	12	14	20	30	46	66	90	123	191	395	760	1,500	2,300	3,300
07340500 Cossatot River near DeQueen, AR	360	1939–1974	1.7	2.5	3.6	5.5	10	16	29	54	93	154	240	390	675	1,400	2,650	5,200	7,650	10,800
07341000 Saline River near Dierks, AR	121	1939–1974	0	0	0	0.07	0.16	0.92	4.2	11	23	43	75	125	210	440	850	1,640	2,300	3,200
07341200 Saline River near Lockesburg, AR	256	1975–1984	–	3.4	4.2	5.9	11	16	23	32	52	105	200	425	700	995	1,370	2,650	3,900	5,350
07341301 Little River at Millwood Dam near Ashdown, AR	4,119	1967–1980	–	–	129	132	148	174	425	975	1,620	2,650	3,900	6,000	11,200	19,100	25,200	33,800	41,800	49,300

1/ 5,936 square miles non-contributing.

Source: U.S. Geologival Survey <54>

Figure 3-5



SOURCE: U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS <54,61>

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 system". <46> Section 2 of Act 1051 of 1985 (see Legal and Institutional Setting) requires the Arkansas Soil and Water Conservation Commission to determine instream flow requirements of (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 (riparian uses).

Determination of instream flow requirements for streams in the Red River Basin above Fulton is necessary so that minimum streamflow, excess streamflow, and the amount of water available for interbasin transfer can be quantified. Not all streams in the basin are included in the determination of instream flow requirements. Streams that go dry or nearly dry during low flow periods were not considered realistic sources for future interbasin transfer of water; therefore, only those streams with a $7Q_{10}$ discharge greater than 1.0 cfs are addressed in this section of the report. Using this criterion, the streams investigated in the Red River Basin above Fulton are the Red River, the Little River, and the Cossatot River.

According to the perennial streams map of Arkansas, the Saline River and Rolling Fork have $7Q_{10}$ discharges of 1 to 10 cfs. <56> However, the $7Q_{10}$ discharges for these streams could not be substantiated from adequate gaging station or other measured data and the adjusted probabilities were lower than 1 cfs due to the presence of no-flow values.

Instream flow requirements in the Red River Basin above Fulton are greatly affected by the operation of four Corps of Engineers' lakes (Gillham, DeQueen, Dierks, and Millwood). These lakes are components of the Little River System, from which releases into the Red River can only be made from Millwood Lake. Information regarding release rates and the system operation is provided below. Project purposes and physical data of each project can be found in this report under Major Projects of the Corps of Engineers.

DeQueen Lake (Rolling Fork River): "The low flow releases from DeQueen Lake are required to satisfy downstream water rights and to furnish protection to fish and wildlife resources in the Rolling Fork River. The storage for water quality in DeQueen Lake, based on 50-year frequency drought, has an average yield of 16 cfs. The average annual downstream water quality control requirement recommended by the Public Health Service is equal to about 15 cfs." <71>

Gillham Lake (Cossatot River): "Low flow releases will be regulated to provide the recommended discharge and water temperature requirements to benefit fish and wildlife, and for downstream pollution control. The water quality storage in Gillham Lake, based on a 50-year frequency drought, has an average yield of 28 cfs. This is the average annual downstream water quality release requirement recommended by the U.S. Public Health Service." <71>

Dierks Lake (Saline River): "In addition to flood control, Dierks Lake will be regulated for the development of recreation, fish and wildlife, water supply, and regulation of streamflow for aesthetics, fish and wildlife, recreation, and other environmental enhancements downstream." <71>

Millwood Lake (Little River): "Low flow releases from Millwood Lake of 155 cfs will satisfy the 50-year water quality control flow requirements on the Little River and Red River. There is no water quality storage in Millwood Lake; however, minimum flow requirements below the dam will be provided from the low flow releases from the upstream projects through Millwood Lake. These low flow releases are required to satisfy downstream water rights and to furnish protection for fish and wildlife resources." <71>

The low flow releases from each lake are shown in Table 3-5.

TABLE 3-5: LOW FLOW RELEASES FOR VARIOUS INSTREAM REQUIREMENTS
(Cubic Feet Per Second)

Month	Millwood Lake	Gillham Lake	DeQueen Lake	Dierks Lake
January	155	14	8	5
February	155	14	8	5
March	155	15	9	5
April	155	20	12	6
May	155	28	16	9
June	155	52	30	16
July	155	53	30	17
August	155	53	30	17
September	155	39	22	12
October	155	19	11	6
November	155	15	8	5
December	155	14	8	5
Average	155	28	16	9

Source: U.S. Corps of Engineers <71>

1. Water Quality Requirements

One of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The $7Q_{10}$ low flow characteristic is the criterion used by the Arkansas Department of Pollution Control and Ecology (ADPC&E) in determining the permissible rate of waste disposal into a given stream. The Department manages water quality conditions in streams when flow meets or exceeds the $7Q_{10}$ discharge. The ADPC&E also monitors point-source discharges in streams when the flow is less than the $7Q_{10}$ discharge and requires concentrations of certain pollutants to be maintained below critical levels. Sufficient water is not available at times during the year to dilute the effluent discharges; therefore, streamflow water quality may not meet the quality standards during all times of the year. Regulated streams are addressed on a case-by-case basis to determine instream flow requirements for water quality.

The $7Q_{10}$ discharges were determined at gaging station locations on the major streams addressed in the Red River Basin above Fulton. The discharges required to meet water quality standards at gaging station locations are:

Red River at Index, AR	1,290 cfs
Little River near Horatio, AR	194 cfs
Cossatot River near Vandervoort, AR	8.4 cfs
Red River at Fulton, AR	1,110 cfs

2. Fish and Wildlife Requirements

Several methods are presently available for determining instream flow requirements for fisheries. Some of these methods require considerable field work to characterize fish habitats. However, Tennant <63> 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 Tennant's extensive study showed that: (1) 10% of the average annual streamflow is the minimum flow required for short-term survival of most aquatic life forms, (2) 30% of average annual streamflow is required to sustain a good survival habitat, and (3) 60% of the average annual streamflow will provide excellent to outstanding habitat for most aquatic life forms. Tennant also suggested dividing the water year into two seasons and applying appropriate discharge percentages to account for seasonal variability in flow.

Filipek and others <22> have developed a new method (termed the "Arkansas method") which utilizes some of Tennant's 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 as well as the flow required for maintenance of fisheries during each season are described in Table 3-6. 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 also satisfied.

The Arkansas method was applied to streamflow data from the U. S. Geological Survey gaging stations in the Red River Basin above Fulton. Instream flow requirements for fisheries were determined at the Index, Arkansas, and Fulton, Arkansas, gaging station locations on the Red River. Instream flow requirements for fisheries were also determined for the Horatio, Arkansas gaging station on the Little River, and for the Vandervoort, Arkansas gaging station on the Cossatot River. These results are shown in Tables 3-7 through 3-10.

Table 3-6: DESCRIPTION OF PHYSICAL/BIOLOGICAL SEASONS IN THE ARKANSAS METHOD OF INSTREAM FLOW QUANTIFICATION

Time of Year	November-March	April - June	July - 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 ground water (aquifers).	-High average monthly flows. -Increasing (preferred) water 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 also 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 a this time of year cause: Decrease in spawning egg and fry survival and overall reproduction success of important sport and non-game fish. Weak year classes of important sport, commercial, non-game, and threatened fish species.	Reduced flows a 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; fishkills. Increase concentration of pollutants and sediments in water. Additional decrease in ground water table.

Source: Arkansas Game and Fish Commission, Filipek and Others, 1985

TABLE 3-7: MEAN MONTHLY DISCHARGE AND MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE RED RIVER AT INDEX, ARKANSAS

Station Number: 07337000
Period of Record: 1974-1984

Month	Mean Monthly Discharge (CFS)	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	8,972	50	4,486
November	13,580	60	8,148
December	9,606	60	5,764
January	5,874	60	3,524
February	10,110	60	6,066
March	12,100	60	7,260
April	12,010	70	8,407
May	17,060	70	11,942
June	23,470	70	16,429
July	8,266	50	4,133
August	4,611	50	2,306
September	4,715	50	2,358

TABLE 3-8: MEAN MONTHLY DISCHARGE AND MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE LITTLE RIVER NEAR HORATIO, ARKANSAS

Station Number: 07340000
Period of Record: 1971-1984 (Regulated Period)

Month	Mean Monthly Discharge (CFS)	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	1,736	50	868
November	3,755	60	2,253
December	5,300	60	3,180
January	3,485	60	2,091
February	4,411	60	2,647
March	6,134	60	3,680
April	5,646	70	3,952
May	6,013	70	4,209
June	5,037	70	3,526
July	1,772	50	886
August	1,028	50	514
September	1,493	50	747

TABLE 3-9: MEAN MONTHLY DISCHARGE AND MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE COSSATOT RIVER NEAR VANDERVOORT, ARKANSAS

Station Number: 07340300
Period of Record: 1968-1984

Month	Mean Monthly Discharge (CFS)	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	84.5	50	42
November	185	60	111
December	316	60	190
January	196	60	118
February	234	60	140
March	390	60	234
April	299	70	209
May	278	70	195
June	174	70	122
July	70.4	50	35
August	29.7	50	15
September	66.2	50	33

TABLE 3-10: MEAN MONTHLY DISCHARGE AND MONTHLY FISH AND WILDLIFE INSTREAM FLOW REQUIREMENTS FOR THE RED RIVER AT FULTON, ARKANSAS

Station Number: 07341500
Period of Record: 1946-1981

Month	Mean Monthly Discharge (CFS)	Percent of Mean Monthly Flow for Fish and Wildlife Requirements	Fish and Wildlife Instream Flow Requirements (CFS)
October	9,837	50	4,919
November	13,310	60	7,986
December	15,410	60	9,246
January	15,060	60	9,036
February	21,260	60	12,756
March	20,990	60	12,594
April	23,660	70	16,562
May	33,390	70	23,373
June	23,510	70	16,457
July	9,462	50	4,731
August	6,239	50	3,120
September	7,844	50	3,922

Comparison of the instream flow requirements as determined by the Arkansas method with those determined by the Montana method indicates that the flow requirements using the Arkansas method would provide excellent to outstanding habitat for most aquatic life forms. To protect stream fisheries and to satisfy water needs for fish and wildlife in the Red River Basin above Fulton, the instream flow requirements as determined by the Arkansas method represents and amount of water that is unavailable for interbasin transfer.

3. Navigation Requirements

The general rule for the determination of navigability of a watercourse is that "any watercourse is navigable which the federal government so declares or that can be found as a matter of fact." <15> When water-related activities affect interstate commerce, Congress can exercise control over these activities through the commerce clause of the U. S. Constitution which authorizes Congress to preempt the state's right to regulate that area. The navigability for purposes of federal control, depends upon, among other things, the volume of water, the regularity of the flow and the availability for navigation. <15>

The Red River and the Little River are the navigable streams of the Red River Basin above Fulton with basin navigable lengths of 22.3 miles and 1 mile, respectively. <15> The Red River at Index, Arkansas (river mile 458.3) is considered the head of navigation on the Red River for purposes of developing the river to accomodate two barge-tow barge traffic. Index is 22.3 river miles above Fulton, Arkansas. At present, minimum flow requirements for navigation have not been established on either river by the U.S. Corps of Engineers. Section 5.05 of the Red River Compact allocates the Red River water from Index, Arkansas to the AR/LA state line, but does not specifically provide for a minimum flow for navigation. (See Section 5.05 (d)) <25>

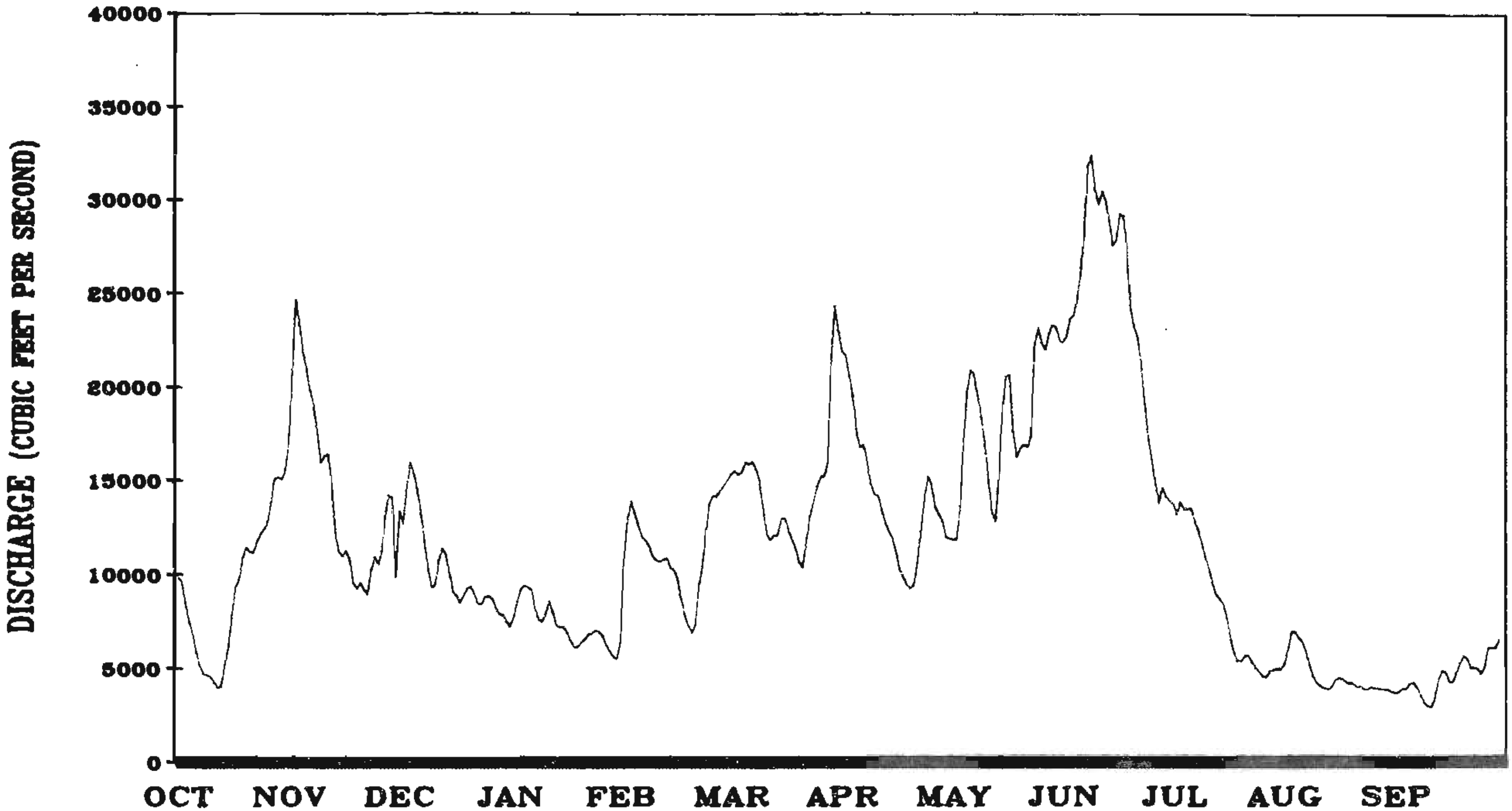
Installation of improved channel and other navigation features are required on the Red River in Arkansas before navigation is practical. Congress authorized a Red River Waterway Project in 1968 which includes the construction of certain navigation features; however, no navigation features are presently authorized for construction on the Red River in Arkansas.

The mean daily discharge hydrograph on Figure 3-6 for the period 1974-1985 indicates that the Red River normally contains sufficient flow to support some navigation at the Index stream gage.

Construction of navigation features have not been authorized or planned for the Little River in Arkansas by the Corps of Engineers. Navigation may not be practical on the Little River since a flow of 425 cfs is equaled or exceeded in the river only 80 percent of the time. (See Table 3-4).

Figure 3-6

MEAN DAILY DISCHARGE
RED RIVER AT INDEX, ARKANSAS



PERIOD OF RECORD USED: 1974-1985.

SOURCE: DAILY DISCHARGE DATA FROM U.S. GEO. SURVEY STREAMFLOW RECORDS.

4. <u>Interstate Compact Requirements</u>

Authorized by Act of Congress, Public Law No. 346 (84th Congress, First Session), the consent of the United States was granted for Arkansas, Louisiana, Oklahoma, and Texas to negotiate and enter into a compact providing for an equitable apportionment of water of the Red River. Known as the Red River Compact, its initial purpose was the allocation of the waters in the Red River and its tributaries among the four states. It required 22 years of negotiations for the states to reach agreement. One of the missions of the Red River Commission was to make the Red River navigable as far north as the community of Index, Arkansas near Texarkana.

The Red River reach from Index to the AR/LA boundary line is a segment of the reach from Denison Dam to the AR/LA state boundary designated by the Compact as Reach II and includes all tributaries which contribute to the flow of the Red River within this reach. Reach II is one of 5 reaches defining the Red River from the New Mexico/Texas state boundary to the mouth. See Figure 3-7 for delineation of Reaches I-V.

According to Article I of the 1984 Red River Compact, one principal purpose of the compact is to promote interstate comity and remove causes of controversy between each of the affected states by governing the use, control, and distribution of the interstate water of the Red River and its tributaries. <25> According to Article II, Section 2.01 of the Compact, each affected state may use the water allocated to it by this Compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to the availability of water in accordance with the apportionments made by this Compact. <25>

The apportionment of waters of the Red River water within Reach II is set forth in Article V of the Compact. The following information is from Sections of the Red River Compact that pertain to the Red River Basin above Fulton area.

Article V

Apportionment of water - Reach II

Arkansas, Oklahoma, Texas, and Louisiana subdivision of Reach II and allocation of water therein.

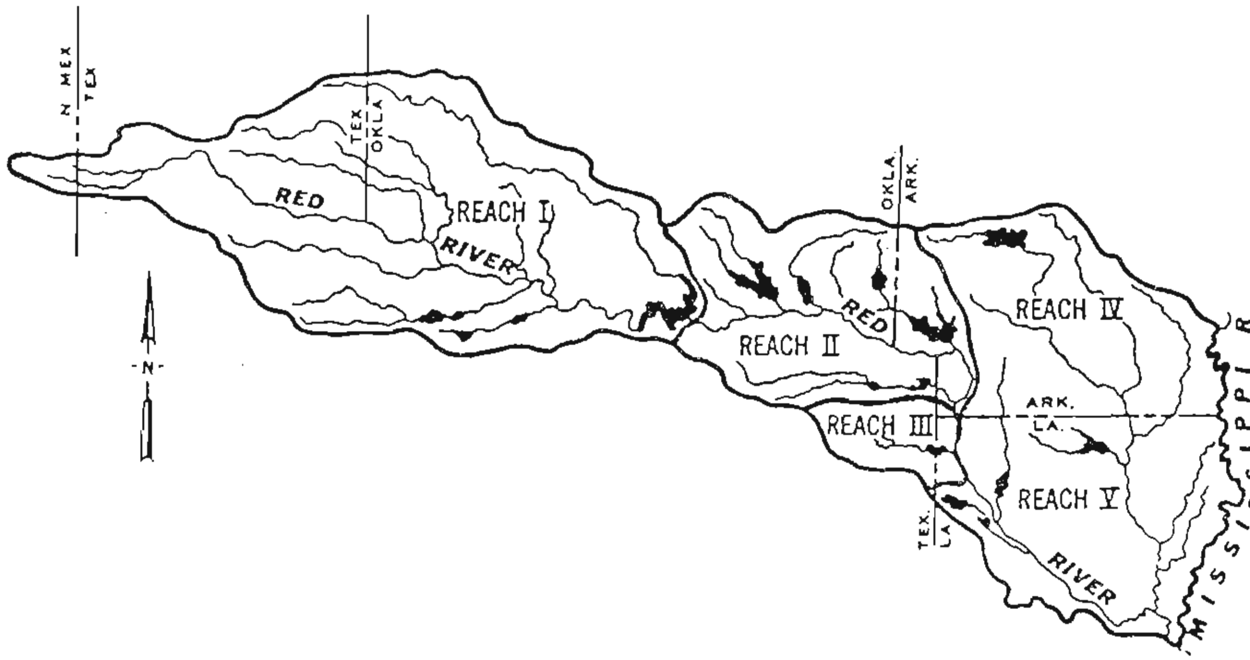
Reach II of the Red River is divided into topographic subbasins, and the water therein is allocated as follows:

SECTION 5.04. Subbasin 4 - Interstate streams - Texas and Arkansas.

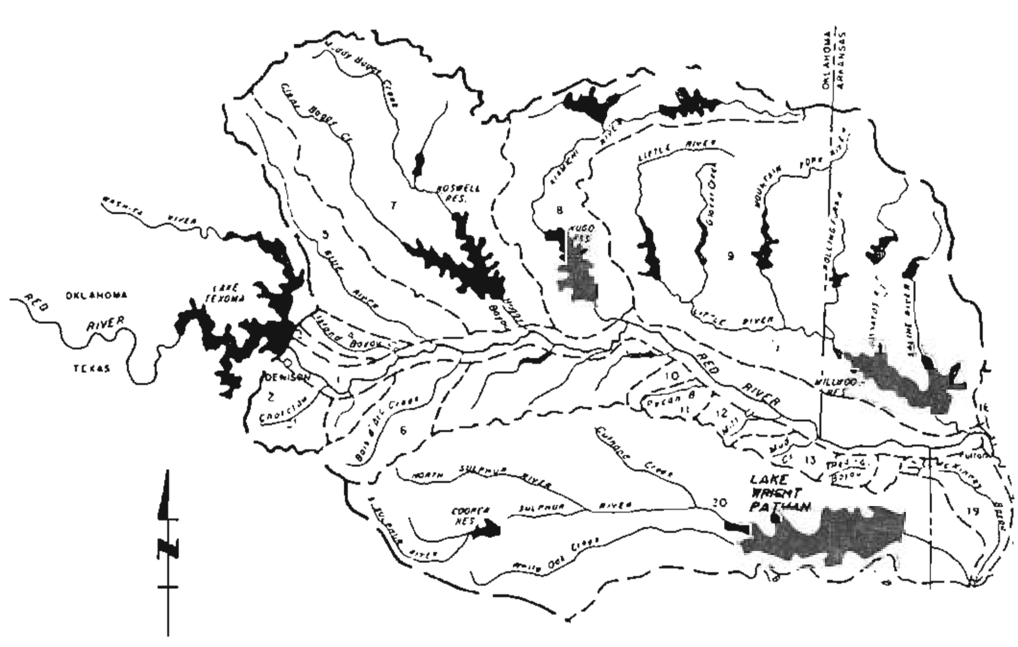
(a) This subbasin shall consist of those streams and their tributaries above existing, authorized or proposed last downstream major damsites, originating in Texas and crossing the Texas-Arkansas state boundary before flowing into the Red River in Arkansas. These streams and their tributaries with existing, authorized or proposed last downstream major damsites are as follows:

Figure 3 - 7

RED RIVER BASIN COMPACT AREA



REACHES I - V



REACH II

Stream	Site	Ac-ft	Location: Latitude	Location: Longitude
McKinney Bayou Trib.	Bringle Lake	3,052	33°30.6'N	94°06.2'W
Barkman Creek	Barkman Reservoir	15,900	33°29.7'N	94°10.3'W
Sulphur River	Texarkana	386,900	33°18.3'N	94°09.6'W

(b) The State of Texas shall have the free and unrestricted use of the water of this subbasin.

SECTION 5.05. Subbasin 5 — Mainstem of the Red River and tributaries.

(a) This subbasin includes that portion of the Red River, together with its tributaries, from Denison Dam down to the Arkansas-Louisiana state boundary, excluding all tributaries included in the other four subbasins of Reach II.

(b) Water within this subbasin is allocated as follows:

(1) The Signatory States shall have equal rights to the use of runoff originating in subbasin 5 and undesignated water flowing into subbasin 5, so long as the flow of the Red River at the Arkansas-Louisiana state boundary is 3,000 cubic feet per second or more, provided no state is entitled to more than 25 percent of the water in excess of 3,000 cubic feet per second.

(2) Whenever the flow of the Red River at the Arkansas-Louisiana state boundary is less than 3,000 cubic feet per second, but more than 1,000 cubic feet per second, the States of Arkansas, Oklahoma, and Texas shall allow to flow into the Red River for delivery to the State of Louisiana a quantity of water equal to 40 percent of the total weekly runoff originating in subbasin 5 and 40 percent of undesignated water flowing into subbasin 5; provided, however, that this requirement shall not be interpreted to require any state to release stored water.

(3) Whenever the flow of the Red River at the Arkansas-Louisiana state boundary falls below 1,000 cubic feet per second, the States of Arkansas, Oklahoma, and Texas shall allow a quantity of water equal to all the weekly runoff originating in subbasin 5 and all undesignated water flowing into subbasin 5 within their respective states to flow into the Red River as required to maintain a 1,000 cubic foot per second flow at the Arkansas-Louisiana state boundary.

(c) Whenever the flow at Index, Arkansas, is less than 526 c.f.s., the states of Oklahoma and Texas shall each allow a quantity of water equal to 40 percent of the total weekly runoff originating in subbasin 5 within their respective states to flow into the Red River. Provided, however, this provision shall be invoked only at the request of Arkansas, only after Arkansas has ceased all diversions from the Red River itself in Arkansas above Index, and only if the provisions of Sub-sections 5.05 (b) (2) and (3) have not caused a limitation of diversions in subbasin 5.

(d) No state guarantees to maintain a minimum low flow to a downstream state.

SECTION 5.06. Special Provisions.

(a) Reservoirs within the limits of Reach II, subbasin 5, with a conservation storage capacity of 1,000 acre feet or less in existence or authorized on the date of the Compact pursuant to the rights and privileges granted by a Signatory State authorizing such reservoirs, shall be exempt from the provisions of Section 5.05; provided, if any right to store water in, or use water from, an existing exempt reservoir expires or is cancelled after the effective date of the Compact the exemption for such rights provided by this section shall be lost.

(b) A Signatory State may authorize a change in the purpose or place of use of water from a reservoir exempted by subparagraph (a) of this section without losing that exemption, if the quantity of authorized use and storage is not increased.

(c) Additionally, exemptions from the provisions of Section 5.05 shall not apply to direct diversions from Red River to off-channel reservoirs or lands.

5. Aquifer Recharge Requirements

Recharge to the major aquifers in the Red River Basin above Fulton is primarily from precipitation and percolation in the outcrop area. High streamflows during the spring may also contribute to aquifer storage through lateral movement of flow from the streams to the aquifers. Conversely, when stream levels are lowest during the fall, the aquifers may discharge water to the streams for several months.

Basin instream flow requirements necessary to recharge aquifer depletions were not investigated for this report. Surface water requirements, such as minimum stream flows, and other computations, such as excess surface water available for interbasin transfer, were determined independent of aquifer recharge requirements.

6. Riparian Use Requirements

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) requires the Arkansas Soil and Water Conservation Commission 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 32,812 acre-feet of water in the Red River Basin above Fulton as determined from Arkansas Soil and Water Conservation Commission's records of registered diversions. Of the total 32,812 acre-feet of water diverted, 1,200 acre-feet were used for wildlife improvement, 30,499 acre-feet for municipal and industrial purposes and 1,112 acre-feet for irrigation. The 1,112 acre-feet represents the current irrigation riparian needs in the 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 irrigation 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.

7. Aesthetic Requirements

According to the Arkansas National Heritage Commission, the Red River Basin above Fulton provides habitat for thirteen aquatic species of federal and/or state concern. They are:

Lampsilis orbiculata	pink mucket	Endangered (USFWS)
Percina pantherina	leopard darter	Threatened (USFWS)
Arkansia wheeleri	Ouachita rock pocketbook	Candidate for federal listing (Category 2)
Ammocrypta clara	western sand darter	Candidate for federal listing (Category 2)
Etheostoma fusiforme	swamp darter	
Nerodia cyclopion cyclopion	green water snake	
Notropis atrocaudalis	blackspot shiner	
Notropis hubbsi	bluehead shiner	
Notropis snelsoni	Ouachita Mountain shiner	Recently described endemic.
Percina phoxocephala	slenderhead darter	
Regina rigida sinicola	gulf crayfish snake	
Sternotherus carinatus	razorback musk turtle	
Gomphus ozarkensis	Ozark clubtail dragonfly	

Of these, the fish and mussel species are most likely to be affected adversely by extremely low flows. In addition, the Arkansas Game and Fish Commission has recommended adding the paddlefish (Polydon spatula) to the list. AGFC is initiating work to evaluate abundance, life history information, and spawning site location on this fish which they claim is presently being exploited.

It is likely that these, as well as other aquatic species, would be adversely affected if basin stream flows are reduced to a point where natural biological and physical processes are disrupted. However, agricultural and non-agriculture development in the basin should be managed so that the detrimental affects on the aquatic and terrestrial biota is minimized.

Minimum Streamflow

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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. A minimum streamflow is established to protect instream needs during low flow conditions which may occur naturally or during periods of significant use from the stream. The minimum streamflow also represents a critical low flow condition below which some minimum instream need will not be met. The minimum streamflow is not a target level or a flow that can be maintained for an extended period of time without serious environmental consequences. Therefore, 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 long before this point is reached. Allocation of water should help to maintain streamflow above the established minimum discharge.

With the exception of fish and wildlife requirements, minimum streamflows for streams in the Red River Basin above Fulton were determined based upon the instream flow requirements described in the Instream Flow Requirements section of this report. The minimum instream flow requirements for fish and wildlife were determined according to the method developed by the ASWCC. In developing their method, the ASWCC divided the year into the three seasons identified in the Arkansas method <22> to account for the seasonal variability of stream flow. The seasons are based on physical processes that occur in the stream and the critical life stages of the fish and other aquatic organisms inhabiting the stream. The minimum instream flow requirements for fish and wildlife were determined by taking 10 percent of the average seasonal flows. In addition to requirements for fish and wildlife, instream flow requirements for water quality and interstate compacts were considered in the determiniation of minimum streamflows. Instream flow requirements are not additive and the highest instream need for each season was used to establish the minimum streamflow for each season. Minimum streamflows were established at gaging station locations and at other selected sites and are presented in Table 3-11. It should be noted that the instream flows required to satisfy the interstate compact were not quantified in this report although, at times, these flows may govern. Instream flow requirements for the interstate compact, computed according to the compact formulas, may vary considerably with changing streamflow, runoff conditions, withdrawal of water in states upstream of Arkansas, and water rights of Louisiana.

Figure 3-8 portrays graphically the fish and wildlife requirements compared to stream discharges of the Red River at Fulton. This figure shows the fish and wildlife requirements as determined by the Arkansas method and the method recommended by ASWCC. Also, the maximum, median, and minimum daily discharges for the Red River at Fulton for the period of record (1946-1981) are shown for comparison. Figure 3-9 presents the same information on the Little River near Horatio, Arkansas.

TABLE 3-11: MINIMUM STREAMFLOWS IN THE RED RIVER BASIN ABOVE FULTON 1/
(by season)

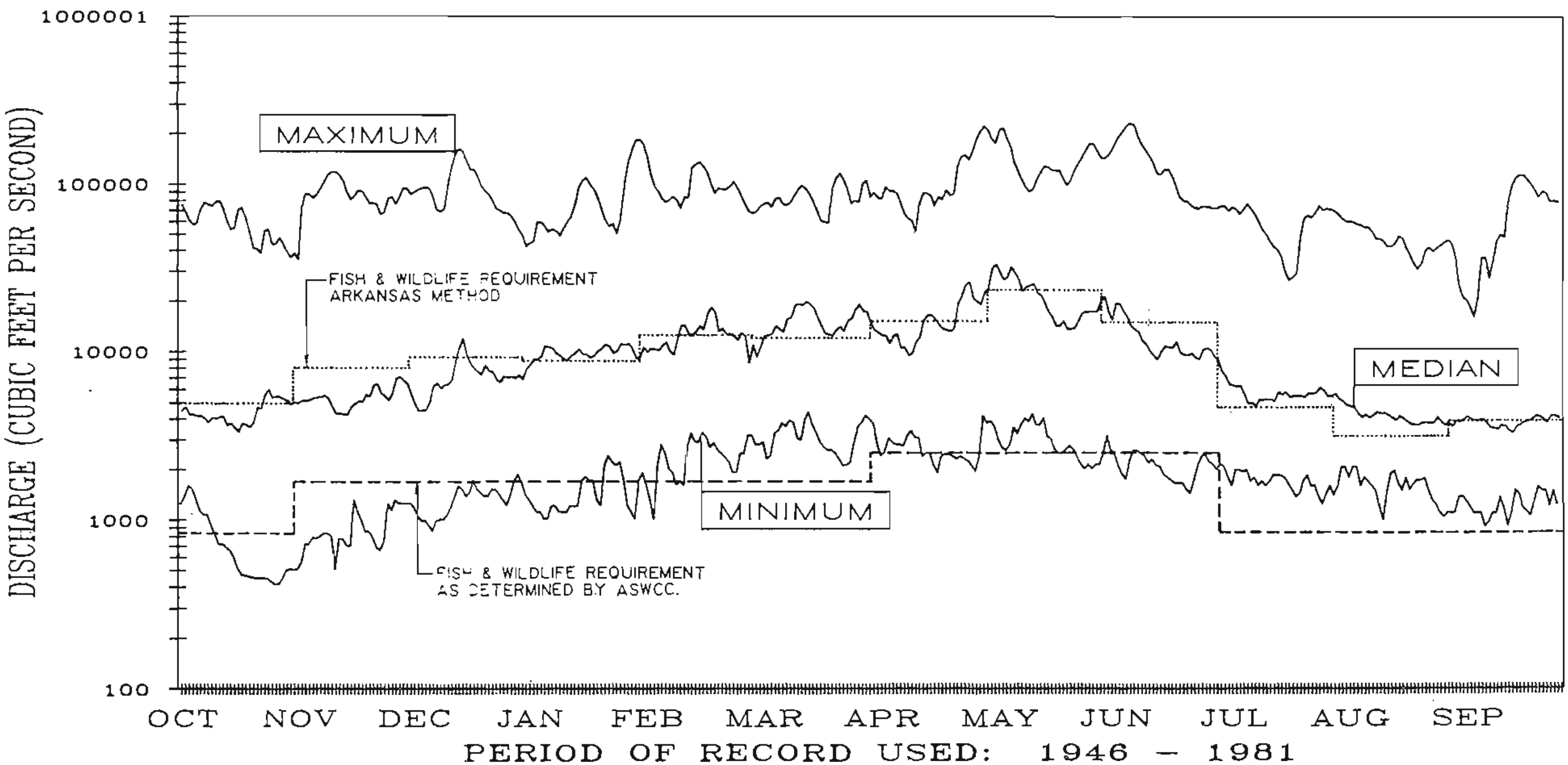
Location	Period of Record	November-March (CFS)	April-June (CFS)	July-October (CFS)
Red River at Fulton, AR	1946-1981	1,721	2,685	1,110 2/
Red River at Index, AR	1974-1984	1,290 2/	1,751	1,290 2/
Little River near Horatio, AR	1971-1984	462	557	194 2/
Cossatot River near Vandervoort, AR	1968-1984	26	25	8.4 2/

1/ Fish and wildlife is the governing instream requirement unless otherwise noted.

2/ Water quality is the governing instream requirement.

Figure 3-8

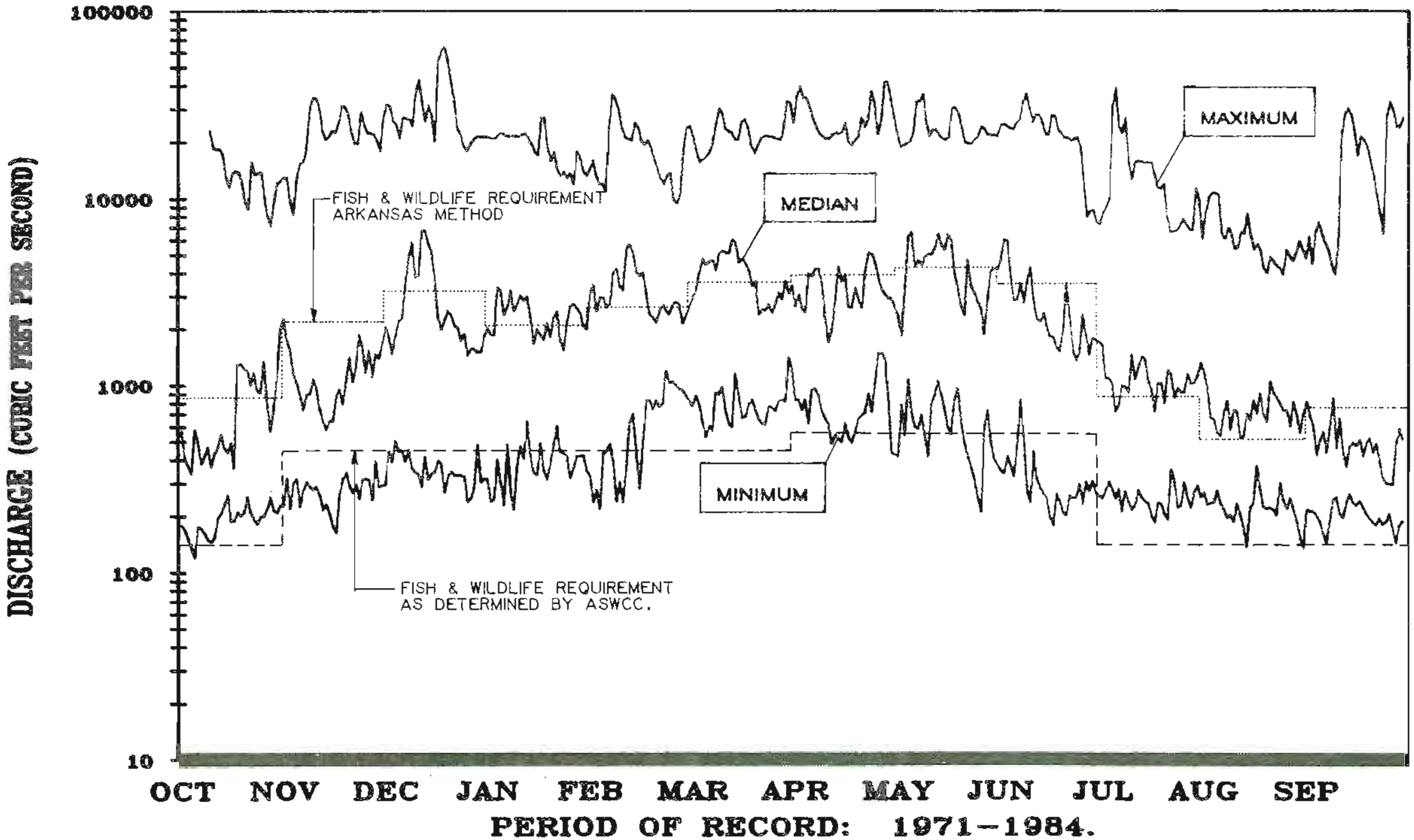
DAILY DISCHARGE VALUES
RED RIVER AT FULTON, ARKANSAS



Source: Daily discharge data from U.S. Geological Survey streamflow records.

Figure 3-9

DAILY DISCHARGE VALUES
LITTLE RIVER NEAR HORATIO, ARKANSAS



SOURCE: DAILY DISCHARGE DATA FROM U.S. GEOLOGICAL SURVEY STREAMFLOW RECORDS.

Safe Yield

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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.

To quantify the safe yield of streams in the 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 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 Red River Basin above Fulton and previously determined in this report, represent discharge that is not available for use. 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 period (July - October). See Table 3-4 for flow values which were equaled or exceeded 95 percent of the time.

Table 3-12 shows the safe yield of the streams at gaging stations for which flow requirements for water quality and fish and wildlife were computed.

TABLE 3-12: SAFE YIELD

Stream	Flow Which Was Equaled or Exceeded 95 Percent of the Time (CFS)	Minimum Streamflow July-October (CFS)	Safe Yield (CFS)
Red River at Index, Arkansas	1,830	1,290	540
Red River at Fulton, Arkansas	2,200	1,110	1,090
Little River near Horatio, Arkansas	260	194	66
Cossatot River near Vandervoort, Arkansas	12	8.4	3.6

The designation of safe yield for some streams is not applicable since the minimum streamflow is greater than the 95 percent flow. This indicates that, at times during the year, water is not available in some streams for other uses and some type of streamflow storage would be required at these locations to provide a sustained yield.

Potential For Development

Safe yield has been addressed by considering existing streamflow conditions, but the potential for development must also be considered to get an accurate portrayal of the water yielding capabilities of the basin. Water supply development, within a given basin, is the construction of reservoirs with water supply being one of the official purposes. These reservoirs store runoff so that water may be supplied to users as it is needed.

Studies have been made by the Soil Conservation Service and other agencies to locate flood control or multi-use impoundments in the basin. At present, six artificial impoundments of 25 or more surface acres exist in the basin. The largest is Millwood Reservoir with 29,500 surface acres followed by DeQueen Reservoir (1,680 surface acres), Gillham Reservoir (1,370 surface acres), Dierks Reservoir (1,360 surface acres), Lake Wilhelmina (324 surface acres), and Shady Lake (25 surface acres). The largest natural lake is Grassy Lake with 1,800 surface acres which is owned by the Hempstead County Hunting Club.

The U.S. Geological Survey has identified two potential reservoir sites in the basin where surface water could be stored for multiple use or to serve as ground water recharge. Table 3-13 summarizes the information for each site.

TABLE 3-13: POTENTIAL STORAGE RESERVOIRS

Name	Drainage Area (Sq. Mi.)	Average Stream Flow (Ac-Ft/Yr)	Pool Elevation Feet (NVGD)	Height of Dam (Ft.)	Length of Dam (Ft.)	Storage Capacity (Ac-Ft)
West Flat Creek near Foreman, AR	10.6	9,400	400	50	4,700	12,300
			390	40	3,200	5,300
			380	30	2,600	2,000
Calton Creek near Foreman, AR	9.0	8,000	400	35	3,200	7,500
			390	25	2,900	3,000
			380	15	2,200	850

Source: U.S. Geological Survey <58>

As a result of studies to date, the SCS has recommended channel improvements but has not completed studies in sufficient detail to determine potential reservoir sites. The U.S. Army Corps of Engineers has proposed channel stabilization and bank protection primarily for the Red River but has not identified or recommended additional artificial impoundments.

Although the basin offers some potential for development of surface water storage, no other specific activities to develop such resources exist at the present time. Since there are no immediate plans for surface water development, safe yields will not be appreciably affected by potential impoundment storage.

Water Use

For ease of comparison, water use and water use trends of both surface water and ground water are discussed in this section. Surface water use and ground water use were also combined in developing total water use projections. (See Potential Water Use)

In 1980, a total of 92.6 million gallons per day (mgd) of surface water and ground water was used in the Red River Basin above Fulton. Surface water accounted for 81.6 mgd or 88 percent of the total while ground water use amounted to 11.0 mgd or 12 percent. <12>

Of the total surface water used, 86 percent (70 mgd) was used for self-supplied industry. The remaining 14 percent of surface water was used for irrigation (5.6 percent), public supply (3.5 percent), rural use (3.4 percent), and fish farms (1.4 percent). Figure 3-10 and Table 3-14 show water use by category. <12>

Of the 70 mgd use of surface water in the basin during 1980, 69.6 mgd was used in Little River County. Southwest Arkansas Water District was the largest single user of surface water. The District utilizes a 25 mgd capacity channel to transport water from Millwood Reservoir to municipal, industrial, and agricultural water users.

Only 6.6 mgd (9 percent) of the 69.6 mgd of surface water used in Little River County in 1980 was consumed. About 13 mgd or 16 percent of the total surface water used in the basin was consumed. Of the total 92.6 mgd used in the basin, approximately 21 mgd or 23 percent was consumed. The consumed portion was either ingested, incorporated into a product, transpired, or evaporated. <12>

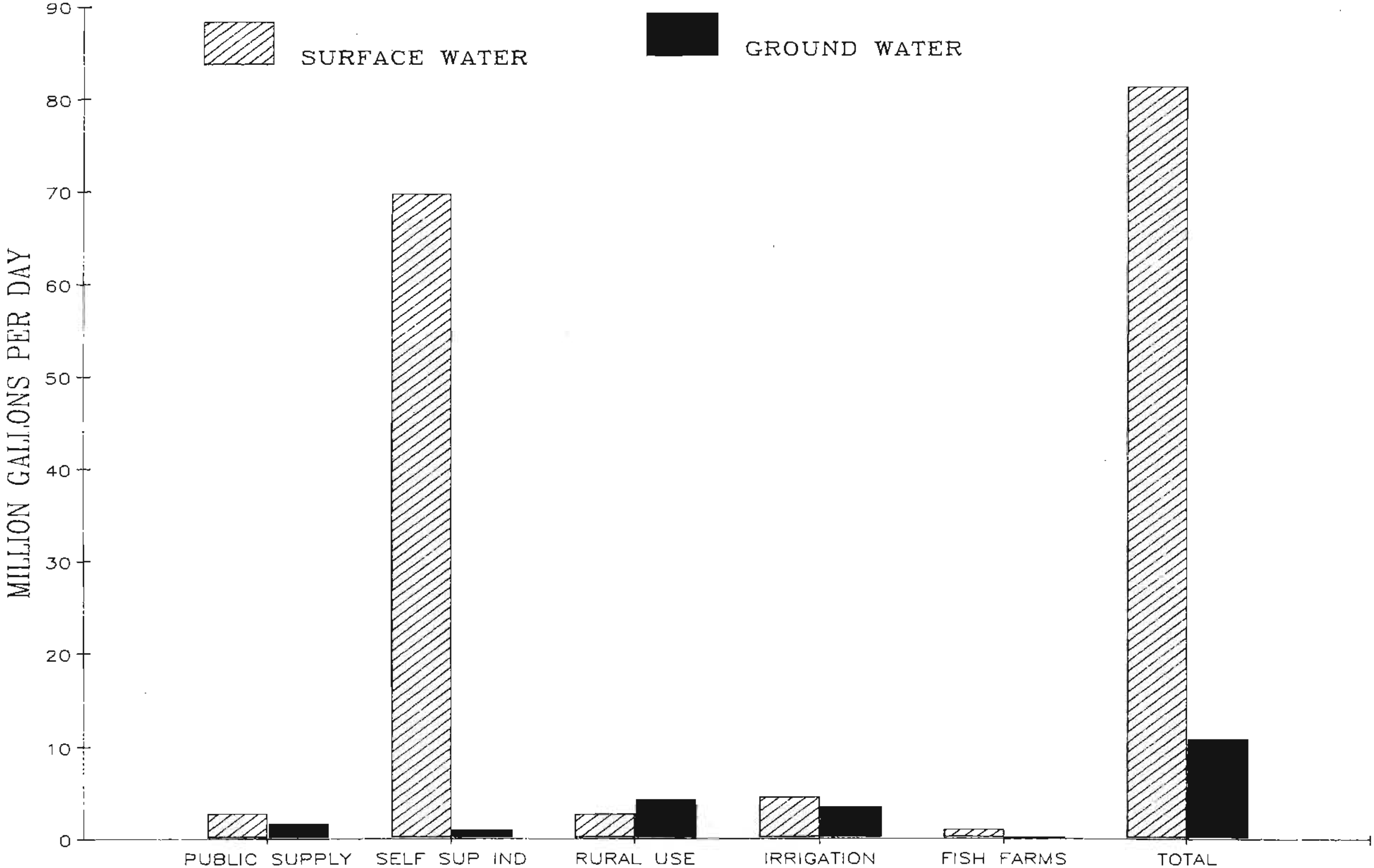
Water Use Trends

Water use trends are shown in Figures 3-11 and 3-12. The necessity of applying procedure differences to development of some water use data caused water use values for 1980, shown in Table 3-14, to disagree slightly with a few water use trend values shown in Figures 3-11 and 3-12. (Irrigation and Rural Use) <7, 9, 10, 11, 12>

With the exception of fish farms, water use during the period 1960-1980 increased in every use category. Significant increases occurred in both Irrigation and Self-Supplied Industry use categories.

Figure 3-10

SURFACE WATER AND GROUND WATER
USED IN THE BASIN – 1980



SOURCE: ARKANSAS GEOLOGICAL COMMISSION AND U.S. GEOLOGICAL SURVEY.

TABLE 3-14: USE OF WATER IN THE BASIN, BY CATEGORY - 1980

(million gallons per day)

Use Category	Ground Water	Surface Water	Total
Public Supply:	1.8	2.9	4.7
Self-Supplied Industry	1.1	70.0	71.1
Rural Use:			
Domestic	2.6	0.0	2.6
Livestock	1.8	2.8	4.6
Subtotal	4.4	2.8	7.2
Irrigation:			
Rice	0.9	2.9	3.8
Other Crops	2.7	1.8	4.5
Subtotal	3.6	4.7	8.3
Fish Farms	0.1	1.2	1.3
Total	11.0	81.6	92.6

Source: Holland and Ludwig, Arkansas Geological Commission and U.S. Geological Survey <12>

Figure 3-11

WATER USE TREND
IN THE
STUDY AREA

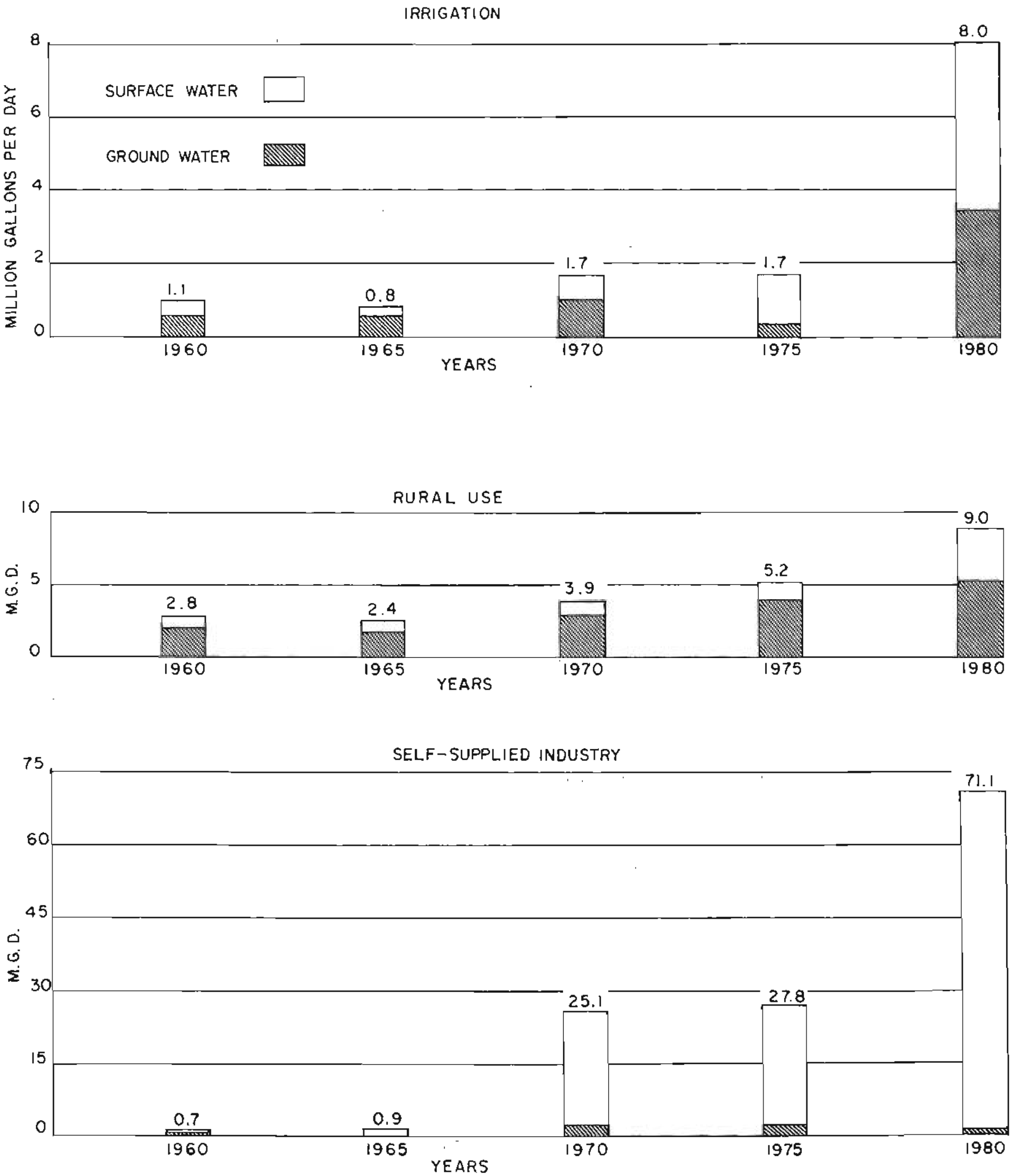
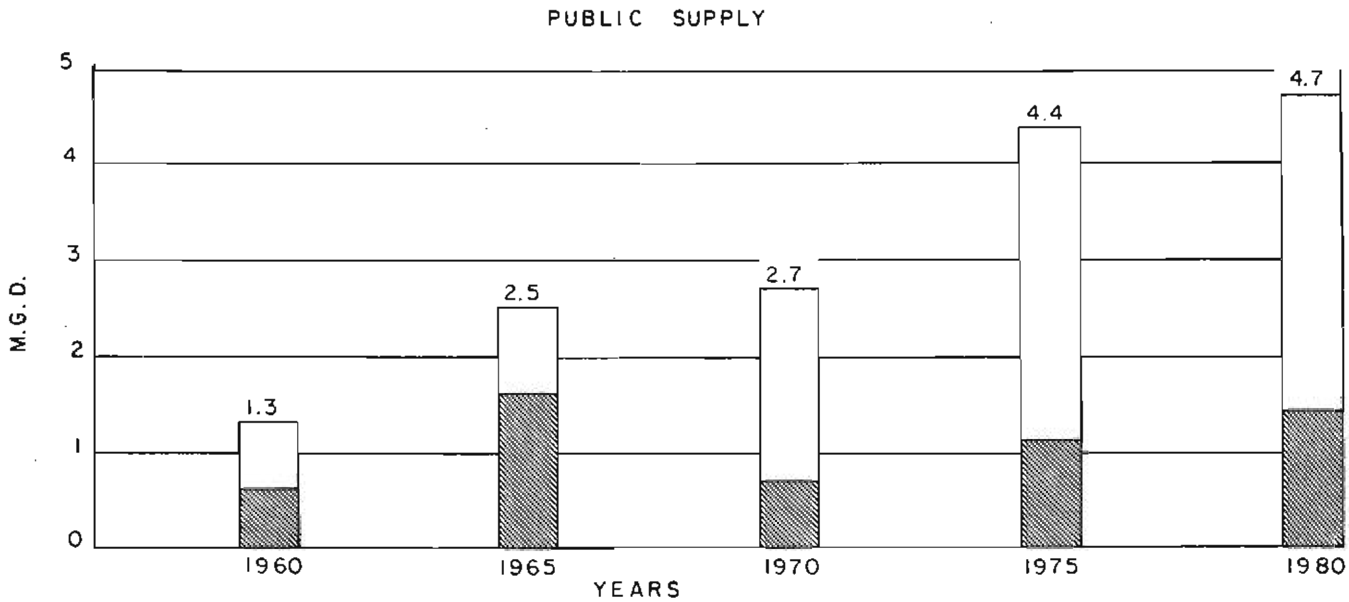
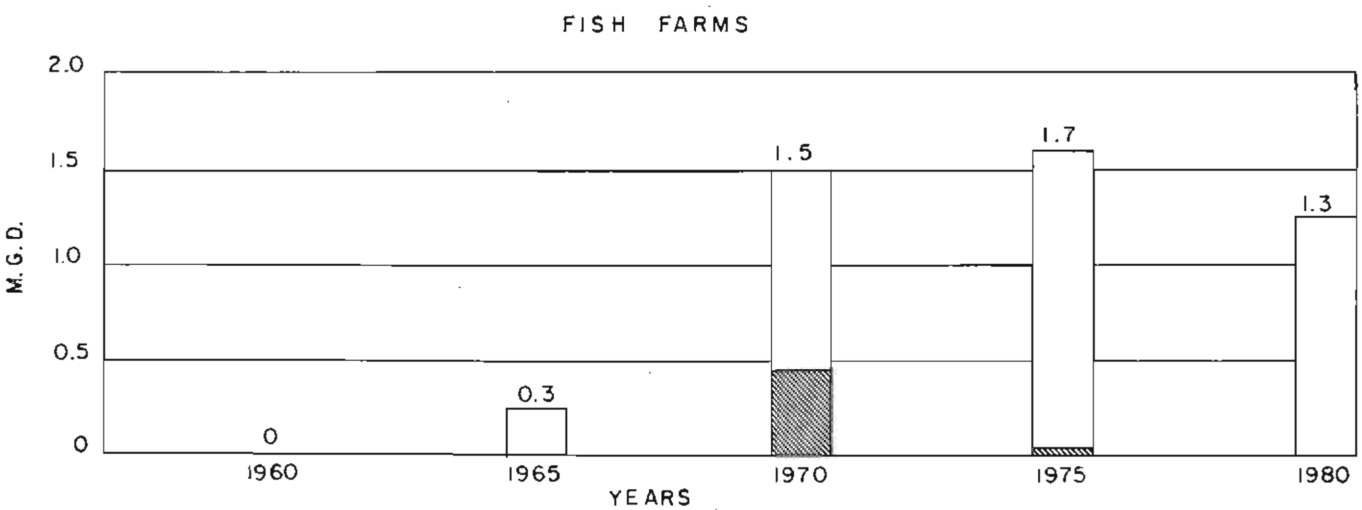


Figure 3-12

WATER USE TREND IN THE STUDY AREA

(CON'T)





SOURCE : ARKANSAS GEOLOGICAL COMMISSION AND U.S. GEOLOGICAL SURVEY

Potential Water Use

Total water use projections in the Red River Basin above Fulton indicate a large increase in the demand for water during the next 20 years. By the year 2000, 293.1 mgd (over three times the 92.6 mgd used in 1980) may be required to meet the needs of water users. Projections indicate, for the year 2030, water needs may be 451.6 mgd or 54 percent higher than for the year 2000. (See Table 3-15 and Figure 3-13) These projections of water demand were made without considering the availability of water or the cost of capital investments. It was assumed that landowners and operators would make additional investments. These investments would be for irrigation equipment and systems, rather than land holdings and dry land farming equipment.

In 1980, 88 percent of the total water used was obtained from surface water sources. Water need projections indicate that, in the year 2030, approximately 77 percent of the total water used could be obtained from surface water sources. (See Figure 3-13) However, to what degree surface water must be utilized cannot be accurately determined until studies, now underway, regarding safe ground water yields are available.

TABLE 3-15: TOTAL WATER USE PROJECTIONS

RED RIVER BASIN ABOVE FULTON

(million gallons per day)

	YEAR								
	1980			2000			2030		
Use Category	Ground Water	Surface Water	Total	Ground Water	Surface Water	Total	Ground Water	Surface Water	Total
Public Supply	1.8	2.9	4.7	2.5	6.4	8.9	4.0	11.9	15.9
Self-Supplied Industry	1.1	70.0	71.1	1.1	70.9	72.0	1.6	102.4	104.0
Rural Use:									
Domestic	2.6	0.0	2.6	3.7	0.0	3.7	5.9	0.0	5.9
Livestock	1.8	2.8	4.6	2.8	4.2	7.0	3.1	4.8	7.9
Subtotal (Rural Use)	4.4	2.8	7.2	6.5	4.2	10.7	9.0	4.8	13.8
Irrigation 1/	3.7	5.9	9.6	60.5	141.0	201.5	89.0	228.9	317.9
Total	11.0	81.6	92.6	70.6	222.5	293.1	103.6	348.0	451.6

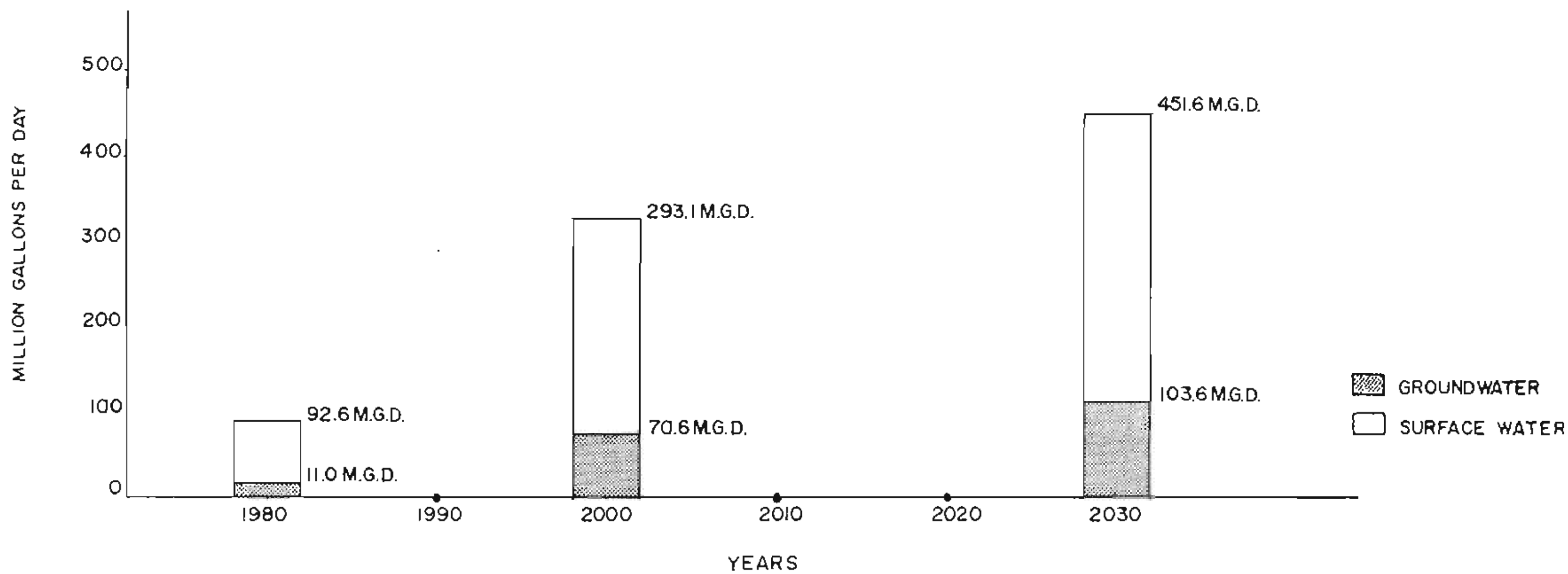
1/ Irrigation includes fish and minnow farms and on-farm wildlife impoundments.

Sources: 1980 - Arkansas Geological Commission and U.S. Geological Survey
2000 - USDA, Soil Conservation Service
2030 - USDA, Soil Conservation Service

Figure 3-13

TOTAL WATER USE PROJECTIONS

(By Source and Years)



SOURCES:

1980 - ARKANSAS GEOLOGICAL COMMISSION AND U.S. GEOLOGICAL SURVEY

2000 - USDA, SOIL CONSERVATION SERVICE

2030 - USDA, SOIL CONSERVATION SERVICE

There is a substantial increase of potential water use by the year 2030 over the 1980 total. The percent of increase is much greater during the period 1980-2000 than during the period 2000-2030. This is attributed primarily to increased irrigation efficiency. Following is a discussion of potential water uses by category.

1. Public Water Supply

In 1980, public supplies drew 62 percent of their water requirement from surface water sources and the remaining 38 percent from ground water sources. The total water use was 4.7 million gallons per day. Projections of total water used for the year 2000 indicate an 89 percent increase over the 1980 figures. The water use for public supplies in the year 2030 is estimated to be 15.9 mgd, an increase of 79 percent over the year 2000 figures. Between 1980 and 2030, public supplies could more than triple their use of water.

2. Self-Supplied Industries

In 1980, surface water provided 98.5 percent of the water requirement for self-supplied industries. Ground water provided only 1.5 percent of the total 71.1 mgd used. The projections for the years 2000 and 2030 indicate an increase in total water use of 1 and 44 percent, respectively. Total water use for self-supplied industries is projected to be 104.0 mgd in the year 2030.

3. Rural Use

a. Domestic: Present and projected use of all water for rural domestic supplies in the basin comes from ground water sources. The projections for years 2000 and 2030 show increases of 42 percent and 59 percent respectively. The overall projection is a 127 percent increase for use of water in 2030 compared with 1980 water use data.

b. Livestock: Livestock relied significantly on surface water in 1980. Almost 61 percent of the water supplied to livestock came from surface water sources. The total usage by livestock in 1980 was 4.6 mgd. In the year 2000, 7.0 mgd is projected to be needed, an increase of 52 percent over 1980 figures. A 13 percent increase in water use between 2000 and 2030 is anticipated. In 2030, livestock could be using 72 percent more water than in 1980.

4. Irrigation

For purposes of water use projections, water use requirements for fish farms, wildlife impoundments, and irrigation were combined under the single category of irrigation. The 1980 combined total water use figure of 9.6 mgd for irrigation, fish farms, and wildlife impoundments accounts for 10 percent of the total water use in the basin. Of all irrigation water used in 1980, 61 percent came from surface water sources and 39 percent from ground water. Irrigation is expected to increase significantly by the year 2000. The projections show that by the year 2000, 201.5 mgd (21 times the 9.6 mgd utilized for irrigation in 1980) could be needed for irrigation. The projections for the year 2030 predict a use of 317.9 mgd for irrigation, or an increase of 58 percent over the year 2000. The declining percentage increase from 2000 to 2030 is attributed partly to increased irrigation efficiency during that period.

Excess Streamflow

Excess streamflow, defined in Section 5 of Act 1051, 1985, is 25 percent of the 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 this report, excess water does not allow for the possible restriction of basin streamflow uses to comply with Section 5.05 of the Red River Compact. Therefore, the amount of excess water actually available on an average annual basis could vary significanly from the amount determined here. The Red River, Little River and Cossatot River were considered the appropriate sources for determining excess water in the basin, since only these three streams had flows significant enough to qualify as sources for instream flow requirements. Table 3-16 shows mean annual discharges for several basin streams in addition to the Red River, Little River, and Cossatot River. However, the limited and variable discharges of these streams excluded them for instream flow requirement consideration. If the discharges of these streams were reduced by the governing instream flow requirement amount, the excess water remaining would be less than one percent of the total excess water available in the basin.

To determine the excess streamflow in the Red River Basin above Fulton, the U.S. Geological Survey streamflow data compiled at the Red River at Fulton, AR streamflow gage was utilized. The Fulton, AR streamflow gage was used to determine excess streamflow because all surface water runoff in the basin exits the basin through the Red River at Fulton, AR stream gage.

As previously stated, excess streamflow is 25 percent of the flow available on an average annual basis above the amount needed to satisfy existing and projected water requirements of the basin. Existing streamflow requirements include water quality, fish and wildlife, interstate compacts, riparian, navigation, aquifer recharge, and aesthetic uses. Table 3-16 shows the requirements for water quality (determined by ADPC&E) and fish and wildlife (as determined by the Arkansas method). Although no less important, values for other categories were excluded from the table because flow requirements for navigation have not been established, interstate compact requirements are variable, aquifer recharge was not determined in this report, riparian uses are withdrawn from the stream prior to measurement, and aesthetic requirements are assumed to be met by fish and wildlife needs.

The instream flow requirements for the streamflow use categories are not additive; therefore the category with the greatest instream flow need will govern. The instream flow requirements for fish and wildlife (as established by the Arkansas method), are the highest flow requirements determined in this report. On an average annual basis, sixty percent of the mean annual basin stream yield at the Fulton, Arkansas Red River stream gage (17,190 CFS from Table 3-16) or 10,314 CFS will satisfy fish and wildlife instream flow requirements. The value of 17,190 CFS minus 10,314 CFS or 6,876 CFS represents the net average annual basin discharge available after existing instream flow requirements are met.

TABLE 3-16: MEAN ANNUAL DISCHARGES AND
FLOW REQUIREMENTS OF SIGNIFICANT STREAMS

Stream	Drainage Area (Sq. Mi.)	Mean Annual Discharge (CFS)	Water Quality Requirement (CFS)	Average Annual Fish and Wildlife Requirement (CFS)
Red River at Fulton, AR	52,336 1/	17,190	1,110	10,314
Red River at Index, AR	48,030 1/	11,490	1,290	6,894
Little River near Horatio, AR	2,662	3,750	194	2,250
Cossatot River near Vandervoort, AR	89.6	193	8.4	116
Rolling Fork near DeQueen, AR	182	292	0.2	2/
Saline River near Dierks, AR	121	194	2/	2/

1/ 5,936 square miles probably non-contributing.

2/ Value not determined.

To determine projected surface water needs, the total water requirement of 451.6 mgd estimated for the year 2030 (Table 3-15), was reduced by the 1980 surface water use (81.6 mgd) and ground water use (11.0 mgd). The net projected surface water need is 359 mgd (556 cfs). The value of 6,876 cfs minus 556 cfs or 6,320 cfs (4,575,680 acre-feet) represents the net average annual discharge available after existing and projected instream flow requirements are met.

According to Act 1051, 25 percent of the 6,320 cfs of surface water (0.25 x 6,320) or 1,580 cfs (1,143,920 acre-feet) is excess surface water in the basin and is available on an average annual basis for other uses such as interbasin transfer. It must be remembered that the majority of the excess surface water is available during the period of high flow (December through May) and significantly less available during the period (June through November). Also, the implementation of Red River Compact requirements may alter the discharge available.

Quality of Streamflow

The Red River Basin above Fulton includes all of Water Quality Planning Segments 1C and 1D as delineated by the Arkansas Department of Pollution Control and Ecology. In addition, approximately one-third of Segment 1B makes up nearly eight percent of the basin. Water quality planning segment boundaries and locations of water quality sampling stations are shown in Figure 3-14. <5> A description of each segment follows:

Segment 1B - Red River

The Red River Basin above Fulton comprises about 151,070 acres of the total 846,150 acres in Segment 1B. The basin portion of the segment is confined to Little River County. Major streams include the Red River and Walnut Bayou. <5> The segment portion of the basin is composed of 27 percent cropland, 35 percent grassland, 25 percent forest land, and 13 percent miscellaneous uses such as water, urban areas, farmsteads, roads, and feedlots. <38>

Only one active water quality sampling station, identified as RED 25, is located on the Red River in the basin portion of the segment. (See Table 3-17 and Figure 3-14) <5>

TABLE 3-17: SUMMARY OF ACTIVE WATER QUALITY COLLECTION SITES 1/

ADPC&E Station No.	USGS Station No.	Station Name	Period of Record	Drainage Area (Sq. Mi.)
RED 01	07338720	Mountain Fork near Hatfield, AR	1979-Present	168
RED 02	07340000	Little River near Horatio, AR	1968-Present	2,662
RED 25	07336860	Red River south of Foreman, AR	1974-Present	47,648
RED 31	07340400	Cossatot River at Hghwy. 4 east of Wickes, AR	1983-Present	385
RED 32	07340945	Saline River at Hghwy. 4 north of Dierks, AR	1983-Present	47.4
RED 33	07339795	Bear Creek, Process City, AR	1983-Present	2/

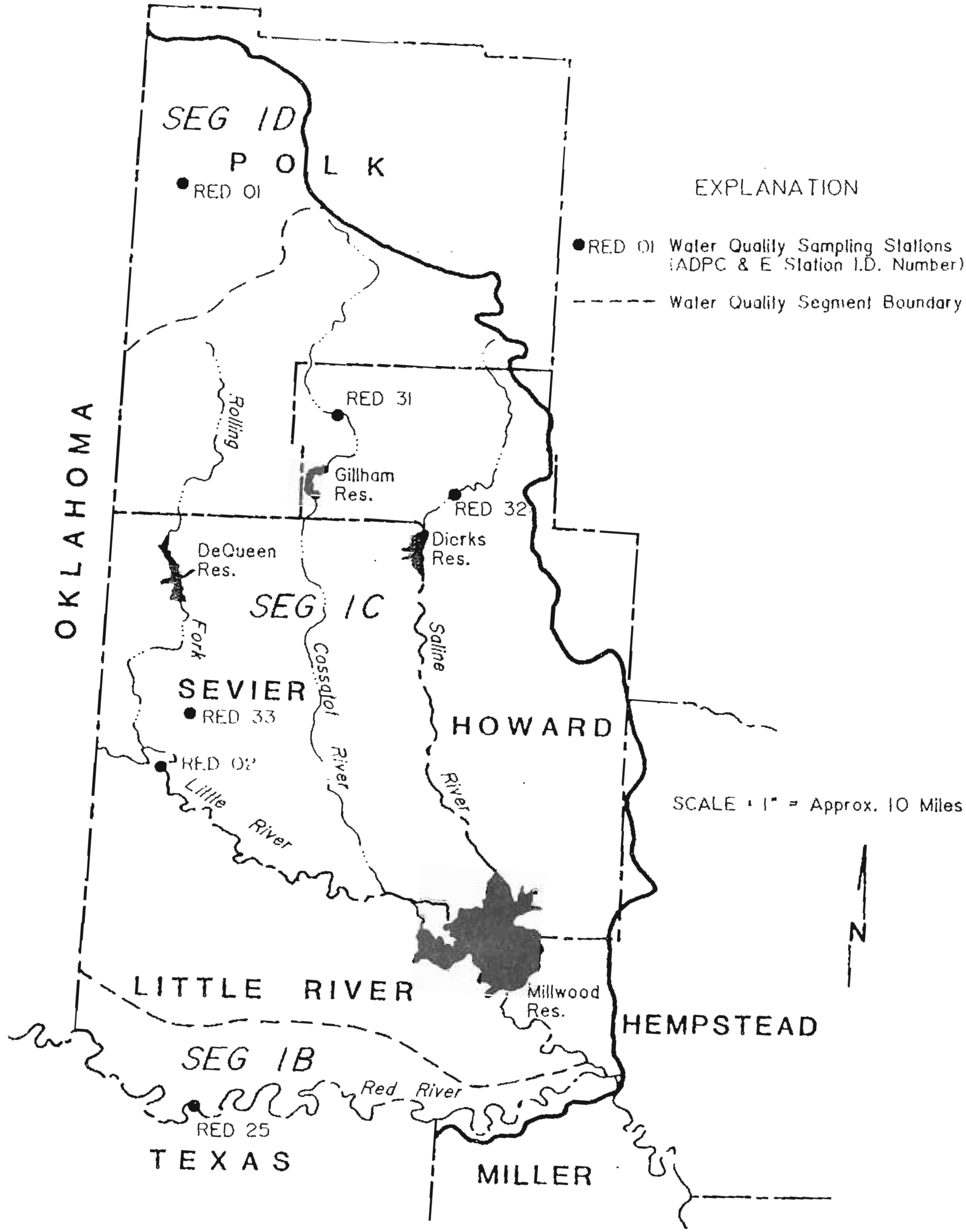
1/ Water quality data currently being collected. Historical data available from four additional stations not listed. ADPC&E station numbers correspond to those in Figure 3-14.

2/ Drainage area not computed

Source: Arkansas Department of Pollution Control and Ecology <5>

Figure 3-14

WATER QUALITY PLANNING SEGMENTS AND LOCATIONS OF ACTIVE WATER QUALITY SAMPLING STATIONS



SOURCE : ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY

Segment 1C - Little River and Tributaries

Segment 1C comprises 1,157,997 acres in Sevier, Little River, Hempstead, Howard and Polk counties. (See Figure 3-14) Major streams include Little River, Rolling Fork, Cossatot River, Saline River, and Mine Creek. <5> Land use is composed of 2 percent cropland, 25 percent grassland, 68 percent forest land, 2 percent urban, and 3 percent water and other miscellaneous uses. <18>

There are four active water quality sampling stations in this segment: RED 02; RED 31; RED 32; and RED 33. (Figure 3-14 and Table 3-17) <5> These stations are located on Little River, Cossatot River, Saline River, and Bear Creek, respectively. Historical data are also available from four other stations. <5>

Segment 1D - Mountain Fork and Tributaries

Segment 1D comprises 147,505 acres in Polk County. <5> The major stream in this relatively small segment is Mountain Fork of Little River. Land use is 1 percent cropland, 22 percent grassland, 72 percent forest land, 3 percent urban, and 2 percent water. <18>

There is one water quality sampling station, designated as RED 01, in the segment. (Figure 3-14) <5> Information about the station is provided in Table 3-17.

Impoundments

Inventory

The inventory of the lakes of the Red River Basin above Fulton was taken from the Lakes of Arkansas publication of the AS&WCC. <17> For lakes over 5 surface acres, data were compiled for the hydrologic region of the basin. Information for impoundments under 5 acres covers 4 counties identified as the study area. Data for Hempstead and Miller Counties were not included because of the small area of the counties located within the basin. Also, data for these counties were included in the Red River Basin below Fulton report.

There are 66 impoundments with over 5 surface acres within the Red River Basin above Fulton. These impoundments have a total surface area of 37,390 acres and impound 323,853 acre-feet. (See Table 3-18) It is estimated that within the 4 county study area, 5,894 impoundments under 5 surface acres exist. These impoundments cover 3,135 acres and impound 10,068 acre feet of water. (See Table 3-19) Total storage of all impoundments is 333,921 acre-feet.

TABLE 3-18: BASIN IMPOUNDMENTS EXCEEDING 5 ACRES IN SIZE
(by ownership)

Arkansas Game and Fish Commission

County	Number/Name	Use 1/	Area (acres)	Capacity (acre-feet)
Polk	Lake Wilhelmina	R	324	3,240
Subtotal	1		324	3,240

U. S. Forest Service

County	Number/Name	Use 1/	Area (acres)	Capacity (acre-feet)
Polk	Shady Lake	R	25	270
Subtotal	1		25	270

U. S. Corps of Engineers

County	Number/Name	Use 1/	Area (acres)	Capacity (acre-feet)
Howard	Gillham	FC, M, R	1,370 2/	33,100 2/
Howard and Sevier	Dierks	FC, M, R, FWL	1,360 2/	29,700 2/
Howard, Hempstead, Little River, and Sevier	Millwood	FC, M, R	29,500 2/	208,040 2/
Sevier	DeQueen	FC, M, R, FWL	1,680 2/	34,900 2/
Subtotal	4		33,910 2/	305,740 2/

Private

County	Number/Name	Use 1/	Area (acres)	Capacity (acre-feet)
Hempstead	7	R	1,864	7,466
Howard	13	R, L, Ir, M	222	1,570
Little River	19	R, L, Ir, FC	670	3,724
Miller	1	R, L	160	640
Polk	5	R, L, I	36	231
Sevier	15	R, I, M, L, Ir	179	972
Subtotal	60		3,131	14,603
Basin Total	66		37,390	323,853

1/ R - Recreation
FC - Flood Control
L - Livestock
I - Industrial
M - Municipal
Ir - Irrigation
FWL - Fish and Wildlife

2/ Conservation Pool

Source: Arkansas State Water Plan <17>

TABLE 3-19: IMPOUNDMENTS UNDER 5 SURFACE ACRES IN THE STUDY AREA

County 1/	Number	Area (acres)	Capacity (acre-feet)
Little River	1,056	863	2,746
Sevier	1,451	578	1,168
Howard	1,493	747	2,366
Polk	1,894	947	3,788
Total	5,894	3,135	10,068

1/ Excludes Hempstead County and Miller County data.

Source: Arkansas Soil and Water Conservation Commission <17>

Impoundment Water Quality

Regulatory procedures for Gillham, Dierks, and DeQueen reservoirs, constructed and operated by the U. S. Army Corps of Engineers in the Red River Basin above Fulton, are conducted to provide, as near as possible, the recommended discharge rates and water temperature requirements for water quality, fisheries, water supply, and recreation. <71> All reasonable efforts are made to limit variations in release temperatures of water to a maximum of 1°C per hour. Additional releases will be made, as necessary, to alleviate or respond to emergency conditions, such as fish kills and flow augmentation for pollution abatement or aesthetics. <71>

Millwood Lake, also constructed and operated by the Corps of Engineers, releases 155 cfs throughout the year. This release satisfies the minimum low flow requirement and downstream water rights. It also provides protection for fish and wildlife resources.

Shady Lake in Polk County is operated by the U. S. Forest Service and the Arkansas Game and Fish Commission. The lake water quality is good and swimming is allowed. Water samples collected on a weekly basis show that concentrations of fecal coliform bacteria have never exceeded 100 colonies per 100 ml of water.

Impoundment Water Use

Total storage of all impoundments in the basin is 333,921 acre-feet. Total reported releases from impoundments was 3,382,700 acre-feet in the 1980 water year. Public water supply and self-supplied industry surface water use amounted to 81,648 acre-feet in 1980. Table 3-20 provides storage and storage information for the four resorvoirs regulated by the Corps of Engineers.

TABLE 3-20: CORPS OF ENGINEERS' RESERVOIR STORAGE AND USE OATA

Reservoir	Conservation Storage	Active Water Supply Allocation	Future Water Supply Allocation	Water Quality and Low Flow Allocation	Uncommitted Storage
	Acre - feet				
Millwood	153,260	32,828 1/	117,172 1/		3,260
Dierks	15,050	200 2/	10,400 2/	4,450	
Gillham	29,312	600 2/	20,000 1/	8,712	
DeQueen	25,550	0	0	7,650	17,900
Total	223,172	33,628	147,572	20,812	21,160

1/ Southwest Arkansas Water District

2/ Tri-Lakes Water District

Source: U.S. Army Corps of Engineers <71>

USDA SOIL CONSERVATION SERVICE AND U.S. ARMY CORPS OF ENGINEERS PROJECTS

Soil Conservation Service

Refer to Legal and Institutional Setting for an explanation of the programs mentioned in this section. Table 3-21 identifies watersheds in the Red River Basin above Fulton by name and corresponding watershed acres. The table also shows the Public Law 83-566 status of watersheds on which applications for PL 83-566 assistance have been submitted. Haney Creek Watershed, a flood prevention and drainage project located in Little River County, was completed in 1974. The project consisted of one floodwater retarding structure and 17 miles of channel at a total installation cost of $664,538. Construction of the Bois d'Arc watershed project was completed in 1984. This flood prevention and drainage project in Little River County consisted of 8 miles of channel work with a total installation cost of $951,350.

Drainage District Number 2, a sub-watershed of the Walnut Bayou Watershed, is a flood prevention and drainage project now in the preauthorization planning stage.

A request for PL 83-566 land treatment planning authorization for the Walnut Bayou Watershed will be submitted to the Chief (SCS), in February, 1987. The principal concern is outlet control for approximately 80 major gullies entering the Bayou. Figure 3-15 shows the basin watershed locations and corresponding PL 83-566 watershed protection potential status.

A total of three Resource Conservation and Development (RC&D) measures have been identified in the Red River Basin above Fulton. The measures include Sycamore Creek flood prevention in Sevier County, erosion and urban flooding control for the City of Ashdown in Little River County, and erosion and flood control on Upper Yellow Creek in Hempstead and Howard Counties. All three measures are currently inactive.

TABLE 3-21: RED RIVER BASIN ABOVE FULTON WATERSHEDS

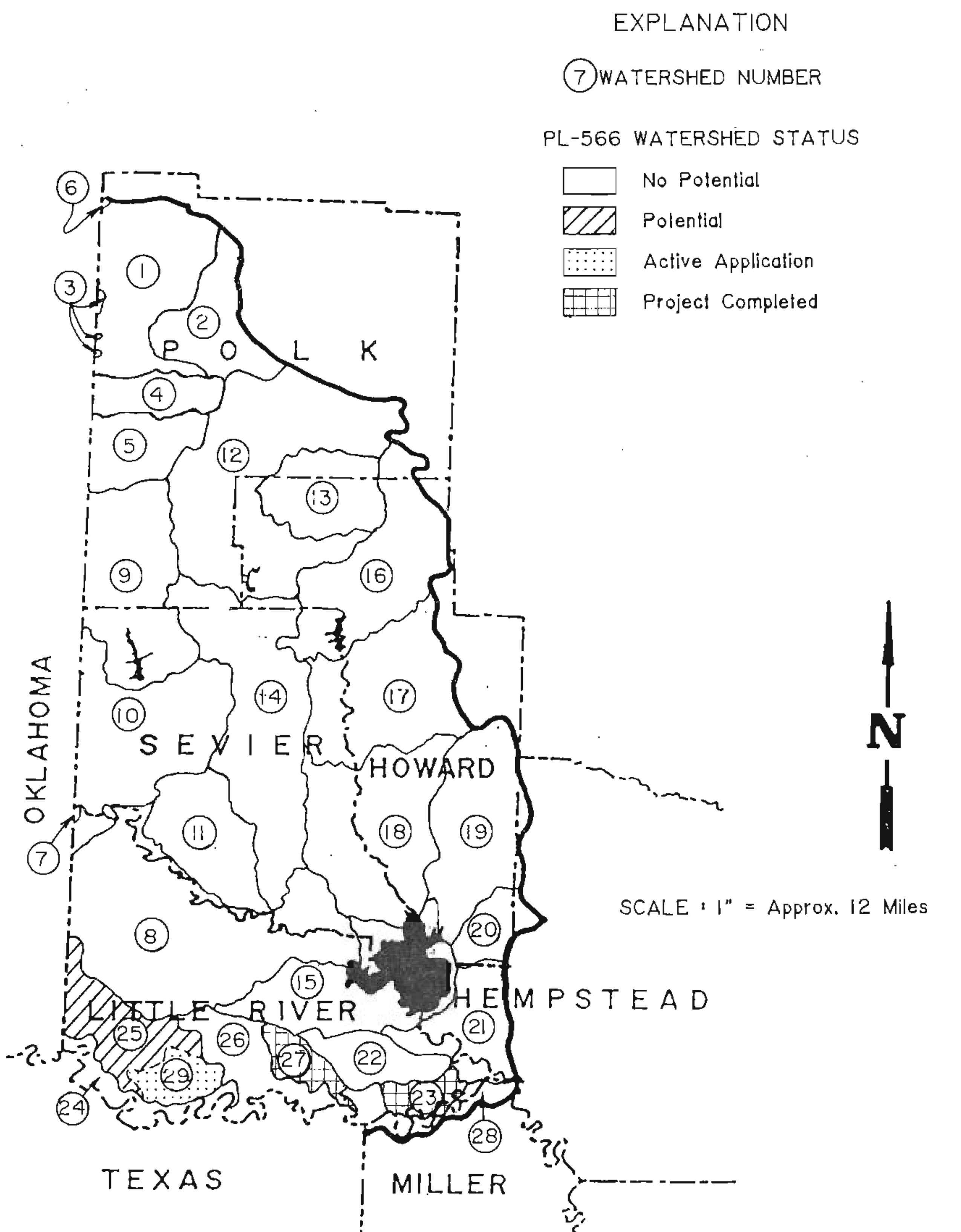
Map Watershed Number	Watershed Name	Drainage Area (Acres)	PL 83-566 Projects Potential	PL 83-566 Projects Status 2/	Structures Channels	Structures Dams
1	Upper Mountain Fork	66,054	No	-	-	-
2	Potter	29,129	No	-	-	-
3	Middle Mountain Fork	628	No	-	-	-
4	Cove - Hatfield	22,565	No	-	-	-
5	Lower Mountain Fork	29,129	No	-	-	-
6	Upper Kiamichi River	70	No	-	-	-
7	Lower Little River	5,810	No	-	-	-
8	Caney - Flat Creek	143,188	No	-	-	-
9	Upper Rolling Fork	78,400	No	-	-	-
10	Lower Rolling Fork	78,742	No	-	-	-
11	No. Bank Lat. of Little River	53,151	No	-	-	-
12	Upper Cossatot River	133,560	No	-	-	-
13	Harris Creek	42,024	No	-	-	-
14	Cossatot River	109,926	No	-	-	-
15	Millwood Laterals	84,333	No	-	-	-
16	Upper Saline River	84,845	No	-	-	-
17	Middle Saline River	77,329	No	-	-	-
18	Starch Creek	99,706	No	-	-	-
19	Mine Creek	68,738	No	-	-	-
20	Plum Creek	20,930	No	-	-	-
21	Yellow Creek	42,594	No	-	-	-
22	Hudson Creek	24,181	No	-	-	-
23	Bois D'Arc Bayou	10,540	-	7	Yes	No
24	Red Rv. No. Bank Laterals	20,150	No	-	-	-
25	Walnut Bayou	56,422	Yes	-	Yes	No
26	Bull Creek	32,241	No	-	-	-
27	Haney Creek	15,380	-	7	Yes	Yes
28	Cutoff Lakes	26,807	No	-	-	-
29 1/	Drainage District #2	13,000	-	1	Yes	No

1/ Sub-watershed to Walnut Bayou (Number 25).

2/ USDA, SCS, PL 83-566 Status Code
1 - Active Application
7 - Project Completed

Figure 3-15

RED RIVER BASIN ABOVE FULTON WATERSHEDS



U. S. ARMY CORPS OF ENGINEERS

Table 3-22 lists the major projects of the U. S. Army Corps of Engineers for the Red River Basin above Fulton. Figure 3-16 shows the project locations. <40>

TABLE 3-22: MAJOR PROJECTS OF THE CORPS OF ENGINEERS

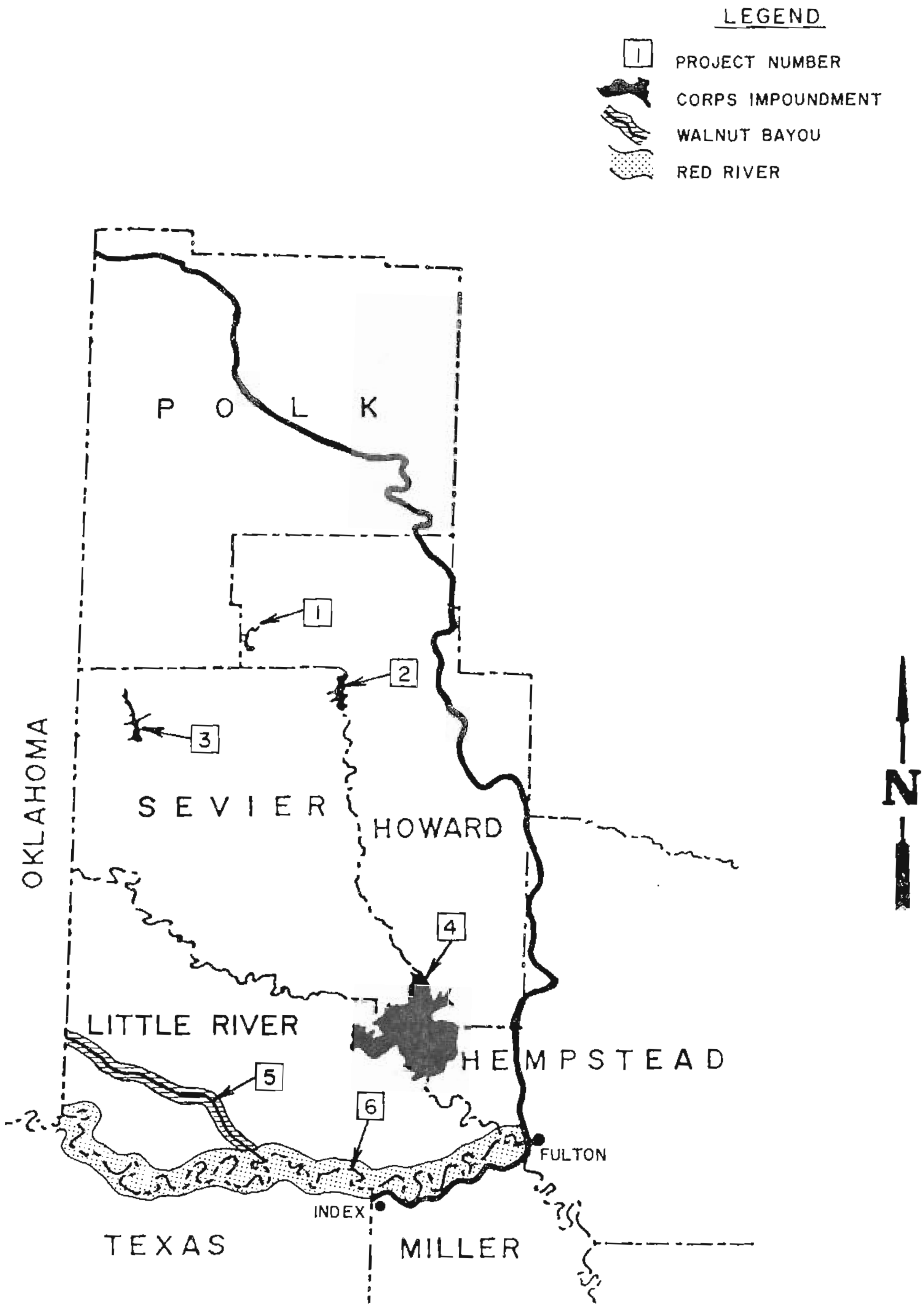
Project Number 1/	Project Name	Status
1	Gillham Lake (Gillham Dam)	Completed
2	Dierks Lake (Dierks Dam)	Completed
3	DeQueen Lake (DeQueen Dam)	Completed
4	Millwood Lake (Millwood Dam)	Completed
5	Walnut Bayou	Completed
6	Red River Waterway	Not Started

1/ Project numbers in this table correspond to project numbers on Figure 3-16 and in the following narrative.

Source: U.S. Army Corps of Engineers <40>

Figure 3-16

MAJOR PROJECTS OF CORPS OF ENGINEERS



1. Gillham Lake (Gillham Dam). Gillham Lake and Dam is a unit of the Little River Basin system of lakes authorized by the Flood Control Act of 1958. "Gillham Lake is a multi-purpose project for flood control, water supply, water quality control, and fish and wildlife conservation." <71> Gillham Dam is an earth and rock embankment 1,750 feet long, rising 160 feet above the original streambed and is constructed across the Cossatot River about six miles northwest of Gillham. The lake is located in Howard and Polk Counties.

   "Construction started in June 1968 with work on an access road. First concrete at the spillway was poured in November 1968 and the'project completed for useful operation by May 1975. Over $2.5 million in flood damages was prevented by the project since operation began." <40>

   "The conservation (normal) pool with an elevation of 502.0 feet mean sea level (msl) covers an area of 1,370 acres and provides more than 33,000 acre-feet of storage for water supply. It has a 36-mile shoreline. The flood control pool, elevation 569.0 feet, msl, covers an area of 4,680 acres and contains almost 190,000 acre-feet for flood control storage." <40>

   "Gillham Dam controls the runoff from 271 square miles of rugged woodlands in commercial timber. Long, narrow, forrested ridges project into the lake nestled in the Ouachita Mountains. Rock bluffs, pine forests and distant higher mountains make the reservoir an area of unique appeal for recreation. Over 159,000 visitors came to the project in 1979." <40>

2. Dierks Lake (Dierks Dam). Dierks Lake and Dam is a unit of the Little River Basin system of lakes authorized by the Flood Control Act of 1958. It is a multi-purpose project for flood control, water supply, water quality control, fish and wildlife conservation, and recreation. Dierks Dam is an earth embankment about 2,760 feet long, rising 153 feet above the riverbed. The damsite is located on the Saline River about five miles northwest of Dierks. The reservoir lies in Sevier and Howard Counties. Dierks Lake is operated for maximum flood control benefits on the Saline River to Millwood Lake, and in conjunction with other lakes in the Little River system, minimizes flooding on the lower Little River and the lower Red River. <40>

   Construction of the Dierks Lake project began in June 1968 and it was placed in useful operation in May 1975. The project has already prevented more than $1.4 million in flood losses through September 1979. Benefits from water storage contracts during the period have exceeded $77,000. <40>

   The conservation (normal) pool, at elevation 526 feet, msl, covers an area of 1,360 surface acres and has more than 41 miles of shoreline. It contains 29,500 acre-feet of storage for water supply. The flood control pool has a capacity for storing 67,100 acre-feet of flood-water from a drainage area of 114 square miles. At full flood stage, elevation 557 feet, msl, the pool has a surface area of 2,970 acres. <40>

3. DeQueen Lake (DeQueen Dam). This Lake and Dam is a unit of the Little River Basin system of lakes authorized by the Flood Control Act of 1958.

It is a multi-purpose project for flood control, water supply, water quality control, fish and wildlife conservation, and recreation. DeQueen Dam is a 2,360-foot earth embankment 160 feet in height above the riverbed. The dam is constructed across the Rolling Fork River about four miles northwest of DeQueen and controls the runoff from 169 square miles of hilly and mountainous country, mostly covered with a heavy growth of oak, pine, and hickory forest lands. The 1,680-acre lake is located entirely within Sevier County. The project controls flooding, stores water for urban and industrial use, sustains streamflow during low flow periods which benefits fish and wildlife, and provides unusual opportunities for recreation. <40>

The first construction on DeQueen Lake project started in April 1966, and the unit was placed in useful operation in the fall of 1977. The conservation pool has a normal elevation of 437 feet, msl, and a 32-mile shoreline. The pool provides 34,900-acre-feet of storage for water supply. The flood control pool, with an elevation of 473.5 feet, msl, forms a 4,050-acre lake which provides over 100,000 acre-feet for flood control storage. The project has prevented nearly $2.4 million in losses from flooding through September, 1979.

4. Millwood Lake (Millwood Dam). Millwood Lake and Dam is a unit of the Little River Basin system of lakes authorized by the Flood Control Act of 1958. It is a multi-purpose project for flood control, water supply, water quality control, fish and wildlife conservation, and recreation. Millwood Lake is located on Little River about seven miles east of Ashdown. Millwood Lake is formed by an earth embankment dam more than 17,500 feet long which rises 88 feet above the streambed. The top of the flood control pool (elevation 287 feet, msl) covers about 95,000 acres of Little River, Sevier, Howard and Hempstead Counties. The lake is a key unit in the general flood plan for the Red River below Lake Texoma, operating in conjunction with Texoma, Pat Mayse and Hugo Lakes and five upstream lakes in the Little River Basin. Millwood Dam controls a drainage area of more than 4,100 square miles and forms a lake with a 65-mile shoreline at the top of the conservation pool (elevation 259.2 feet, msl). <40>

   Construction of the dam began in September 1961 and was completed for control operation in August 1966. The lake's normal conservation pool has a storage capacity of more than 153,000 acre-feet for water supply and sediment. The flood control pool has a storage capacity in excess of 1.6 million acre-feet for flood control. <40>

   The Millwood Lake project has been credited with preventing $3.9 million in flood damages through September 1979. The lake also provides a dependable water supply for the industrial and urban needs of Southwest Arkansas. <40>

5. Walnut Bayou. Walnut Bayou is a minor tributary of the Red River. Improvements include channel clearing, realignment, and enlargement of Walnut Bayou starting at the Arkansas-Oklahoma state line and continuing downstream for about 20 miles where a one-half mile cutoff diverts the stream into the Red River. The project became operative in late 1959. Flood damages of $227,000 have been prevented as a result of the work. Local interests are responsbile for operation and maintenance. <40>

6. Red River Waterway.
The Corps of Engineers, Vicksburg District, has the major responsibility for the Red River Basin with cooperative assistance from the Little Rock, Tulsa, and New Orleans Districts.

A flood control plan below Dennison Dam (Texas and Oklahoma) was authorized by the Flood Control Act of 1946 and modified at later dates. Generally, the authorization provides construction of water storage areas including seven in Oklahoma, five in Texas, one in Louisiana and four in Arkansas. Other project features include enlarging and strengthening the Red River Levee System, channel and bank construction work at designated locations, and the incorporation of other previously authorized project works.

This project was authorized in 1946 as a feature of the comprehensive "Red River Below Denison Dam, Comprehensive Basin Study, Louisiana, Arkansas, Oklahoma and Texas" project. Additional modifications were authorized in 1968. This project authorizes the raising and strengthening of existing levees below Denison Dam to provide protection against a flood equivalent to that of 1945. Other project features are for bank protection and channel stabilization in highly developed areas where levee relocations are unfeasible. Cumulative benefits through September 1979 in the New Orleans District are estimated in excess of $2.25 million.

The levee system within the project totals nearly 400 miles on either side of the Red River along parts of Arkansas, Louisiana, and Texas. Nearly 20 miles of bank protection work is also authorized in Arkansas with more than half the authorized total (12 miles) constructed.

One of the modifications provided by the River and Harbor Act of 1968 is as follows: A comprehensive plan for bank stabilization on the Red River from Denison Dam to the Mississippi River. This would be a modification of the "Red River Levees and Bank Stabilization Below Denison Dam, Texas, Arkansas, and Louisiana" project. Works authorized for construction in Arkansas include more than 100 miles of channel stabilization as well as recreational facilities related to the project. The first phase of preconstruction planning for the Shreveport, Louisiana, to Index, Arkansas, segment was initiated in fiscal year 1977 and is continuing. <40>

Legal and Institutional Setting

Surface Water in Federal Law

Federal laws exist which relate to surface water in this basin. The Clean Water Act was passed to improve or maintain water quality throughout the Nation. The Water Resource Planning Act was passed to provide coordinated planning of water and related land resources; and the Watershed Protection and Flood Prevention Act was passed to prevent damages caused by erosion, floodwaters, and sediment.

Water Pollution Control Act: This law was set up primarily to keep the pollution of water at a minimum, and is a direct descendent of the Refuse Act, which was set up to give the Corps of Engineers control of navigable streams. The Refuse Act generally prohibits the discharge of refuse into navigable waters of the United States, and prohibits discharges into tributaries of navigable waters, if the refuse floats or is washed into navigable waters. The Refuse Act also prohibits deposits on the banks of navigable waters and on the banks of tributaries, if the material is likely to be washed into the navigable water, either by ordinary high tide, storms, floods or otherwise, if navigation would thereby be impeded or obstructed. <15>

With the passage of the Water Pollution Control Act, Amendments of 1972 (P.L. 92-500, 33 U.S.C., Sec. 1251), the mission of regulation of water quality by the Environmental Protection Agency was greatly enhanced. In short, the Federal Water Pollution Control Act enabled the Environmental Protection Agency to further carry out the provisions of the Refuse Act by attempting to rid our streams and navigable waters of pollution deposited by industry and non-point pollution. The objectives of the 1972 amendment were to eliminate the discharge of all pollutants into the navigable waters of the United States by 1985. As a result of the passage of this Act, the Environmental Protection Agency was the administrator of our Nation's water quality programs and charged with the responsibility of enforcing existing laws and issuing additional regulations as needed to insure that our waters would remain unpolluted. <15>

Clean Water Act of 1977: Congress recognized the need to amend the Federal Water Pollution Control Act and did so with the Clean Water Act in 1977 (P.L. 95-217, 91 Stat. 1566, 33 U.S.C. 1251). This amendment extends the appropriations as set out in the original act and requires the Environmental Protection Agency to enter into written agreements with the Secretaries of Agriculture, Army and Interior to provide maximum utilization of the laws and programs to maintain water quality. It also deals with the processing of permits for dredged or fill material in any navigable waters of the United States. <15>

Water Resources Planning Act: Congress passed the Water Resources Planning Act, (P.L. 89-90, 79 Stat. 244, 42 U.S.C. 1962), as amended by P.L. 94-112, with the intention of providing for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources. This was achieved, partially, by the establishment of a Water Resources Council in this Act. Additionally, financial assistance was to be afforded to the individual states in order to increase their participation in all phases of water resources planning. <15>

The responsibilities of the Water Resources Council, composed of the Secretary of the Interior, the Secretary of Agriculture, the Secretary of the Army, the Secretary of Health, Education, and Welfare and chairman of the Federal Power Commission, includes various assessments and reports to be made periodically. These reports, to be submitted biennally, are to report on and assess the adequacy of water supplies necessary to meet the water requirements in each water resource region in the United States. Another responsibility of the council is to continuously study and assess regional or river basin plans and programs to meet the requirements of larger regions of the Nation and administrative and statutory means for the coordination of the water and related land resources policies and programs of the several federal agencies. Recommendations are to be made to the President of the United States with respect to the Federal policies and programs being studied. <15>

Agriculture and Food Act: The RC&D program was authorized under Section 1528-1538 of Public Law 97-98. The purpose of the program which is administered by the SCS is to accelerate the conservation, development, and utilization of natural resources to improve the general level of economic activity, and to enhance the environment and standard of living in authorized RC&D areas. Authorized areas are locally sponsored areas designated by the Secretary of Agriculture for RC&D technical and financial assistance program funds.

Watershed Protection and Flood Prevention Act: This Act, (P.L. 83-566, 1954), declared the intention of Congress to be that a cooperative program should be in effect between the federal government and the states, their political sub-divisions, soil or water conservation districts, and other local public agencies for the purpose of preventing such damages caused by erosion, floodwaters, and sediment in the watersheds of the rivers of the United States. It allows and directs the Secretary of Agriculture to cooperate with the aforementioned entities in flood prevention matters. This act was passed to diminish damages in watersheds causing loss of life and damage to property, and for the purpose of furthering the conservation, development, utilization, and disposal of water and conservation and utilization of land. <15>

Surface Water in State Law

Water Rights: Arkansas water law is based on the old English common law as is the case in most of the humid Eastern States. Under the common law, the right to use water is incidental to ownership of riparian land - land adjacent to surface water or overlying ground water.

Initially, the legal use of surface water was limited by the "natural flow" rule that each riparian landowner has the right to insist that the water in the stream continue to flow unimpaired in quality or quantity. The courts have generally decided disputes over water according to a "reasonable use" test which allows each owner to use the water for his own purpose having due regard for the effect of that use upon other riparian owners and on the public in general. What is or is not deemed to be a reasonable exercise of riparian rights, of course, depends upon the circumstances of the case and the philosophy of the courts in the various jurisdictions.

Generally, the following criteria test the "reasonableness" of a given use:

1. The purpose of the use must be lawful and beneficial to the user and suitable to the stream involved;

2. The social utility of a proposed or existing use should be considered;

3. Use of the water must be made on riparian land (used by the riparian owner on land adjacent to the stream or lake);

4. The quantity of water diverted to the exclusive use of the riparian user must be viewed in light of the total flow;

5. The use must not pollute the water so as to significantly harm lower riparian users;

6. The manner of flow must not be appreciably altered.

Specifically, the Arkansas Supreme Court has declared the following general rules and principles with regard to the reasonable use of water which is subject to riparian rights:

a. The right to use water for strictly domestic purposes--such as for household use--is superior to many other uses of water, such as for fishing, recreation, and irrigation.

b. Other than the use mentioned above, all other lawful uses of water are equal, (some recognized lawful uses are fishing, recreation, and irrigation).

c. When one lawful use of water is destroyed by another lawful use, the latter use must yield or it may be enjoined.

d. When one lawful use of water interferes with or detracts from another use, then a question arises as to whether, under all the facts and circumstances of that particular case, the interfering use shall be declared unreasonable and, as such, enjoined, or whether a reasonable and equitable adjustment should be made having due regard to the reasonable rights of each.

Arkansas statutory law authorized the Arkansas Soil and Water Conservation Commission to allocate surface water during periods of shortage and delineates priority of use during times of scarcity as (1) sustaining life; (2) maintaining health; and (3) increasing wealth.

Water Quality Management: The Arkansas Water Quality Management Plan provides tools by which water quality can be more effectively and efficiently managed. The provisions of the Federal Water Pollution Control Act, as amended, set forth requirements for the establishment of comprehensive statewide water quality planning programs. These programs are marked by three distinct phases of development. Phase I plans were completed in 1976 and provide, for each major basin in Arkansas, an identification of existing water quality problems, programs to control or eliminate those problems and an identification of major sources of water pollution within each basin. The Phase I Basin plans are often referred to as 303(e) plans and are available for review at the Department of Pollution Control and Ecology.

Phase II is defined as the planning, which occurred between 1976 and May 29, 1979, that focused upon the requirements of Section 208 of the Federal Water Pollution Control Act. Phase II planning is often referred to as the initial 208 planning effort. Phase III refers to the continuation of planning initiated under Phase II, including revisions of the initial 208 plan. Phase III planning was authorized by the 1977 amendments to the Federal Water Pollution Control Act (Clean Water Act).

Section 208 of the Clean Water Act directs the governor of each state to identify each area within the state which, as a result of urban industrial concentrations or other factors, has substantial water quality control problems. Section 208 of the Act provides for the designation of areas with substantial water quality control problems which are located in two or more states by the governors of the respective states. If an area fulfills the requirements for designation and the governor (or governors) fail to act, either by designating or determining not to make a designation, Section 208 (a)(4) of the Act provides that the chief elected officials of local governments in the area may designate the area by agreement.

The Governor of Arkansas subsequently designated the following agency in this basin:

1. June 1975 - ARK/TEX Council of Governments, portion of Miller County in Arkansas, and of Bowie and Cass Counties in Texas.

<u>Institutional Setting</u>

Federal and state agencies, as well as local organizations have various responsibilities in water resource management. The following sections describe the responsibilities and objectives of several of these organizations.

<u>Federal Agencies</u>:

1. The Soil Conservation Service (SCS) was established in the United States Department of Agriculture by Congress in 1935 to plan and carry out a national program to conserve and develop our soil and water resources. The mission of the SCS is to provide national leadership in the conservation and wise use of soil, water, and related resources through a balanced cooperative program that protects restores, and improves these resources. SCS directs efforts toward two national priorities:

   A. Reduce excessive erosion on crop, range, pasture, and forestlands.

   B. Conserve water used in agriculture, and reduce flood damages in small upstream watersheds. Specific programs of the SCS relating to surface water include technical assistance which is provided to individuals and groups through conservation districts to conserve soil and water resources; water resources activities including watershed projects; river basin investigations; resource conservation and development; technical assistance for the Water Bank Program; and emergency conservation measures.

2. The Corps of Engineers, established in 1779 by Congress, has been assigned a broad range of civil works projects to develop, manage, and conserve the Nation's water resources. The Corps is heavily involved with water resource planning and development. Activities of the Corps include commercial navigation, hydroelectric power development, flood reduction, land and water recreation, irrigation, water supply, shore and beach erosion protection, hurricane protection, water quality management, and studies of urban area problems including wastewater management. In developing and managing water resources, the Corps seeks to balance the developmental and environmental needs of our country. <40>

3. The U. S. Geological Survey was established through legislation of 1879. In 1888 and 1894, legislation authorized the U. S. Geological Survey to survey irrigable lands in arid regions and provided funds for gaging streams and determining the water supply of the Nation. The mission of the U.S. Geological Survey is to provide hydrologic information needed by others and to appraise the Nation's water resources.

   The water resources activities of the U.S. Geological Survey are diverse ranging from collecting data on the quantity, quality, and use of surface and ground water to conducting hydrologic and water-related research. The Survey conducts water resources investigations and also acquires information useful in predicting and delineating water-related natural hazards from flooding, volcanoes, mudflows, and land subsidence.

4. The Environmental Protection Agency was formed in 1970, through executive action termed Reorganization Plan No. 3 which brought together several environmental programs. Enactment of new laws and important amendments to older laws in the 1970's greatly expanded EPA's responsibilities. The Agency now administers the nine comprehensive environmental protection laws listed below. <45>

   A. Clean Air Act

   B. Clean Water Act

   C. Safe Drinking Water Act

   D. Comprehensive Environmental Response, Compensation, and Liability Act (superfund)

   E. Resource Conservation and Recovery Act

   F. Federal Insecticide, Fungicide, and Rodenticide Act

   G. Toxic Substance Control Act

   H. Marine Protection, Research, and Sanctuaries Act

   I. Uranium Mill Tailings Radiation Control Act

State Agencies:

1. The Arkansas Department of Pollution Control and Ecology (ADPC&E) has powers of regulation and enforcement over waters of the state through the authority of Act 472 of 1949. The activities of ADPC&E as they relate to water include making basin surveys, reviewing and approving waste treatment designs, administering funds for the construction of municipal treatment plants, monitoring streams for the construction of municipal treatment plants, monitoring streams to determine water quality, and conducting and sponsoring research. ADPC&E also has the responsibility of the state-level administration of the Clean Water Act mentioned previously. <15>

   ADPC&E has developed regulations to protect the waters of the state, and two of these regulations relate to surface water. One of the regulations was developed for the prevention of pollution by saltwater and other field wastes produced by wells while the second regulation was developed to establish water quality standards for the surface waters of the state.

2. The Arkansas Forestry Commission is the designated management agency for the silvicultural portion of Arkansas' Water Quality Management Plan. In that capacity, the Forestry Commission has produced a phamplet entitled, "Best Management Practices Guidelines for Silviculture," which is available upon request. <70>

3. The Arkansas Game and Fish Commission was established under authority of the Arkansas Constitutional Amendment 35, passed July 1, 1945. In summary, Section 1 of the Amendment, states that the AGFC is responsible for protecting the state's wildlife resources. The AGFC has developed numerous regulations to assist in the conservation and management of all fish and wildlife resources in the state.

4. Arkansas Act 81 of 1957 established the Arkansas Water Conservation Commission, now the Arkansas Soil and Water Conservation Commission. Primary functions given the Commission by this Act were:

   1. Regulate construction of facilities by permit to store surplus streamflow;

   2. Inspection of permitted dams annually for safety and maintenance;

   3. Allocation of water between persons taking water from streams during periods of shortage;

   4. Gather data periodically on the use of surface water and the need;

   5. Review petitions for the formation of regional water districts to utilize water stored in federal reservoirs; and

   6. Register water diverted from streams, lakes, or ponds to assure proper allocation of water during periods of shortage.

Act 217 of 1969 authorized the Commission to develop the Arkansas State Water Plan which would serve as the state water policy for the development of water and related land resources in the State of Arkansas. All reports, studies, and related planning activities are required to take the State Water Plan into consideration. In 1975, the first State Water Plan was published. Work on revising the 1975 plan began in 1980.

Act 1051 of 1985 outlined many variables that need to be quantified or delineated and included in the State Water Plan, which is expected to be released by late 1987. Some requirements of the Act were: (a) determine current and projected needs of public water supplies, industry, and agriculture; (b) define and quantify the safe yield of all streams, reservoirs and aquifers; (c) quantify instream flow requirements for water quality, fish and wildlife, navigation, interstate compacts, riparian rights, and aesthetics; and (d) define and determine minimum stream flows. In addition, the act authorized interbasin transfer and non-riparian use of water contingent upon guidelines developed by the Commission and required all ground water users to report the quantity of ground water withdrawn on an annual basis. The Commission will now collect and compile ground water use data in addition to surface water use data which was authorized by Act 180 of 1969.

Act 417 of 1985 will provide incentives for construction of surface reservoirs in the form of a state tax credit not to exceed 50% of the total construction cost or a maximum of $33,000 over an 11-year period. Any applicant that converts to surface water from ground water sources may receive a tax credit equal to 10% of the total conversion cost. Persons seeking eligibility for the tax breaks must apply to Arkansas Soil and Water Conservation Commission for evaluation and acceptance.

5. The basin, like all others within the state, is entirely within the boundaries of conservation districts. Districts are legal entities of State Government and are funded in part from funds administered from the various quorum courts and from state funds administered by the Arkansas Soil and Water Conservation Commission. The major function of these districts, organized under authority of Act 197 of the General Assembly of the State of Arkansas in 1937, as amended, is to assist the owners and farm operators in developing individual land use plans on their farms. These plans show necessary corrective methods, works of improvement and best management practices necessary to control soil erosion, improve surface water quality, lower floodwater and sediment damages, and further the conservation, development and utilization of soil and water resources. Each conservation district has entered into a memorandum of understanding with the U.S. Department of Agriculture and a supplemental memorandum of understanding with the Soil Conservation Service to provide them with the technical assistance. The Department of Agriculture administers a cost sharing program for certain on-farm conservation practices through county offices of the Agricultural Stabilization and Conservation Service.

Local Organizations:

Irrigation, drainage, watershed improvement, and levee districts are formed to provide facilities for irrigation, drainage, flood control, recreation, fish and wildlife, and to prevent soil erosion and sediment damages. The districts, through their boards, may assess damages and benefits to all lands within a particular district. <15>

Drainage districts were formed to construct and maintain works of improvement. Drainage districts presently in existance are listed below. (The county is shown in parenthesis)

1. Drainage District No. 2 (Little River)

2. Walnut Bayou Drainage District (Little River)

Watershed Improvement Districts were formed to sponsor and maintain watershed projects within their district under the SCS small watershed program (P.L. 83-566). Listed below are Watershed Improvement Districts currently within the basin.

1. Bois d'Arc Bayou Improvement District (Little River)

2. Haney Creek Improvement District (Little River)

Levee Districts operate and maintain Waterway Levee Improvement projects planned and constructed by the Corps of Engineers. There are currently no Levee Districts within the basin.

SURFACE WATER RESOURCES PROBLEMS

To insure future productivity and economic growth, adequate water supplies must be available. The overriding policy of the Arkansas Soil and Water Conservation Commission in the area of water management is to insure Arkansans of sufficient water quantity of a quality satisfactory for the intended beneficial use. This basin is a highly productive region of a diverse economic base which includes agriculture, forestry, mining, and industry. Without adequate quantities of suitable water, these economic activities will suffer setbacks in current levels of production and increases in production would be impossible.

A series of public meetings were held within each conservation district to determine the public perception of problems and concerns associated with soil, water, and related resources. The meetings fulfilled the requirements of the Soil and Water Resources Conservation Act (RCA) passed by Congress in 1977. The Act directed the Secretary of Agriculture to conduct a continuing appraisal of the status and condition of our soil, water, and related resources. The purpose of RCA is to insure that programs administered by the Secretary of Agriculture for the conservation of soil, water, and related resources shall respond to the nation's long-term needs. Broad based participation in the RCA effort by groups, organizations, and the general public is a primary objective of the Act and is necessary to ensure that programs respond to the public needs. Included in the following list are those concerns and problems voiced by the public and various state and federal agencies.

The categories of expressed concern within the basin were as follows: <1>

1. Water Supply
2. Soil Erosion
3. Forestry (Nonfederal Land)
4. Fish and Wildlife Habitat
5. Food and Fiber Production
6. Flooding
   Recreation

This basin has the potential to substantially increase water use. With the increases in water use by public supply and industry along with the maximum development of irrigated cropland, this basin could use a total of almost 452 mgd of water by the year 2030. The maximum development of irrigated cropland would require 318 mgd.

The current status of surface water and associated problems within the basin is discussed below.

Surface Water Quantity Problems

Availability

The primary surface water sources in the Red River Basin above Fulton for instream use are the Red River and the four Corps of Engineers' Reservoirs (Millwood, Gillham, Dierks and DeQueen). Approximately 3.4 million acre-feet (3,036 mgd) was released from the four Corps of Engineers' reservoirs in 1980 and an average yearly flow of about 8.4 million acre-feet (7,500 mgd) is measured in the Red River at Index, Arkansas.

In 1980, total surface water use in the Red River Basin above Fulton was 91,392 acre-feet (81.6 mgd). However, by the year 2030, the surface water use is expected to increase to about 390,000 acre-feet (348 mgd). The additional demand for surface water is anticipated to result from increased irrigation. This includes irrigation of both newly developed cropland, irrigation of presently non-irrigated cropland, and increased irrigation of presently irrigated cropland.

In 1984, eighteen separate user entities registered with the Arkansas Soil and Water Conservation Commission (ASWCC) for use of surface water for irrigation. The demand was primarily for Red River and Millwood Lake surface water. Registration with ASWCC showed that 1,050 acre-feet were used in 1984 for irrigation. A total of 61 acre-feet of surface water were used for irrigation under registration from all other surface water sources in the basin.

Municipal and Industrial surface water use accounted for 89 percent (73 mgd) of all surface water used in the basin during 1980. Projections show that, in 2030, the M&I surface water use could increase by as much as 46 percent, but will account for only 29 percent of the total surface water used in the basin. Although the total quantity of surface water available in the basin far exceeds the current use, other problems concerning availability do exist.

Surface water is not always readily accessible to large cropland areas or major Municipal and Industrial (M&I) surface water use entities. In some instances, surface water is transported through many miles of open earth channels from the source to its use destination. This results in continuous maintenance requirements, excessive water loss, and significant economic loss.

Seasonal variability of surface water flow in basin rivers and streams may have considerable impact on identified instream flow requirements such as fish and wildlife, water quality, and irrigation. Both instream flow requirements and surface water use demand are normally highest during the period of lowest average stream flow. As future surface water needs increase, limited use based on established priorities may become necessary during the periods of low streamflow.

At times, surface water is available for irrigation or M&I use, but the water quality is unsuitable for use without extensive treatment. (See Surface Water Quality Problems section)

In summary, surface water quality, distribution of surface water, and seasonal availability are the primary problems yet to be delt with regarding basin rivers and streams. These problems could have major economic impact on basin development. Further investigation toward the identification of these problems and corresponding extent of impact on basin development is needed.

Flooding

Many areas in the Red River Basin above Fulton are designated as flood-prone areas. By definition flood-prone areas are, "areas adjoining rivers, streams, watercourses, bays, lakes, alluvial fans and plains, or other areas that in the past have been covered by floodwater or could be expected to be flooded in the future." Flood-prone areas are subject to inundation by a flood having an average recurrence interval of once in 100 years (floods having a 1 percent chance of occurring in any given year). <60> Likely sources to identify and locate flood-prone areas are SCS project-type studies such as PL-566, Flood Prevention, River Basin, and Resource Conservation and Development. Other SCS sources are flood hazard studies, soil surveys, and aerial photographs of historic floods. Corps of Engineers' sources include flood plain information reports, special flood reports, local protection, and flood control project reports. Additional sources are Housing and Urban Development flood insurance study reports; maps by U.S. Geological Survey, Corps of Engineers, and National Oceanic and Atmospheric Administration; studies by private firms and other units of government; U.S. Geological Survey flood-prone areas, quadrangle sheets, and hydrologic maps; stream gage data; and surficial deposit maps.

A total of 288,241 acres of land are located in flood-prone areas of this basin. <38>. The entire 288,241 acres would flood and suffer severe losses if the 100-year frequency flood occurred. Table 3-23 shows the land use within the flood-prone areas.

TABLE 3-23: FLOOD PRONE LAND USE

Land Use	Acres	Percent of Total
Cropland	33,701	12
Grassland	106,919	37
Forest Land	147,621	51
TOTAL	288,241	100

Source: USDA, Soil Conservation Service <38>

Many areas of the basin, especially cropland areas, are subjected to some flooding almost each year. An estimated 2,400 acres of cropland are flooded once every 2 years. The annual damage to all land in the basin caused by flooding is 2.5 million dollars <38>. In addition to cropland, grassland, and forest land flood damage, damages occur to urban and other agriculture properties, highways, and utilities. These damages are estimated to be 2.8 million dollars annually and the total annual damages from flooding are 5.3 million dollars (1977 price base). <38>

Surface Water Quality Problems

General descriptions of each of the three Water Quality Planning Segments located in the basin have been included in the Quality of Streamflow section. Locations of segments and water quality sampling stations are shown in Figure 3-18. Discussions of problems in each segment follow:

Segment 1B - Red River

The only water quality sampling station in Segment 1B is located on the Red River south of Foreman, Arkansas. <5> Water quality at this station, RED 25, is influenced not only by factors within Arkansas, but also by the large drainage area of the Red River in Oklahoma. Therefore, water quality problems are not necessarily caused by local conditions. Water quality data for the Red River south of Foreman, Arkansas from ADPC&E's Arkansas Water Quality Inventory Report 1986 are shown in Table 3-24. <5> Chloride, sulfate, total suspended solids (TSS), and trace metal concentrations generally increase in the Red River during periods of high flow <5>. Red River water is generally unsuitable for drinking as a result of the high chloride (320 mg/l) and TSS concentrations (479 mg/l) which also occasionally impair agricultural uses of the water. (See Table 3-24) Fecal coliform bacteria concentrations (2900/100 ml) exceed the state standards for primary contact recreation thus impairing the Red River from this designated use.

An estimated 106,700 tons of sediment are delivered to watershed outlets annually in the basin portion of Segment 1B. Sediment originates as erosion which annually totals 355,520 tons. Erosion from different sources is summarized in Table 3-25. <38>

TABLE 3-24: SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 25

RED RIVER SOUTH OF FOREMAN, AR

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	23	17.5	30	2.0
Dissolved Oxygen (mg/l)	21	9.2	12.8	7.5
pH	22	7.9	8.3	7.6
Chlorides (mg/l)	21	145	320	5
Sulphates (mg/l)	22	116	200	52
Total Suspended Solids (mg/l)	23	144	479	23
Total Phosphorus (mg/l)	20	.15	.52	.07
Nitrite+Nitrate-N (mg/l)	22	.17	.49	.01
Turbidity, ntu	21	87.1	410	10
Fecal Coliforms/100ml	19	388	2900	4
Cadmium (mg/l)	22	.57	1	.5
Chromium (mg/l)	22	5.0	18	1
Copper (mg/l)	21	26.9	69	12
Lead (mg/l)	18	32.8	112	4
Zinc (mg/l)	17	87.0	193	26

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-25: ANNUAL EROSION RATES BY SOURCE - SEGMENT 1B
RED RIVER BASIN ABOVE FULTON

Erosion Source	Erosion (Tons per Year)	Percent of Total Erosion
Road Surface	4,000	0.8
Road Bank	8,430	1.7
Gully	9,230	1.9
Stream Bank	111,960	22.9
Sheet and Rill	355,520	72.7
Total	489,140	100.0

Source: USDA, Soil Conservation Service, RIDS 1977 <38>

Of the total soil loss, sheet and rill erosion comprises 72.7 percent. Cropland is responsible for 83.6 percent of the total sheet and rill erosion (Table 3-26) and 60.7 percent of total erosion from all sources. This is especially significant since cropland comprises only 26.4 percent of the land area. Streambanks and feedlots are also significant sources of erosion comprising 22.9 percent and 7.3 percent, respectively, of the total erosion from all sources. Average erosion rates on cropland and feedlots are excessive in terms of protecting the long-term productivity of the soil (Table 3-26). <38>

Other sources of agricultural non-point source pollution include pesticides and nutrients. In 1977, about 116,000 pounds of active ingredients of pesticides and 9,700 tons of commercial fertilizers were applied. <2>

Table 3-26: AVERAGE SHEET AND RILL EROSION RATES BY LAND USE - SEGMENT 1B

Land Use	Percent of Total Land Use	Average Sheet and Rill Erosion Rate (tons/acre/year)	Percent of Total Erosion
Cropland	26.4	7.5	83.6
Grassland	35.5	0.4	5.7
Forest Land	25.5	0.1	0.7
Urban	1.5	1/	1/
Water	9.6	0	0
Feedlots	1.5	15.2	10.0
Total	100		100

1/ Erosion rate not computed.

Source: USDA, Soil Conservation Service, RIDS 1977 <38>

Segment 1C - Little River and Tributaries

Water quality data for stations -- RED 31, 32, and 33 from ADPC&E's Arkansas Water Quality Inventory Report 1986 are presented in Tables 3-27, 3-28, and 3-29. <5> These tables indicate that about 85 percent of the waters in Segment 1C support designated use classifications established for streams by the ADPC&E.

The classifications assigned to streams are: (1) suitable for desirable species of fish, wildlife, and other aquatic and semi-aquatic life; (2) primary and secondary contact recreation; and (3) public, industrial, and agricultural water supplies. Aquatic, recreational, and water supply uses have been impaired in a short section of Bear Creek below DeQueen's sewage treatment plant. Primary contact recreational uses are impaired in Little River near Horatio because of high concentrations of fecal coliform bacteria from non-point source contributions. No major public health concerns have developed in this segment due to water quality. <5>

TABLE 3-27: SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 31

COSSATOT RIVER AT HWY. 4, EAST OF WICKES, AR

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	23	15.7	29	2
Dissolved Oxygen (mg/l)	21	9.8	13.6	7.2
pH	22	6.9	7.5	6.4
Chlorides (mg/l)	21	3.2	5	2
Sulphates (mg/l)	22	6	11	1
Total Suspended Solids (mg/l)	23	7.5	31	1
Total Phosphorus (mg/l)	20	.02	.06	.01
Nitrite+Nitrate-N (mg/l)	22	.03	.08	.01
Turbidity, ntu	21	6.5	39	1
Fecal Coliforms/100ml	21	29.3	192	4
Cadmium (mg/l)	22	.73	3	.5
Chromium (mg/l)	22	1.8	12	1
Copper (mg/l)	21	13.4	30	.1
Lead (mg/l)	18	42.1	204	2
Zinc (mg/l)	18	32.3	204	3

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-28: SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 32

SALINE RIVER NEAR BURG, AR

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	23	15	28	2
Dissolved Oxygen (mg/l)	21	9.4	13.6	5.1
pH	22	6.7	7.1	6.3
Chlorides (mg/l)	21	3.3	5	2
Sulphates (mg/l)	22	4.3	8	1
Total Suspended Solids (mg/l)	23	11.6	42	4
Total Phosphorus (mg/l)	20	.03	.09	.01
Nitrite+Nitrate-N (mg/l)	22	.34	.72	.03
Turbidity, ntu	21	11.7	30	4
Fecal Goliforms/100ml	21	66.3	210	8
Cadmium (mg/l)	22	.57	1	.5
Chromium (mg/l)	22	1.2	3	1
Gopper (mg/l)	21	15.9	46	6
Lead (mg/l)	18	35.8	340	2
Zinc (mg/l)	18	68	790	3

Source: Arkansas Department of Pollution Control and Ecology <5>

TABLE 3-29: SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 33

BEAR CREEK NEAR PROCESS CITY, AR

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	23	15.5	26	2
Dissolved Oxygen (mg/l)	21	6.7	11.9	.0
pH	22	6.9	7.3	6.3
Chlorides (mg/l)	20	12.6	48	3
Sulphates (mg/l)	22	10.4	20	4
Total Suspended Solids (mg/l)	22	25.8	95	7
Total Phosphorus (mg/l)	20	1.2	7.4	.08
Nitrite+Nitrate-N (mg/l)	22	.57	3.2	.01
Turbidity, ntu	21	29.3	130	9
Fecal Coliforms/100ml	21	357.9	1100	8
Cadmium (mg/l)	22	.55	1	.5
Chromium (mg/l)	22	11.6	48	1
Copper (mg/l)	21	20.1	32	10
Lead (mg/l)	18	9	21	1
Zinc (mg/l)	18	49.2	155	3

Source: Arkansas Department of Pollution Control and Ecology <5>

In Segment 1C, an estimated 719,200 tons of sediment are delivered to watershed outlets annually. This sediment orginates as erosion which totals 3,359,830 tons (see Table 3-30). <18>

TABLE 3-30: ANNUAL EROSION RATES BY SOURCE - SEGMENT 1C

Erosion Source	Total Erosion (Tons per Year)	Percent of Total Erosion
Road Surface	128,550	3.8
Road Bank	285,460	8.5
Gully	17,380	0.5
Stream Bank	235,150	7.0
Sheet and Rill	2,693,290	80.2
Total	3,359,830	100.0

Source: Arkansas Soil and Water Conservation Commission <18>

Of the total soil loss, sheet and rill erosion comprises 80.2 percent. Forest lands are responsible for 77.1 percent of the total sheet and rill erosion and 61.8 percent of the total of all types of erosion (Table 3-31). <18>

The ADPC&E attributes periodic high turbidity concentrations in streams in this segment to clear-cutting practices in the area. <5> Streambanks are another significant source of erosion. <18> Average erosion rates on cropland are excessive in terms of protecting the long-term productivity of the soil. However, the small total cropland acreage results in this land use accounting for only a minor portion of the total erosion in the segment. <18>

Table 3-31: AVERAGE SHEET AND RILL EROSION RATES BY LAND USE -- SEGMENT 1C

Land Use	Percent of Total Land Use	Average Sheet & Rill Erosion Rate tons/acre/year	Percent of Total Erosion
Cropland	2.1	11.4	10.1
Grassland	25.0	1.1	12.8
Forest Land	67.9	2.6	77.1
Urban	1.8	1/	--
Water	3.1	1/	--
Mining	0.1	1/	-
Total	100		100

1/ Total Erosion rate not computed.

Source: Arkansas Soil and Water Conservation Commission <18>

In addition to sediment, another non-point source pollutant is pesticides. In 1977, more than 131,000 pounds of active ingredients of pesticides were applied. <18> Toxic forms of chlorinated hydrocarbons were detected in fish flesh in 1983, but were absent from sediment samples in 1983 and 1984. <5>

In 1977, over 23,000 tons of commercial fertilizers were applied in the segment. <18> A 1983 confined animal inventory of Arkansas' 22 counties was conducted by the SCS. This inventory revealed 3,688 tons of nitrogen and 1,555 tons of phosphorus from animal wastes were available annually for application as fertilizer. This equates to 2.57 tons of nitrogen and 1.09 tons of phosphorus per square mile within the portions of the segment that were included in the inventory. In contrast, the average amounts of animal nutrients for the entire 22-county area were 2.77 tons of nitrogen and 1.37 tons of phosphorus per square mile. Confined animal operators used an average of 87 percent of the available animal waste nutrients on their own farms. Most of the remaining waste was sold to neighbors for fertilizer. On land owned by confined animal operators, annual application rates averaged 147 pounds of nitrogen and 61 pounds of phosphorus. These quantities are within presently accepted animal waste application rates, indicating minimal nutrient impacts to surface waters. Confined animal areas may be contributing to high fecal coliform concentrations during periods of high runoff. However, impacts of confined animals on water quality within the segment have not been adequately studied. Table 3-32 summarizes the types and numbers of confined animals in the segment. <32>

TABLE 3-32: SUMMARY OF CONFINED ANIMALS - SEGMENT 1C

Type of Operation	Number of Operations	Annual Numbers of Animals Produced
Broilers	586	80,277,000
Layers	13	232,500
Breeders	2	41,000
Pullet Grow-Out	9	206,000
Swine	15	14,245
Dairy	3	260

Source: USDA, Soil Conservation Service <32>

Segment 1D - Mountain Fork and Tributaries

The only water quality sampling station in Segment 1D, RED 01, is located on Mountain Fork River near Hatfield, Arkansas. Water quality data for this station from ADPC&E's Arkansas Water Quality Inventory Report 1986 are shown in Table 3-33. <5>

TABLE 3-33: SUMMARY OF WATER QUALITY DATA FROM ADPC&E SAMPLING STATION RED 01

MOUNTAIN FORK NEAR HATFIELD, AR

Parameter	Number of Samples	Average	Maximum	Minimum
Temperature, °C	23	16.3	30.0	2.0
Dissolved Oxygen (mg/l)	20	10.5	17.8	7.3
pH	22	6.7	7.3	6.3
Chlorides (mg/l)	19	7.8	90	2
Sulphates (mg/l)	18	4.5	8	2
Total Suspended Solids (mg/l)	21	5.9	36	1
Total Phosphorus (mg/l)	19	.05	.16	.01
Nitrite+Nitrate-N (mg/l)	20	.10	.38	.01
Turbidity, ntu	22	22.3	200	2.2
Fecal Coliforms/100ml	19	112	900	2
Cadmium (mg/l)	22	.51	.9	.5
Chromium (mg/l)	21	1.3	4	1
Copper (mg/l)	20	12.4	17	9
Lead (mg/l)	14	7.1	55	1
Zinc (mg/l)	19	23.6	124	3

Source: Arkansas Department of Pollution Control and Ecology <5>

Water quality within the segment is presently adequate to support the uses of municipal, industrial, and agricultural water supply sources and the fishable use designation. Agricultural non-point source pollution may be responsible for high concentrations of fecal coliform bacteria which preclude the primary recreation contact use within some stream reaches. However, an estimated 95 percent of the surface waters are meeting the designated beneficial uses. <5>

The major public health concern in the basin centers around a wood-treating plant at Mena which has caused major fish kills in the Mountain Fork River and resulted in local contamination of soils and ground water. The U.S. Environmental Protection Agency is working toward correcting these problems through the Superfund program. <5>

An estimated 157,600 tons of sediment are being delivered to watershed outlets annually. Sediment originates as erosion which totals 480,809 tons. (Table 3-34) <18>

TABLE 3-34: ANNUAL EROSION RATES BY SOURCE - SEGMENT 1D

Erosion Source	Total Erosion (Tons Per Year)	Percent of Total Erosion
Road Surface	20,210	4.2
Road Bank	13,206	2.8
Stream Bank	13,017	2.7
Sheet and Rill	434,376	90.3
Total	480,809	100.0

Source: Arkansas Soil and Water Conservation Commission <18>

Of the total erosion, sheet and rill erosion comprises 90.3 percent. Forest land is responsible for 83.4 percent of the total sheet and rill erosion and 75.3 percent of the total of all types of erosion. (Table 3-35) Average erosion rates on forest land (Table 3-35) are not excessive in terms of protecting the long-term productivity of the soil. However, these erosion rates are excessive for forest land since proper management can easily reduce erosion on this land use to less than 0.1 ton per year. <18>

TABLE 3-35: AVERAGE SHEET AND RILL EROSION RATES BY LAND USE -- SEGMENT 1D

Land Use	Percent of Total Land Use	Average Sheet & Rill Erosion Rate (tons/acre/year)	Percent of Total Erosion
Cropland	1.0	0.73	0.4
Grassland	22.6	2.23	16.2
Forest Land	72.0	3.74	83.4
Urban	2.7	1/	-
Water	1.7	0	0
Total	100		100

1/ Erosion rate not computed.

Source: Arkansas Soil and Water Conservation Commission <18>.

Pesticide use in this segment is insignificant; however, over 50,000 tons of commercial fertilizers were applied in the segment in 1977. <18> A 1983 confined animal inventory of Arkansas' 22 counties was conducted by the SCS. This inventory revealed that 332 tons of nitrogen and 178 tons of phosphorus from animal wastes were annually available for application as fertilizer. This equates to 1.44 tons of nitrogen and 0.77 ton of phosphorus per square mile within the segment. In contrast, the average amounts of animal waste nutrients for the entire 22-county area were 2.77 tons of nitrogen and 1.37 tons of phosphorus per square mile. Confined animal operators used an average of 81 percent of the available animal waste nutrients on their own farms. Most of the remaining waste was sold to neighbors for fertilizer. On land owned by confined animal operators, annual application rates averaged 199 pounds of nitrogen and 100 pounds of phosphorous. These quantities are within presently accepted animal waste application rates, indicating minimal nutrient impacts to surface waters. Confined animal areas may be contributing to high fecal coliform concentrations during periods of high runoff. However, impacts of confined animals on water quality within the segment have not been adequately studied. Table 3-36 summarizes the types and numbers of confined animals in the segment. <32>

TABLE 3-36: SUMMARY OF CONFINED ANIMALS -- SEGMENT 1D

Type of Operation	Number of Operations	Annual Numbers of Animals Produced
Broilers	54	4,840,000
Layers	11	121,000
Pullet Grow-Out	8	231,000
Swine	1	5,190

Source: USDA, Soil Conservation Service <32>

Data Base Problems

Irrigated Cropland

Additional information on irrigated cropland is needed for planning purposes. About 10 percent of the total water use in the basin in 1980 was for irrigation. However, accurate 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 from sampling procedures. The information is available by county only. For planning purposes, information should be reported by hydrologic boundaries (basins). The Soil Conservation Service reported irrigated cropland figures by basin for 1980 in its publication "Agricultural Water Use Study, Phase V, Arkansas Statewide Study" <29>; however, irrigated cropland was only reported for one year.

Reports on irrigated cropland in the Red River Basin above Fulton vary with individual reporting services according to the methods used to gather information. With such a variation in reporting of irrigated cropland, and the difficulty in obtaining information, there is a need for accessibility and consistency in the reporting of irrigated cropland.

Streamflow Data

Data from available stream gaging stations were used in computations for determining instream flow requirements and excess surface water for this report. A total of ten continuous streamflow gaging stations were used (nine in the Red River Basin above Fulton and one in Texas).

Additional stream gages on streams in this basin could provide valuable surface water data for estimating the available water supplies for future irrigation and M&I needs but current gages were very useful in generating some reasonable estimates of streamflow.

Several streams in the basin are subject to some degree of regulation by large storage reservoirs either on or off the main stems. Regulation of the Little River is aided by reservoirs in Oklahoma and Arkansas and of the Red River by reservoirs in Oklahoma and Texas. Regulation of the Rolling Fork, Cossatot, and Saline Rivers is aided by the DeQueen, Gillham, and Dierks reservoirs, respectively. The Corps of Engineers control releases from their reservoirs according to variations in actual or expected runoff. Data provided by available stream gaging stations indicate that fluctuations in streamflow are less extreme subsequent to regulation by reservoir construction.

Diversion Reporting

Annual registration of surface water diversions has been required since the passage of Act 180 or 1969 to amend Act of 1957. All surface water diversions are included except 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. Reporting is beneficial when periods of shortage make allocation necessary. No penalty for non-registration is assessed. However, should allocation become necessary, diverters who are registered may receive preference.

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, 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 because they are either not familiar with the diversion registration requirements, or they disregard the law due to the lack of a penalty (other than during allocation). In addition, some report initially but fail to report in subsequent years even though reporting is required annually.

Determining Instream Flow Requirements

The Arkansas Soil and Water Conservation Commission was 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, limited information is available to quantify instream flow requirements for most significant streams in the Red River Basin above Fulton. Problems for each of the instream flow categories are described below:

(1) Water quality - The $7Q_{10}$ stream discharge has been established as the instream flow requirement for water quality by the Arkansas Department of Pollution Control and Ecology. The low flow characteristics have been determined for only seven sites in the Red River Basin above Fulton.

(2) Fish and wildlife - A new method, called the Arkansas method, has been developed by Filipek and others <22> 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. Instream flow requirements determined by the Arkansas method represent flow requirements for "excellent" fisheries habitat.

(3) Navigation - Instream flow requirements for navigation have not been established for navigable streams in the Red River Basin above Fulton by the Corps of Engineers.

(4) Interstate compacts - The interstate compact for the Red River Basin above Fulton has been defined in the Red River Compact and the flow requirements established by the Compact have been included in this report.

(5) Aquifer recharge - Instream flow requirements necessary to recharge the aquifers in the Red River Basin above Fulton were not investigated or computed for this report.

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

(7) Aesthetics - Although the importance of aesthetic value in the Red River Basin above Fulton is recognized, specific minimum instream or terrestrial needs were not addressed in this report. Identification of concerned species furnished by the Arkansas Natural Heritage Commission have been listed in this report. Possible adverse effects on aquatic and terrestrial biota should be evaluated before action, which would disrupt the natural biological and physical processes, is taken.

Critical Surface Water Areas

Section 2 of Act 1051 of 1985 (See Legal and Institutional Setting) 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 next 30 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.

Determining critical surface water areas in the Red River Basin above Fulton using current streamflow data is difficult. Reservoirs constructed on each of four major streams in the basin are primarily flood control structures and releases made by the Corps of Engineers primarily according to reservoir storage levels and existing or expected runoff. To the extent possible, releases to satisfy water quality, M&I, recreation, and irrigation needs are provided. On occasion, emergency releases are made to avoid fish kills or to alleviate situations of extreme stream pollution. However, it must be remembered that flood control is the first priority in reservoir operation.

To help determine the possible existence of critical surface water areas in the Red River Basin above Fulton, the estimated demand for irrigation water in the year 2030 was compared with the expected water availability. Irrigated cropland in the basin by the year 2030 has been estimated at 100,710 acres. The major crops grown and acres of each crop are soybeans, 77,760 acres; rice, 14,940 acres; and cotton, 7,530 acres.

Dr. James Ferguson, Associate Professor of Agriculture Engineering at the Univeristy of Arkansas, has provided the information in relation to total water used per crop per month. These values are shown in Table 3-37.

From Table 3-38, it can be seen that the maximum irrigation water demand is during August when monthly flows in all streams is at a minimum. Ignoring the distribution factor, the mean monthly flow of the Red River during August measured at the Fulton stream gage is 6,239 cubic feet per second. If all basin irrigation needs of 1,696 cfs were withdrawn from the Red River, there would be 4,543 cfs remaining for other needs such as water quality, fish and wildlife, interstate compact, navigation, aesthetics, and M&I.

Obviously, all surface water needs in the basin cannot be provided by the Red River. The unfavorable location of the Red River with respect to the majority of the basin area presents problems of distribution for use. Also, during high flows, concentrations of chloride and total suspended solids frequently results in the Red River discharging water of marginal quality for many basin uses.

Most farmers with cropland situated near the Red River are reluctant to withdraw water from the Red River for irrigation because of the possible harmful effect on crops and soil. Constant water quality monitoring would be required to protect crops and also to determine the extent of water treatment necessary to satisfy M&I use standards. Some basin farmers have been forced to develop off-stream or on-farm surface water storage capability to be assured of suitable quality water during peak irrigation demand periods. Although Millwood Reservoir can provide an additional 3,260 acre-feet of surface water from presently uncommitted storage, distribution of this water to areas of need in the basin still presents a problem.

Currently, there is insufficient rationale or justification for proposing the establishment of critical surface water areas in the basin. Further studies regarding quality, availability, and demand of surface water should be conducted so that critical surface water areas (if they exist) can be accurately identified.

TABLE 3-37: CROP WATER USE PER MONTH
RED RIVER BASIN ABOVE FULTON

Crop	Month	Depth in Inches	Total
Rice	June	17	36 inches
	July	10	
	August	9	
Soybeans	June	0.5	18 inches
	July	6.5	
	August	9	
	September	2	
Cotton	June	3.5	18 inches
	July	9	
	August	5.5	

Using the above data, the total irrigation water requirements by month were computed and are shown in Table 3-38.

TABLE 3-38: IRRIGATION WATER DEMAND IN THE YEAR 2030

RED RIVER BASIN ABOVE FULTON

Crop	Acres	Month	Irrigation Depth (Inches)	Water Used (Ac-Ft/Mo.)	Water Used (CFS)	Water Required at 70 Percent Irrigation Efficiency (CFS)
Rice	14,940	June	17.0	21,165	356	
Soybeans	77,760	June	0.5	3,240	54	
Cotton	7,530	June	3.5	2,196	37	
Subtotal (June)				26,601	447	639
Rice	14,490	July	10.0	12,450	202	
Soybeans	77,760	July	6.5	42,120	685	
Cotton	7,530	July	9.0	5,648	92	
Subtotal (July)				60,218	979	1,399
Rice	14,940	August	9.0	11,205	182	
Soybeans	77,760	August	9.0	58,320	949	
Cotton	7,530	August	5.5	3,451	56	
Subtotal (August)				72,976	1,187	1,696
Soybeans	77,760	September	2.0	12,960	218	311
Subtotal (September)				12,960		
Total				172,755		

SOLUTIONS AND RECOMMENDATIONS

Arkansas has the reputation of having an abundance of water. However, experience has taught that water is not always available when needed, nor of the quality necessary for our needs. Increases in population, industrial activity, and irrigation have resulted in significant increases in water demand. In addition, water use in this basin has the potential to dramatically increase during the next 50 years.

As mentioned earlier, 12.4 million acre-feet of surface water are available in the basin on a yearly basis. Even with this amount of water available, it is not inexhaustible nor is it exempt from misuse or poor management. Every possible effort must be made to protect and enhance the surface water in this basin.

Surface water quantity and quality problems need to be addressed. Solutions and recommendations to surface water quantity problems include alternate water sources such as additional water storage reservoirs and the possible interbasin transfer of water. Accurate reporting of water use, along with flood prevention and floodplain management, are needed. Best management practices (BMPs) can be used to improve the water quality in this basin, and watershed protection projects can help implement BMPs in agricultural areas. Water conservation, if practiced throughout the basin, will provide more water in the basin and water of a higher quality.

Surface Water Quantity

Availability

At the present time, a sufficient supply of adequate quality surface water to meet the surface water demands in the Red River Basin above Fulton is available. For irrigation purposes, the demand is being met where possible from runoff in the numerous streams, tailwater in drainage ditches, flow in the Red River, and from irrigation wells. About 60 percent of the present irrigation withdrawals is from surface water sources.

To more accurately determine the current and potential surface water availability and demand for each watershed within the basin, additional investigations are needed. Also needed is a Comprehensive Cooperative River Basin Study which would quantify the current and future basin water demands, the water quality and quantity available, and the most feasible methods of distributing and conserving surface water supplies. Since Act 1051 of 1985 authorizes interbasin transfer of surface water in Arkansas, the Cooperative River Basin Study should compare water availability in this basin and adjacent basins. Comparisons would also consider water quality, flood reduction, fish and wildlife enhancement, recreational opportunities, and watershed protection.

Governmental Assistance

Act 81 of 1957 gave the Arkansas Soil and Water Conservation Commission the power to allocate surface water during periods of shortage. This is an emergency measure to be used to uniformly distribute surface water to riparian landowners.

Act 1051 of 1985 allows the Arkansas Soil and Water Conservation Commission to authorize the transportation of excess surface water to nonriparians for their use. The ASWCC is also authorized to contract, with participants in a transfer project, a specific quantity of water for a specific period of time at a reasonable price to cover the transportation of the water. This new law will allow projects such as the transfer of water from one basin to another basin. Such transfers will allow more equitable use as well as improve the quality of water in basins by dilution of nonpoint pollutants. An increase in flow and quality will also improve the fish habitat. The construction of additional on-farm storage reservoirs would be of considerable benefit to Red River Basin above Fulton farmers. Act 417 of 1985, as amended, allows a tax credit for the construction or restoration of water impoundments or control structures having a capacity of 20 acre-feet or more. They are designed for the purpose of storing irrigation water used to produce food and fiber as a business, (excluding aquaculture) and for domestic, or industrial purposes. A maximum credit of $3,000 per year is allowed for a maximum of 11 years or until 50% of the cost is recovered. To qualify, a taxpayer must obtain a construction permit from the ASWCC, or provide proof of exemption from the permit per the requirements of Act 81 of 1957, as amended. Guidelines are being developed by the ASWCC.

Flooding

Flooding and drainage problems can be solved by either structural or non-structural measures. Structural solutions include such measures as channel work and flood water detention dams. Non-structural solutions relate to land treatment measures and floodplain management. Non-structural solutions are probably the most viable alternatives in most areas of the basin since only one watershed is considered to be a potential structural watershed project (see USDA and U.S. Corps of Engineers Projects).

The United States Congress established the National Flood Insurance Program with the National Flood Insurance Act of 1968. The program is administered by the Federal Insurance Administration (FIA) within the Federal Emergency Management Agency (FEMA). The Arkansas Soil and Water Conservation Commission is the coordinating agency for Arkansas. Act 629 of 1969, enacted by the Arkansas General Assembly, authorized the cities, towns, and counties, where necessary, to enact and enforce floodplain management which will curtail losses in flood-prone areas.

Flood insurance is available from private insurance firms at reasonable rates. Rural residents who reside in Miller, Howard, and Sevier Counties in the basin have the opportunity to participate in this program. Urban residents who reside in Ashdown, DeQueen, Nashville, and other towns identified as having flood hazard areas may also insure their property.

Quality of Surface Water

Surface water quality for agriculture and other purposes varies in the Red River Basin above Fulton. Water quality samples from the four Corps of Engineers' reservoirs and contributing streams show the surface waters to be of very high quality suitable for primary contact recreation. Red River water is generally unsuitable for drinking without treatment and occasionally unsuitable for agricultural uses.

Pollution in the form of sediment, plant nutrients, chemicals, pesticides, and M&I wastes could frequently contaminate basin streams and rivers; therefore, they should be closely monitored for water quality. The Arkansas Department of Pollution Control and Ecology has developed Regulation Number 2 which establishes water quality standards for all surface waters, interstate and intrastate, in the State of Arkansas.

Implementation of recommended "Best Management Practices" should reduce non-point pollution sources and enhance the environment by improving water quality throughout the basin. The following Best Management Practices for each of the non-point pollution sources are recommended by the local conservation districts. These practices may or may not be considered as all inclusive.

Best Management Practices (BMPs)

Agricultural BMPs

1. Conservation cropping systems
2. Contour farming
3. Crop residue management
4. Grassed waterways
5. Diversions
6. Terraces
7. Conservation cropping system to include no-till and minimum till
8. Strip cropping
9. Grade stabilization structure
10. Deferred grazing
11. Livestock water facilities
12. Irrigation water management
13. Establishment and management of permanent pasture and hayland
14. Waste management systems
15. Fencing
16. Poultry disposal pits
17. Critical area treatment
18. Brush and weed control
19. Pipe drops
20. Land use conversion

Forestry BMPs

1. Firebreaks
2. Proper pesticide application
3. Proper disposal of pesticide containers
4. Tree planting
5. Woodland site preparation
6. Proper construction and maintenance of access roads
7. Proper gazing use
8. Stream zone management areas
9. Temporary vegetative cover
10. Woodland improvement

11. Planting on contour
12. Minimize mechanical damage
13. Limited clearcuts on steep slopes
14. Selective cutting
15. Skidding across slopes

Construction BMPs

1. Diversions
2. Mulching
3. Grade stabilization structures
4. Debris basins
5. Critical area planting
6. Save topsoil for re-use
7. Traffic barriers
8. Access road design
9. Limited soil disturbance
10. Water control structures
11. Roadside stabilization on existing roads
12. Lined waterways
13. Site planning and proper timing of operations
14. Temporary vegetative cover
15. Conservation of natural vegetation
16. Grassed waterways

Subsurface Disposal BMPs

1. Septic tanks and filter fields properly installed
2. Provide municipal sewer service to rural areas
3. Sanitary landfills
4. Recycling
5. Alternate systems for sewage disposal
6. Limit housing density

Surface Runoff BMPs

1. Holding ponds or pits
2. Critical area planting
3. Mulching
4. Lined waterways
5. Diversions
6. Debris basins
7. Terraces
8. Vegetative waterways
9. Flood water retarding structures

Mining BMPs

1. Mine land reclamation
2. Reshaping strip mines
3. Sediment basins
4. Revegetate bare areas
5. Mandatory reclamation plans for new mines
6. Control measures to collect sediment during mining operations
7. Temporary vegetative cover
8. Mulching
9. Critical area planting
10. Grade control structures
11. Access and haul road design

Hydrological Modifications BMPs

None planned.

Residual and Land Disposal Sites BMPs

1. Critical area planting
2. Diversions
3 Filter strips
4. Fencing
5. Sanitary landfills
6. Sites for disposal of pesticide containers
7. Solid waste collection systems
8. Disposal sites for removal of residual wastes
9. Country-wide refuse disposal plan
10. Roadside stabilization
11. Traffic barriers
12. Process waste daily

Road BMPs

1. Topsoiling ditch banks
2. Paving
3. Grade stabilization structures
4. Diversions
5. Critical area planting
6. Mulching
7. Lined waterways
8. Design site selection to avoid steep areas
9. Water conveyance structures
10. Establishing and maintaining permanent vegetation
11. Turnouts
12. Shaping of roadbanks

Streambank BMPs

1. Critical area planting
2. Flood water retarding structures
3. Lined waterways
4. Sediment basins
5. Revetments and jetties
6. Fencing
7. Grade stabilization structures
8. Streambank protection
9. Streambank vegetation including trees
10. Stream channel stabilization
11. Reshaping banks
12. Concrete mats

Gully BMPs

1. Grade stabilization structures
2. Critical area planting
3. Sediment basins
4. Terraces
5. Diversions
6. Grassed waterways
7. Critical area shaping
8. Water control structures
9. Mulching
10. Fencing

Implementation of recommended "Best Management Practices" will cost an estimated 58 million dollars (1978 dollars) to install in the basin. Fish and wildlife habitat will be enhanced because of improved cover and diversity throughout the region, particularly in the vicinity of the Red River. <18>

Animal waste application practices including optimized application rates and composting of animal wastes before application will result in improved soil tilth and fertility. These practices will also improve water quality by keeping nutrients in the soil where they can be utilized by plants, rather than being leached into the ground water or washed into streams.

Watershed Protection

Erosion is a significant non-point source of pollution in the Red River Basin above Fulton. In this basin, 3.5 million tons of sheet and rill erosion are occurring each year. Nearly 500,000 tons per year of road surface and road bank erosion, 27,000 tons of gully erosion, and 386,000 tons of streambank erosion occur each year. <38> Watershed protection projects establish land treatment measures that will reduce erosion, sediment, and runoff.

When funds are available, the Watershed Protection and Flood Prevention Act, PL 83-566, provides for the technical, financial, and credit assistance by the Department of Agriculture to local organizations representing the people living in small watersheds. A watershed protection plan includes only on-farm land treatment practices for sustaining productivity, conserving water, improving water quality, and reducing off-site sediment damages. Practices might include such BMPs as conservation tillage, terraces, or even land use conversion. Participation within the watershed is voluntary.

For practices sustaining agricultural productivity and reducing erosion and sediment damages, cost share rates may be up to 65 percent of the cost of the enduring practice installed, or the existing rate of ongoing conservation programs, whichever is less. Payments for management practices such as conservation tillage, based on 50 percent of the cost of adoption are limited to a one-time payment not to exceed $10,000 per landowner. No more than $100,000 of cost-shared PL 83-566 funds may be paid to any one individual. <36>

The SCS completed the Crow Creek Watershed (St. Francis County) Plan/Environmental Assessment, Arkansas' first watershed protection plan in 1986. Currently, the SCS has received authorization for developing four other watershed protection plans in Arkansas. An additional watershed has been authorized for flood prevention and watershed protection. Areas with potential for watershed protection projects are watersheds containing highly erodible, fragile soils eroding at excessive rates.

Excessive erosion rates in the basin occur in the Mine Creek, Caney-Flat Creek, North Bank Lateral of Little River, and the Bull Creek Watershed which lies adjacent to the Red River. <38> Applications for assistance in these watersheds have not been previously submitted to the SCS. Application for P.L. 83-566 assistance has been submitted for the Drainage District No. 2 portion of the Walnut Bayou Watershed. The Walnut Bayou Watershed delivers nearly 200,000 tons of sediment to the outlet each year. <38> No watershed treatment proposals are currently under consideration in this basin.

Conservation

Water conservation has not been overly emphasized in this basin because of the high average annual rainfall as observed at three recording stations (Nashville, 53.07 inches; DeQueen, 50.39 inches; and Okay, 50.34 inches). However, water conservation is essential to the future well-being of all Arkansans. Although not sufficient in itself, conservation does offer a means of helping to alleviate some of the basic problems.

Drought periods within the basin emphasize the need for conservation. While the average annual rainfall in the area is high, extended periods of no rainfall do occur. When these periods do occur, some streams cease to flow and storage reservoirs dry up or become too low for serving most intended purposes. Water conservation practiced during dry periods and the sense of emergency that prevails during droughts do not continue through times of plentiful rainfall.

Agriculture

Only 4.6 percent of the land in this basin is cropland with irrigation accounting for about 10 percent of the total water use within the basin. Soybeans accounted for 65 percent of the total irrigated acreage in 1980 within this basin and rice was second with 32 percent. (See Table 2-3).

Without adequate water for irrigation, farmers would be forced to produce different crops requiring smaller amounts of water. On-farm profits would be lowered and the economy of the basin would be adversely affected.

Although agriculture is not the current largest user of water in this basin, irrigation water management should still be initiated on all agricultural water use. Irrigation water management includes maintaining high infiltration rates, using efficient delivery systems, choosing proper application methods, achieving high application efficiencies, employing irrigation scheduling and obtaining sound engineering planning. The water conservation practices are discussed in the following paragraphs.

Infiltration Rates: Water is conserved for agricultural use when rainfall infiltrates the soil and is stored for plant use at a later date. High infiltration rates increase the amount of water that can be stored in the soil. Infiltration of water into the soil may be increased by two methods: (1) practices that keep soil pore space to a maximum, and (2) practices that alter the soil surface to allow more time for infiltration.

Vegetative cover on the soil surface absorbs raindrop impact to keep soil pores open. Stubble mulch tillage and no-till planting keep plant residues on the soil surface to increase infiltration and decrease evaporation. Cover crops, when planted, are also effective in maintaining high infiltration rates.

The soil surface may be altered to allow more time for infiltration. With proper management, runoff can be minimized and more infiltration will occur. The construction of terraces and the practice of farming on the contour are two methods of surface alteration that will allow more time for infiltration.

Delivery Systems: Delivery sytems used in the basin consist of about 5 miles of earthen irrigation canals, 10 miles of underground pipelines, and about 9 miles of above ground pipes (gated pipe). <29>

It is advantageous to replace earthen canals with pipelines. The typical earthen canal will lose from 10 to 40 percent of the total volume of water pumped through the canal; however, an underground pipeline should have virtually no water losses. (See Table 3-39). Replacing canals with pipelines will eliminate seepage and evaporation losses while also reducing labor and system maintenance.

Pipelines also require less land area than canals and allow more positive control in water management. Irrigation water supplied through pipelines will be available for use at the precise time and location it is needed. As delivery systems are upgraded to conserve water, effective methods of applying irrigation water should be chosen to obtain high efficiencies.

Application Methods: The greatest single on-farm saving of water can be accomplished by selecting the most suitable irrigation application method. Contour levee irrigation and furrow irrigation are the two most common methods of applying water to crops in the basin. In 1980, about 40 percent of irrigated acreage in the basin was irrigated by contour levee irrigation, and about 15 percent of the irrigated acreage was irrigated by furrow irrigation. The remaining 45 percent incorporated some type of sprinkler method. <36>

Factors to consider when choosing an application method include slope, soil type (infiltration and permeability), crop, as well as, water, and labor availability. Choosing the proper application method is the first step in obtaining high application efficiencies.

TABLE 3-39: ESTIMATED WATER LOSSES IN AGRICULTURAL SYSTEM COMPONENT

Component	Estimated Range of Water Loss (Percent)
Delivery System	
Canal-Main	40 - 10
Pipe-Main	5 - 0
Field Canal	40 - 10
Portable Pipe	10 - 0
Underground Pipeline	0 - 0
Application Method	
Furrow (without return)	70 - 15
Furrow (with return)	20 - 5
Levee (without return)	60 - 20
Levee (with return)	20 - 5
Traveling Sprinkler	25 - 10
Center-Pivot Sprinkler	25 - 10
Solid Set or Portable Set	25 - 10
Drip Irrigation	15 - 5

Source: USDA, Soil Conservation Service <27>

Application Efficiency: Application efficiency depends on the uniform application of the water at a proper rate at the proper time. Application efficiencies for furrow and contour levee irrigation average about 50 percent, with a range of 30 to 85 percent efficiency. Water losses from furrow irrigation without return systems range from 15 to 70 percent. With return systens, losses range from 5 to 20 percent. Losses from contour levee irrigation without return systems range from 20 to 60 percent, while losses from contour levee methods with return systems range from 5 to 20 percent. (See Table 3-39). <29>

Application efficiency can be increased if the water is applied at a uniform depth over the entire field. Over-application to the upper end of the field causing water loss by deep percolation is a common problem with furrow irrigation; however, methods such as furrow diking and surge irrigation help to obtain uniform applications. Precision land leveling and land smoothing are practices that modify the soil surface to allow for a more uniform application increasing application efficiencies. Water can be saved on contour levee irrigation of rice by shallow flooding. Shallow flooding of rice is practical on a relatively flat precision leveled field where a minimum depth of flood will cover the entire field.

As mentioned earlier, about 45 percent of the irrigated acreage was irrigated using sprinkler methods of application. Sprinkler methods of irrigation are more efficient than gravity methods without return systems, ranging from 75 to 90 percent efficiency. <29> Evaporation losses from sprinklers are normally 5 to 10 percent of the total discharge. High efficiencies are dependent upon climatic factors such as wind and heat. The most popular type of sprinkler irrigation is the center-pivot system, and its use is on the increase. Water savings may result when gravity methods of irrigation are replaced with sprinkler methods of irrigation; however, the high cost of conversion must be considered.

Application efficiencies can be increased significantly on gravity methods of irrigation by installing tailwater recovery systems (return systems). As shown in Table 3-39, both furrow and contour levee irrigation are much more efficient with return systems. The reuse of irrigation water captured in tailwater recovery systems not only conserves water, but keeps chemically concentrated water from degrading receiving streams.

Irrigation Scheduling: Regardless of the method of application, irrigation water must be applied in the proper amounts and at the proper time to obtain high efficiencies. Irrigation scheduling allows the irrigator to apply water only when the crop needs it, but in sufficient quantities to satisfy crop requirements.

Important factors in irrigation scheduling are soil properties, plant characteristics, weather, and management practices. Important soil properties include texture, depth to a restricting layer, available water holding capacity, infiltration, and permeability. The type of crop, drought tolerance, and root depth are important plant characteristics while temperature, wind, relative humidity, and rainfall are important climatic factors. Management practices are the farming practices the operator employs and include planting dates, short or long season crop varieties, and row spacing. If all factors are considered, an efficient irrigation schedule may be developed.

Some specific equipment is needed in irrigation scheduling. Moisture monitoring equipment is used to determine how much and when water is needed. Tensiometers, gypsum blocks, feel methods, speedy moisture testers, and nuclear moisture gauges are the most popular moisture monitoring techniques. Flow meters, flumes, or weirs are installed to determine how much total water is, or can be, pumped onto the field. With this equipment, an irrigation schedule may be developed, implemented, and application efficiency may be determined.

Engineering Planning: An overall engineering plan can make maximum use of available water and be very economical. Irrigation and drainage of individual fields must be carefully planned to fit in the complete irrigation and drainage system. Engineering planning can help determine the size of fields, slopes needed on precision leveled fields, location of drainage ditches, location of underground pipelines, and their outlets, location and size of pipes for water control, and location of wells.

With ground water levels declining, surface water sources are very desirable. A portion of the least productive land can be converted into a reservoir to recover tailwater, and an irrigation storage reservoir developed. Water will be conserved by recovering tailwater and additional water will be available for irrigation by storing winter runoff in the reservoir. Pumping costs will be significantly reduced in most areas by pumping from surface reservoirs rather than wells. Although the intital construction cost is expensive, state tax credits are now available through Act 417, "The Water Resource Conservation and Development Incentives Act of 1985".

Public Supply

About 4.7 million gallons of water per day were used for public supply purposes in 1980. (Table 3-14) This use represents about 5 percent of the total water use in the basin but significant amounts of water can be conserved by individuals if water conservation is practiced at home.

Several water-saving techniques include installing water-use restrictors, checking for leaks, and watering lawns during the coolest part of the day.

Self-Supplied Industries

Self-supplied industries used a total of 71.1 million gallons of water per day in 1980 which is 77 percent of the total water used in the basin. (See Table 3-14). Some industries may be able to reduce the amounts of water they use by substituting or altering their production procedures. The water used by industries in this basin shows a decreasing trend over the past 10 years for ground water use but an increasing trend for surface water use. Industries will respond to the increased cost of water treatment by practicing conservation methods. Water conservation is also expected to increase as technology improves. <24>

Wastewater Reuse and Recycling

Wastewater or sewer effluent discharged by municipalities and industries should be recognized as a valuable resource that can be reused or recycled to help meet growing requirements. Advantages of reuse are savings in money and energy, particularly in the cost of treating wastewaters to make them acceptable for discharge. Due to the availability of high quality water, most municipalities have not sought to develop a market for treated wastewater, rather, they dispose of wastewater as quickly as possible. <24>

Water Pricing

As with any other commodity, increasing the price is a proven and effective means of reducing water consumption. Pricing techniques to encourage the conservation of water rely primarily on the premise that as the price increases, the quantity purchased decreases. The effect of such a price change on quantity is called demand elasticity. A substantial elasticity exists in the demand for water. The price affects the amount consumers will demand. As the price goes up, consumers will use less water. <24>

Data Bases

Irrigated Cropland

The U.S. Department of Agriculture has three agencies involved in reporting irrigated cropland. The Agricultural Stabilization and Conservation Service reports rice acreages while the Crop and Livestock Reporting Service reports irrigated cropland based on sampling procedures. Water resource management is a major function of the Soil Conservation Service, and the SCS has published a report entitled "Agricultural Water Use, Phase V, Arkansas Statewide Study". <29> A joint effort is needed between these three agencies to accurately report irrigated cropland for planning purposes. Through such an effort, accurate and consistent information will be developed which will enhance water resource planning in the state.

Streamflow Data

Although streamflow gaging station data in the Red River Basin above Fulton are available, it would be considerably more informative to install additional gaging stations on streams in the basin. Gages on Walnut Bayou, Mine Creek, and Mountain Fork, for example, would be particularly helpful toward defining streamflow characteristics at other locations in the basin.

Another solution to the problem of limited streamflow data would be to develop a regionalization technique for statistically estimating discharges for sites on streams where data are limited. Development of a regionalization technique for determining low flow characteristics of streams would be extremely helpful since extrapolation of low flow information to ungaged areas can result in unreliable estimates of low flow discharges. Low flow information is necessary for use in the State Water Plan for determining safe yield of streams, instream flow requirements for water quality, minimum streamflows, and critical use areas. A suitable regionalization technique has not been developed for Arkansas at this time. A report by Hines <64> provides an alternative to a regionalization method; however, this technique is limited since it requires several low flow discharge measurements at each ungaged site to estimate the low flow characteristics. A regionalized low flow investigation would provide a method to determine low flow characteristics of streams in Arkansas through the use of regression equations which would extend the usefulness of the present gaging-station network.

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 requiring the Arkansas Soil and Water Conservation Commission to determine the water requirements of riparian landowners. Without diversion registrations, this determination would prove costly and time-consuming. Determination of water used by riparians is necessary to insure that over-utilization of a stream or lake does not occur or if currently over-utilized, to what degree.

One solution to the problem of non-reporting or one-time-only reporting is to amend the current law to include a penalty, other than non-preference in allocation proceedings. A fine, large enough to be an incentive to registration should be considered. 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 water quality, fish and wildlife, aquifer recharge, and interstate compacts for streams in the Red River Basin above Fulton is a problem at the present time. Accurate quantification of the amount of water in the Red River Basin above Fulton available for other uses is not possible until instream flow needs are more closely identified.

The critieria for water quality flow requirements has been established by ADPC&E and the low flow characteristics have been determined for only a relatively small number of sites in the Red River Basin above Fulton. One possible solution to this problem would be the development of a regionalization technique for statistically estimating low flow discharges for sites on streams where data are limited.

The instream flow requirements for fish and wildlife have been addressed by Filipek and others <22> 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 the U.S. Fish and Wildlife Service. This methodology may also be applicable for the determination of minimum instream flow requirements for fish and wildlife.

Section 5.05 of the Red River Compact describes apportionment of the Red River flow between the four involved (signatory) states. The compact also sets forth the restricted usage of Red River water by each state as the river flow decreases to specific rates. Severe testing of the Compact use restriction of the Red River has not, as yet, occurred.

Aquifer recharge requirements have not been incorporated in this report. To further develop aquifer recharge and depletion characteristics in the Red River Basin above Fulton, additional data should be generated for interpretation.

Summary

To summarize the surface water conditions in the Red River Basin above Fulton, most of the water problems center around the marginal quality of much of the available water. Pollution problems within and outside the basin, in general, are detrimental to existing water use entities such as municipal, industrial, rural domestic, livestock, and irrigation; to the propagation of fish and wildlife; and recreational activities. The pollution problems also result in degradation of aesthetics and the general environment.

The most extensive and serious pollution problems occur the Upper Red River Basin from natural brine emmissions and brine discharges of oil field operations. However, development of measures, exclusive of salt control, such as conservation land treatment measures and treatment of waste material, will have a major affect of improvement of water quality in the Red River Basin above Fulton for potential water use.

CHAPTER IV

GROUND WATER

INTRODUCTION

Quaternary, Cretaceous, and Paleozoic Age aquifers in the Red River Basin above Fulton contain freshwater. Quaternary alluvium and terraces cover most of the southern portion of the basin, while the southeasterly dipping Cretaceous formations occur in the central part. Paleozoic rocks are limited to the Ouachita Mountains in the northern part of the basin.

Quaternary deposits cover most of the southern one-third of the basin and form a relatively thin layer on the surface. They contain abundant supplies of ground water and constitute the most important aquifer in the basin. The Red River alluvial aquifer is the most significant Quaternary deposit in the basin.

In the Red River Alluvial Plain and the Gulf Coastal Plain, layers of sediment have accumulated over long periods of time to build up the unconsolidated deposits as they exist today. Fine grained materials (silt, chalk, clay, and marl) which yield little or no water to wells are dominant in the geologic column. However, there are several thick sections of sand, and sand and gravel which are sources of ground water for public supply, irrigation and industry. In addition, several small lenses of sand and gravel serve as sources of supply for small, domestic wells. Principle units are Trinity, Tokio, and Nacatoch. In this report, reference to the Trinity Group also includes data from other undifferentiated cretaceous units.

Rocks of Paleozoic age crop out in uplifted, folded and faulted layers. These rocks extend from the Ouachita Mountains southward under the entire basin. Paleozoic rocks yield small amounts of water to wells and are used only in the northern part of the basin where no other aquifers are available.

Ground water withdrawal data is based on the four county study area, which includes Howard, Little River, Polk, and Sevier counties. The study area differs slightly from the area referred to as the basin, which is a hydrologic unit.

Ground water withdrawals within the study area in 1980, totaled 11.23 million gallons per day (MGD). Pumpage from the Quaternary Aquifer (5.62 MGD) accounted for 50 percent of the ground water withdrawn from all aquifers within the study area in 1980. The remainder was withdrawn from four other units as follows: Paleozoic (2.61 MGD), Tokio Formation (1.46 MGD), Trinity Group (1.24 MGD), and Nacatoch Sand (0.30 MGD). Although the Paleozoic rocks produce 23 percent of the total water withdrawn, these strata, which cover about 40 percent of the basin, generally yield small quantities of water to wells. See Table 4-1 for 1980 ground water withdrawals in the study area by aquifer. <12>

The largest percentage of ground water withdrawn in the study area was used for rural and domestic use (46.7 percent). Irrigated crops other than rice used 23.8 percent while withdrawals for rice production were 6.9 percent. Public supply used 12.7 percent and self supplied industry used 9.9 percent. About 50 percent of the total was used in Little River County. <12> Ground water withdrawal in the basin by use is shown in Table 4-2.

Table 4-1: GROUND WATER WITHDRAWALS BY AQUIFER - 1980
(million gallons per day)

Aquifer	County				Total	Percent of Total
	Howard	Little River	Polk	Sevier		
Quaternary	1/	5.57	1/	0.05	5.62	50
Nacatoch	0.24	0.06	1/	1/	0.30	3
Tokio	1.11	1/	1/	0.35	1.46	13
Trinity 2/	0.35	1/	1/	0.89	1.24	11
Paleozoic	0.47	1/	1.84	0.30	2.61	23
Totals	2.17	5.63	1.84	1.59	11.23	100

1/ No reported use.

2/ Includes withdrawals from other minor undifferentiated cretaceous units.

Source: U. S. Geological Survey, Use of Water in Arkansas, 1980 <12>

Table 4-2: GROUND WATER WITHDRAWALS BY USE - 1980

County	Public Supply		Self-Supplied Industry		Rural and Domestic Use		Irrigation				Total
							Rice		Other Crops		
	MGD	Percent of County Total	MGD	Percent of County Total	MGD	Percent of County Total	MGD	Percent of County Total	MGD	Percent of County Total	MGD
Howard	0.12	5.5	0.49	22.6	1.47	67.7	1/	0	0.09	4.2	2.17
Little River	0.89	15.8	0.47	8.3	0.92	16.4	0.77	13.7	2.58	45.8	5.63
Polk	0.22	12.0	0.03	1.6	1.59	86.4	1/	0	1/	0	1.84
Sevier	0.20	12.5	0.12	7.5	1.27	80.0	1/	0	1/	0	1.59
Total	1.43		1.11		5.25		0.77		2.67		11.23
Percent of Total	12.7		9.9		46.7		6.9		23.8		100

1/ No reported use.

Source: U.S. Geological Survey, Use of Water in Arkansas, 1980 <12>

Water from the Paleozoic rocks is primarily of a mixed calcium and sodium bicarbonate type and chemically is suitable for most domestic and farm uses. Ground water for industrial or municipal use in the Ouachita Mountains may require treatment for removal of iron and calcium magnesium hardness. Water from the Cretaceous aquifers (Trinity, Tokio, and Nacatoch) is generally of fair to good quality near the outcrop area and for a few miles downdip to the south. <67> Water from the Quaternary deposits contains objectionable amounts of iron and hardness and generally is used primarily for agricultural purposes. See Tables 4-3 and 4-4 for primary and secondary drinking water standards established by the Environmental Protection Agency.

A generalized geologic map (Figure 4-1) shows the surface location of the various geologic units in the basin. Note that Quaternary deposits occur in the southern part of the basin, while the older Cretaceous and Paleozoic deposits are found in the central and northern portions of the basin.

Table 4-5 displays a generalized geologic column. This table lists the formation or group, thickness, and lithology, and summarizes the water-bearing characteristics of each geologic unit in the basin.

Table 4-3: PRIMARY DRINKING WATER STANDARDS

Selected Constituent	Maximum Contaminant Level (milligrams per liter unless otherwise noted)
Arsenic	0.05
Barium	1.00
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Fluoride	4.0
Nitrate as N	10.00 1/
Coliform bacteria	
a) For standard samples the arithmetic mean of all samples examined in a compliance period shall not exceed	1 colony per 100 ml
b) When less than 20 samples per month are examined, not more than one sample shall exceed	4 colonies per 100 ml
Turbidity	1 turbidity unit
Endrin	0.0002
Lindane	0.0004
Methoxychlor	0.10
Toxaphene	0.005
2,4 - D	0.10
2,4,5-TP (Silvex)	0.01
TTHM (total trihalomethanes)	0.10
Combined Radium - 226 and radium - 228	5 pCi/L 2/
Gross Alpha Particle Activity (including radium - 226, excluding radon and uranium)	15 pCi/L
Beta Particle and Photon Radioactivity from manmade radionuclides	Average annual conc. shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year
Tritium (total body)	20,000 pCi/L
Strontium-90 (bone marrow)	8 pCi/L

1/ The maximum contaminant level for nitrate applies to community and noncommunity water systems. Other inorganic chemicals apply only to community water systems.

2/ pCi/L = piocuries/liter

Source: U.S. Environmental Protection Agency, 1982

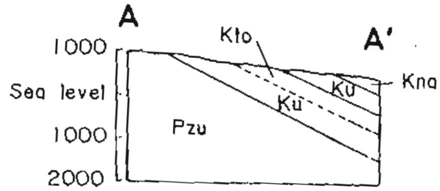
TABLE 4-4: NATIONAL SECONDARY DRINKING WATER REGULATIONS

Constituent	Maximum level
Chloride	250 mg/L
Color	15 color units
Copper	1 mg/L
Corrosivity	noncorrosive
Dissolved solids	500 mg/L
Foaming agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 (threshold odor number)
pH	.65-8.5 units
Sulfate	250 mg/L
Zinc	5 mg/L

Source: U.S. Environmental Protection Agency, 1982

Figure 4-1

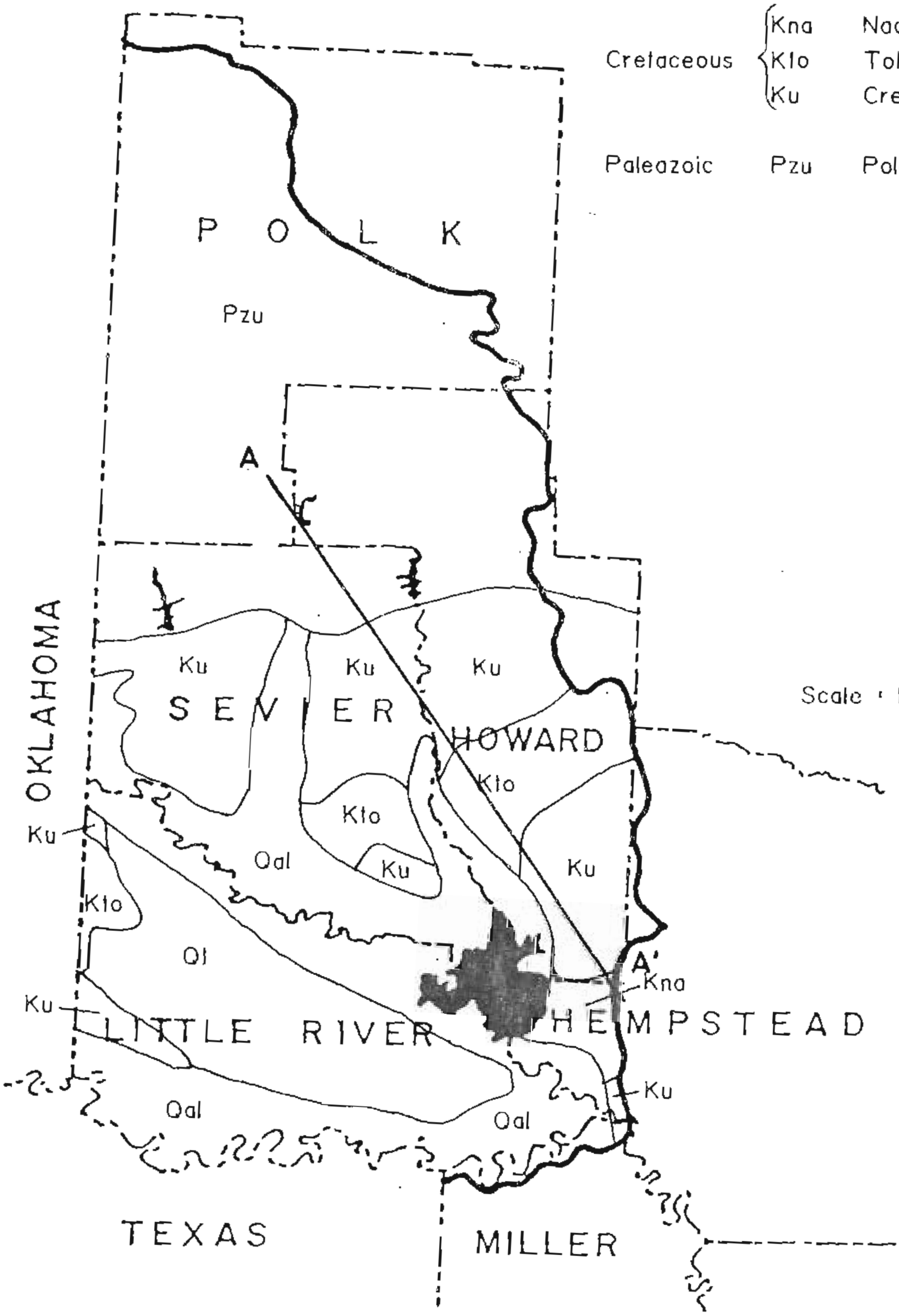
GENERALIZED GEOLOGIC MAP



EXPLANATION

GEOLOGIC UNITS

Quaternary	Qal	Quaternary Alluvium
	Ql	Quaternary Terrace Deposits
Cretaceous	Kna	Nacatoch Sand
	Kto	Tokio Formation
	Ku	Cretaceous Units Undifferentiated
Paleazoic	Pzu	Paleozoic Rocks Undifferentiated



Scale : 1" = Approx. 12 Miles

Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris <49>

TABLE 4-5: GENERALIZED GEOLOGIC COLUMN AND WATER-BEARING CHARACTERISTICS OF DEPOSITS
(Water-bearing characteristics: Small yields, 0-50 gpm; moderate yields, 51-500 gpm; large yields, >500 gpm)

Era	System	Series	Group or Formation	Thickness (feet)	Lithology	Water-bearing characteristics
Cenozoic	Quaternary		Alluvium & terrace deposits	0-90	Sand, gravel, silt, and clay.	Yields moderate to large supplies of hard water to domestic wells and to public supply wells at Ashdown and Foreman.
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	Arkadelphia Marl	0-150	Clay, fossiliferous, calcareous with interbedded limestone. Shale, blue in subsurface.	Does not yield water to wells.
			Nacatoch Sand	0-500	Sand, massive cross-bedded, limestone lenses and calcareous clay.	Yields moderate supplies of good quality water to domestic, industrial, and public supply wells on outcrop area and a distance of 2 to 15 miles downdip to the south.
			Saratoga Chalk	0-60	Chalk, hard, white with inter-bedded blue marl. Fossiliferous.	Does not yield water to wells.
			Marlbrook Marl	0-200	Marl, blue to gray, fossiliferous.	Does not yield water to wells.
			Annona Chalk	0-100	Chalk, massive white.	Does not yield water to wells.
			Ozan Formation	0-250	Clay, bluish to tan and clay and marl, sandy. Sand, glauconitic at base, from 0-20 feet thick.	Yields small amounts of very highly mineralized water to wells.
			Brownstown Marl	0-200	Clay, gray to tan, fossiliferous, calcareous.	Yields small amounts of highly mineralized water to wells.
			Tokio Formation	0-350	Sand, cross-bedded gravels and clay, gray, lignitic.	Yields moderate supplies of good quality water to domestic, industrial, and public supply wells. Locally water has high iron content.
		LOWER CRETACEOUS	Woodbine Formation	0-250	Clay, red & gray, sand & gravel, yellowish cross-bedded.	Yields small amounts of poor quality water to a few domestic wells.
			Kiamichi Formation	0-20	Clay, soft gray, marl fossiliferous and lenses of limestone. Present in very small area in Little River Co.	Does not yield water to wells.
			Goodland Limestone	0-50	Limestone gray sandy & clay gray. Present in very small area in Little River County.	Does not yield water to wells.
			Trinity Group	0-900	Sand, fine, white interbedded with red & clay, and limestone.	Yields moderate supplies of fair quality water in Howard and Sevier counties.
				0-100	Limestone, interbedded gray, clay & gypsum, gray.	Does not yield water to wells.
				0-40	Gravel.	Yields moderate supplies of fair quality water in DeQueen and vicinity.
				0-400	Clay, red, interbedded with gray sand.	Does not yield water to wells.
				0-40	Limestone interbedded with dark shale.	Does not yield water to wells.
				0-50	Gravel.	Yields moderate supplies of fair quality water in DeQueen and vicinity.
	JURASSIC			0-?	Red beds and an hydrite.	Not a source of fresh water.
PALEOZOIC	MISSISSIPPIAN PENNSYLVANIAN DEVONIAN		Jackfork Sandstone Stanley Shale Arkansas Novaculite	0-?	Sandstone, shale, and novaculite, highly folded.	Yields small amounts of hard water to domestic wells.

Source: U.S. Geological Survey <67>

GEOLOGIC UNITS AND THEIR GEOHYDROLOGIC PROPERTIES

Quaternary Deposits

Geology

Approximately 35 percent of the surface material in the Red River Basin above Fulton is alluvium or terrace deposits of the Quaternary System. Where these deposits are present, they are always on the surface. No younger deposits overlie them.

The Quaternary can be divided into the Holocene (Recent alluvium) and the Pleistocene (terrace) Series. The terraces are older but usually are located at higher elevations than the alluvium. In some areas the alluvium and the terraces are highly dissected, consist of slightly different materials, and function as independent aquifers. In other areas, the two units are indistinguishable, and with a basal zone connection, can be treated as one hydrologic unit. Generally, the terrace and alluvial deposits are less than 90 feet thick. <60> Water well depths in the Quaternary vary from 18 feet to 2,200 feet but the average depth is about 60 feet. <75>

Hydrology

The Quaternary aquifer is the single most important aquifer in the basin. About 50 percent of the ground water used in the study area in 1980 was withdrawn from Quaternary deposits. The quantity used within the study area (5.6 MGD) was more than twice the quantity withdrawn from the second most important source of water, the Paleozoic rocks. <12>

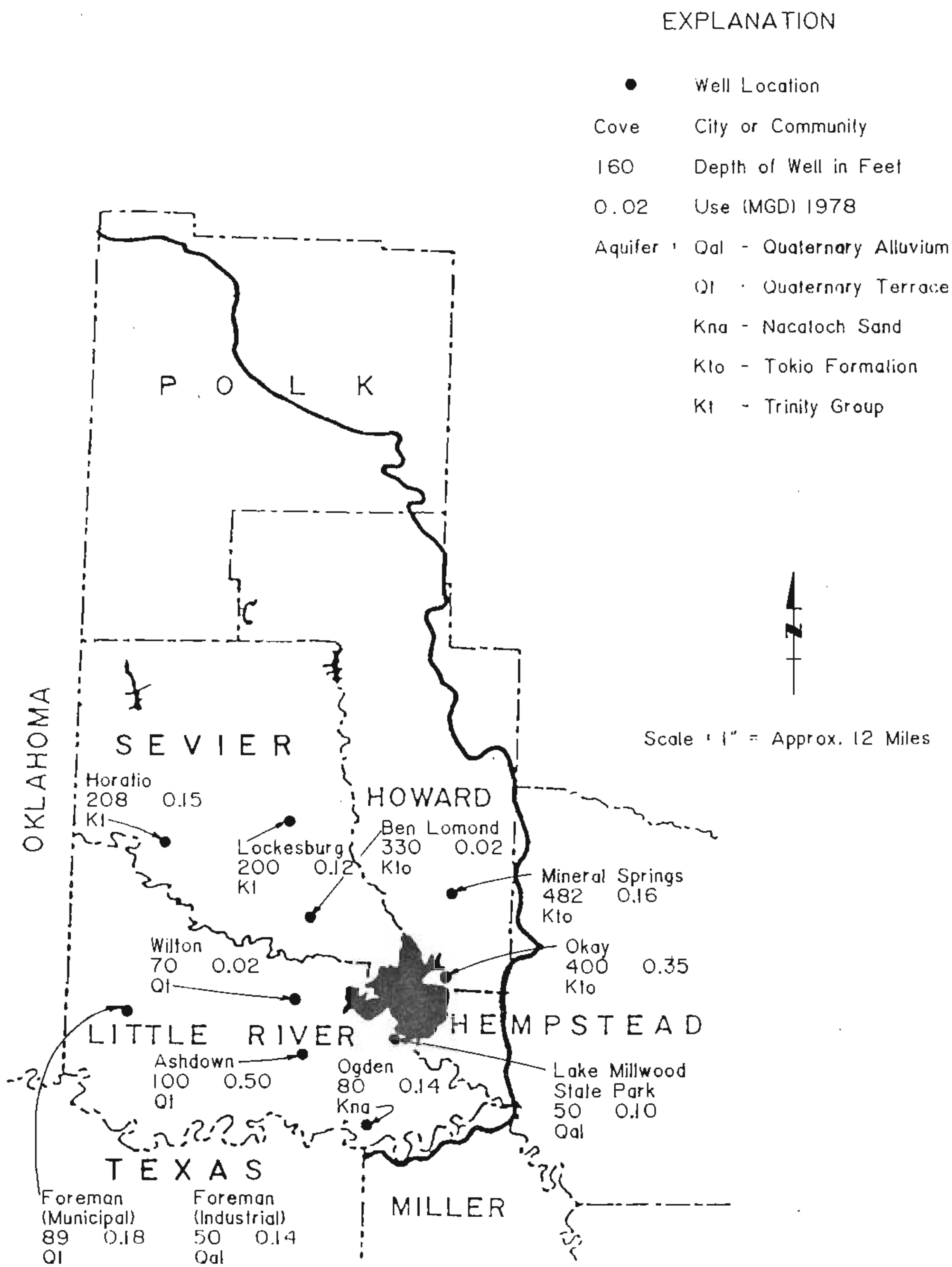
The towns of Ashdown, Wilton, Foreman, and Lake Millwood State Park (Little River County) utilize water from the Quaternary aquifer for public supply. (See Figure 4-2) In 1965, 89 percent of the Quaternary withdrawals in the study area was from Little River County and 11 percent from Sevier County. By 1980, total study area use from the Quaternary had increased from the 1965 use of 1.59 MGD to 5.62 MGD. Withdrawals from Little River County increased from 1.42 MGD in 1965 to 5.57 MGD in 1980 which amounted to 99 percent of the total Quaternary use in the study area. <11> <12>

The importance of the Quaternary aquifer is mainly due to the high yields of fresh water that can be obtained at relatively shallow depths. Yields vary considerably over the basin, depending on permeability and saturated thickness of the deposit. Yields of 150 gallons per minute (GPM) are reported at Ashdown (Little River County) and as much as 800 GPM have been reported from irrigation wells southeast of Ashdown. High yields (800-1,000 GPM) are also found in Little River County along the Red River. <58> <67>

Movement of water within the Quaternary aquifer is regionally controlled by the gentle southeastward slope of the Red River alluvial plain. Locally, movement is away from or toward streams depending on the season, and toward areas of large withdrawal.

Figure 4-2

LOCATIONS OF PUBLIC SUPPLY WELLS



Source : Arkansas Soil and Water Conservation Commission, 1978. <14>

Precipitation is the principal source of recharge to the alluvial aquifer. Water percolates through the upper fine-grained layers at rates dependent on the permeability of the materials. The aquifer is also recharged from rivers and streams during periods of high flow. Recharge varies seasonally. This is reflected in seasonal changes in water levels. <57> During the 1981-1986 period, measurements of two Little River County wells in the alluvial aquifer show net water level changes of plus 2 feet and plus 17 feet. <74>

Quality

Because of the high degree of hardness and high iron content, water in the alluvial aquifer cannot be used for most domestic or industrial purposes without treatment.

Chemical analyses of 22 water samples collected from the alluvium by the U.S. Geological Survey show that hardness ranges from 11 mg/l to 790 mg/l and averages 229 mg/l, an indication that the water generally is very hard (greater than 180 mg/l). The concentrations of iron ranged from 0.03 mg/l to 11 mg/l and averaged 1.7 mg/l. <75> Other constituents and properties of the water do not limit its usefulness. The water is a calcium bicarbonate type and, if treated to remove the iron and reduce the hardness, would be suitable for municipal and many industrial uses. The water generally is suitable for irrigation.

In parts of western Little River County, water supplies are obtained either from cisterns or from dug wells which intercept water seeps at the base of the terrace deposits. Nitrate concentrations of as much as 560 mg/l have been noted from water in shallow wells near Alleene and Crossroads in northwestern Little River County. <75> The high nitrate content is probably caused by contamination from barnyard wastes or septic tanks. <58>

Cretaceous System

Cretaceous deposits occur mostly in the central and southern part of the basin. These deposits rest on the Paleozoic strata and are overlain by Quaternary alluvium and terraces. The Cretaceous deposits have the form of a wedge, thinning to a feather edge to the north against the Paleozoic strata and thickening rapidly to the south. The dip of the strata averages about 80 to 120 feet per mile southward. Although there are a total of 12 geologic units in the Cretaceous System, (see Table 4-5), only three of these units, the Nacatoch Sand, Tokio Formation, and Trinity Group, are significant aquifers in the basin. These three units are discussed in the following paragraphs.

Nacatoch Sand

The Nacatoch Sand crops out as a wide, low ridge southeast of Millwood Reservoir in the southeastern corner of the basin. The outcrop area measures about 6 miles wide and 8 miles long and covers only about 2 percent of the basin area. The formation is approximately 320 feet thick in the area and is composed of fine glauconitic sand with some inter-bedded clay lenses.

The upper part of the formation is composed of sand and is the principal water-bearing part of the Nacatoch. The general direction of ground water movement in the Nacatoch Sand is to the southeast. In southwestern Little River County, from the vicinity of Bull Creek westward, the formation is not considered a significant water supply source. In Hempstead County, the formation can be expected to yield 150-300 GPM. <67>

During 1980, water was withdrawn from the Nacatoch Sand in the study area at the rate of 0.3 MGD. This quantity accounted for 3 percent of the total ground water withdrawn from all aquifers in the study area. Of the total 0.3 MGD, 80 percent was from Howard County and 20 percent from Little River County. <12> Depths of the 59 wells measured by U.S. Geological Survey in the Nacatoch Sand ranged from 30 feet to 850 feet and averaged about 306 feet. <75>

Water from the Nacatoch Sand varies from soft to very hard. From 59 chemical analyses taken, hardness varied from a low of 7 mg/l to 350 mg/l and averaged 79 mg/l. <75> Near the outcrop area, calcium and bicarbonate are the principal constituents. Near the downdip limit of fresh water in the formation, the sodium and chloride content increases with a corresponding increase in dissolved-solids content. The concentration of iron in the water ranges from 0.03 mg/l to 5.2 mg/l and averages 0.5 mg/l. <75> The community of Ogden (Little River County) is the only municipality in the basin that uses the Nacatoch Sand for a public water supply.

Tokio Formation

The Tokio Formation crops out in a northeastward trending band which extends into Little River and Howard Counties. Most of the formation in Little River County is covered by Quaternary deposits (see Figure 4-1). The Tokio Formation increases in thickness from about 50 feet near the edge of its outcrop to about 300 feet in Little River County.

The Tokio Formation is composed chiefly of cross-bedded sand and clay interbedded and intertongued with scattered carbonaceous material and some gravels. The basal gravel is the most common part of the Tokio Formation but other lenticular beds of gravels occur higher in the formation. The gravel is thickest in Howard County and thins eastward and westward. The dip of the gravel bed is not precisely known but is probably about 70 feet per mile south and southeast. The gravels lense out westward in Sevier and Little River Counties and are replaced by medium to fine sand. <67> Depths of 32 wells measured by U.S. Geological Survey ranged from 16 feet to 1,500 feet with the average depth being 430 feet deep. <75>

Approximately 13 percent of the total ground water withdrawn in the study area is from the Tokio Formation. This formation yields water to wells in southern Howard County and southeastern Sevier County. The communities of Mineral Springs, Okay (Howard County), and Ben Lomond (Sevier County) utilize this formation for public water supplies. (See Figure 4-2)

Chemical analyses show water from wells in the Tokio Formation to be a sodium carbonate type but there is a wide variation of hardness, sulfate, iron, and chloride concentrations. Chemical analyses from 115 samples taken by U.S. Geological Survey shows hardness ranging from 3 mg/l to 700 mg/l and averaging 130 mg/l. Chloride concentration varied from 3 mg/l to 1,000 mg/l and averaged 61 mg/l. Sulfate concentration varied from 1 mg/l to 390 mg/l and averaged 48 mg/l. Chemical analyses from 92 samples showed iron concentration ranging from 0.06 mg/l to 54 mg/l and averaging 3 mg/l. From 115 samples taken, pH averaged 8 standard units. <75>

With the exception of chloride concentration, water quality varied throughout the use area. Chloride concentration increased gradually downdip to the southeast in the formation for a few miles and then increased more abruptly.

The Tokio Formation is a source of water for domestic wells in the vicinity of Winthrop, in northwestern Little River County. Information obtained from drillers' logs indicates that a 15-20 foot section of fresh-water-bearing sand underlies the area at a depth of from 30 to 80 feet below the land surface. The wells yield less than 10 gallons per minute, and static water levels in the wells range from 15 to 20 feet below land surface. South of Winthrop, the sand section is either absent or contains saline water (William Pender, driller, personal communication, 1969). <58>

Trinity Group

The Trinity Group crops out in a east-west band which extends across the center portion of the basin. The outcrop area, which is about 23 miles long and 10 miles wide, is included in the Cretaceous units undifferentiated (Ku) shown in Figure 4-1. It includes the lowermost deposits of Cretaceous Age in Arkansas. In the northern part of the outcrop area it overlies the Mississippian and Pennsylvanian systems but in the southern part of the area it lies directly on truncated beds of Jurassic age. At its outcrop and for a short distance downdip the Trinity deposits indicate a shallow water, and occasionally a marginal, environment of deposition. The most common materials are clay, sand, gravel, and limestone. Some carbonaceous material is present in the clay and limestone beds. <67> Wells in the Trinity measured by U.S. Geological Survey ranged in depth from 25 feet to 950 feet. <75>

Approximately 11 percent of the total ground water withdrawn in the study area is from the Trinity Group. Ground water yields from this group are essentially limited to wells in southern Howard County and central Sevier County. The Trinity can be divided into six units described in Table 4-5. Only the units containing significant quanities of sand or gravel yield water to wells in the basin. The upper sand unit of the Trinity is the principal source of water from the sand in the group. Flowing wells from the upper sand occur at the lower elevations in Howard and Sevier Counties. The quality of water from the upper sand is variable but ususally high in sulfate and bicarbonate and low in chloride, except the amount of chloride increases downdip to the south. <67>

The upper and lower gravels of the Trinity yield water of fair quality and quantity to wells in the basin. In the DeQueen area (Sevier County), these gravels have been reported to yield as much as 200 GPM. <67> The towns of Lockesburg and Horatio (Sevier County) also utilize water from the Trinity for public supply. The water from the Trinity Group requires some treatment for most municipal and industrial uses.

Table 4-6 shows results of chemical analyses of wells used for public supply sources in several towns within the basin.

TABLE 4-6: CHEMICAL ANALYSES OF PUBLIC SUPPLY WELLS WITHIN THE BASIN
(Data in mg/l unless otherwise noted)

Aquifer	City or Community	No. of Samples	Year	pH (Stand. Units)	Total Solids	NA	Total Alk.	Total Hard.	Ca	Mg	Fe	Mn	Cl	SO4	F	NO3 (N)
Quaternary Terrace	Foreman	1	1984	5.80	183	19	19	45	12	<5	0.11	0.01	40	<10	<0.2	1.80
Quaternary Terrace	Ashdown 1/	5	1981 1982	6.46	250	28	176	199	45	21	0.2	0.04	26	14	0.2	0.41
Quaternary Terrace	Wilton	1	1984	7.1	598	61	281	335	85	30	0.01	0.05	134	15	0.22	1.25
Nacatoch	Ogden	1	1981	6.97	300	17	232	170	40	17	0.21	0.01	10	10	0.2	0.04
Tokio	Ben Lomond	1	1984	6.39	260	44	68	13	<2	<5	8.0	0.25	10	52	0.30	0.04
Tokio	Mineral Springs 2/	2	1984	8.85	339	145	254	<5	<2	<5	<0.01	<0.01	5	28	0.95	0.04
Tokio	Winthrop 2/	2	1983	8.6	926	295	292	7	<2	<5	0.77	0.01	204	197.5	0.55	0.32
Trinity	Lockesburg 2/	2	1984	5.5	50	4	11	9.5	4	<5	0.015	0.045	6	<10	<0.2	0.775
Trinity	Horatio 2/	2	1984	6.9	202	6	140	22	7	<5	3.6	0.17	6	<10	<0.2	0.04

NA - Sodium dissolved as Na
CA - Calcium dissolved as Ca
MG - Magnesium dissolved as Mg
FE - Iron dissolved as Fe
MN - Manganese dissolved as Mn
Cl - Chloride dissolved as Cl
SO4 - Sulfate dissolved as SO4
F - Fluoride dissovled as F
NO3 - Nitrates dissolved as N

1/ Data represents mean of five wells.
2/ Data represents mean of two wells.

Source: Arkansas Department of Health, File Data <2>

Paleozoic Rocks

Geology

Paleozoic rocks cover about 40 percent of the basin, forming the Ouachita Mountains in the northern portion of the basin. Of the Palezoic strata, the Stanley Shale formation makes up about 85 percent the area. This formation consists of folded and faulted hard shale and sandstone and contains little ground water. However, sufficient amounts usually can be obtained for limited domestic use. <67> In addition to the above formation, the Arkansas Novaculite and Jackfork Sandstone crop out in small areas along the northern part of the basin. The location of the Paleozoic rocks (undifferentiated) is shown in Figure 4-1 and their stratigraphic relationship is displayed in the geologic column in Table 4-5.

Hydrology

The primary porosity of the Paleozoic rocks in the Ouachita Mountains has been destroyed by compaction due to deep burial, deformation pressures, or both. Therefore, ground water in the mountains principally occurs in secondary openings such as joints, fractures, and separations along bedding planes, and its availability at any point largely depends on the degree to which the rocks have been "broken up." Limited supplies of ground water are available at most places because secondary openings have been formed in nearly all the rocks. <68>

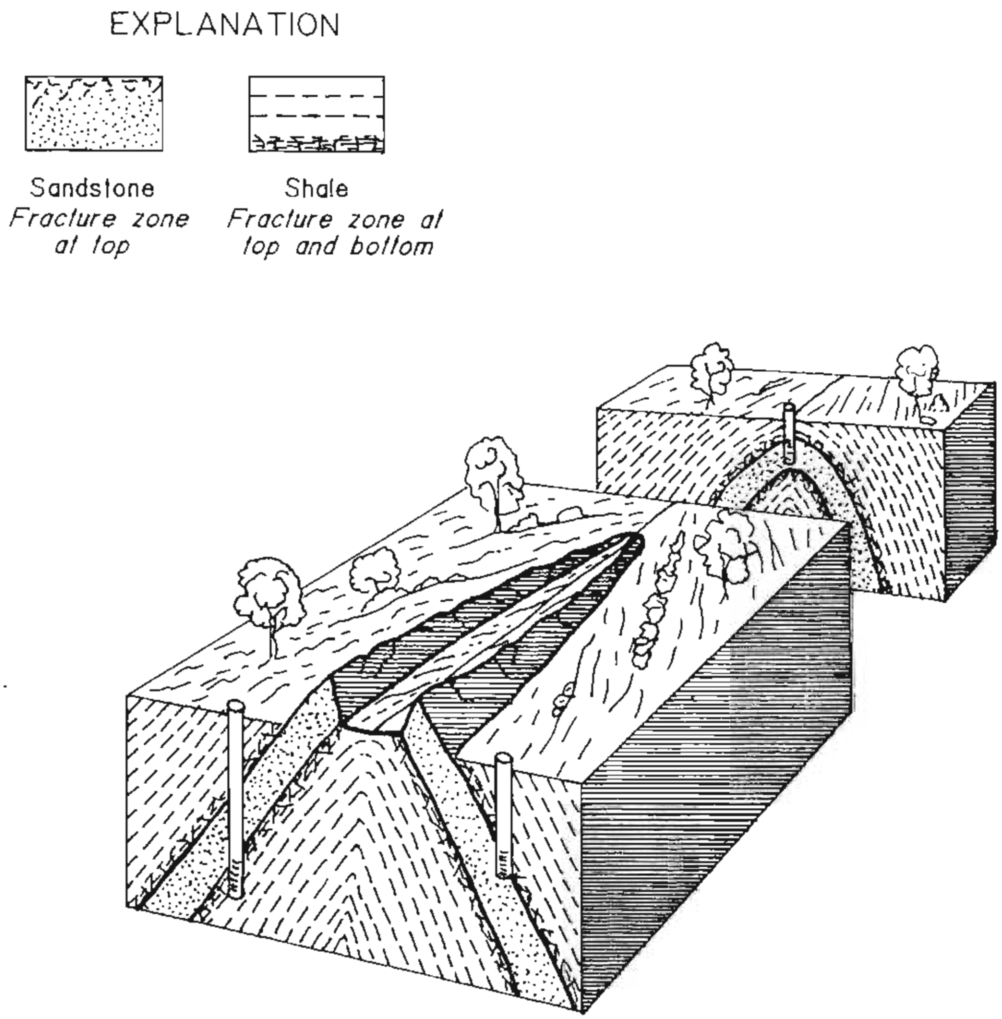
Because the principal joint and fracture pattern runs eastward, wells drilled along this trend commonly tap the same ground water source. Conversely, wells along a north-trending line often are completely independent, and one well may be a "good" water-producer though an adjacent well is not. Additional wells generally can be drilled either east or west from proven supplies, but, if possible, wells should be spaced at least 1,000 feet apart to prevent excessive drawdowns. If this amount of separation is not practicable, a location north or south of the existing wells should be investigated to determine the possibility of developing a separate ground water source. <68>

The best places to drill wells in the Ouachita Mountains portion of the basin generally are on the flanks of anticlines (in synclinal valleys) and off the noses of plunging anticlines. Differential movement between shale and sandstone beds during folding commonly has formed fractures and bedding-plane separations near the contact between the beds. When the resultant fracture zones are exposed to recharge, as on the flanks of anticlines, wells often can be constructed as shown in the foreground of Figure 4-3. If the anticline plunges, wells also may be developed off the nose along the axis as shown in the background of the figure. Wells drilled at this location probably will yield water from the highly fractured sandstone at the crest of the anticline. <68>

Most wells in the mountains are less than 100 feet deep, but the larger yield wells generally range from 100 to as much as 627 feet deep. The static water level generally is less than 20 feet below land surface, and some of the wells have artesian flow. Pumping water levels may be as much as 150 feet below

Figure 4-3

BEST LOCATIONS FOR DRILLING WELLS IN THE PALEOZOIC ROCKS



Source : USGS - modified from D. R. Albin <68>

land surface. Seasonal water-level fluctuations in the wells generally are less than 10 feet. However, larger fluctuations are common in abnormally wet or dry years because the ground water storage capacity is small and recharge is by rapid infiltration of local precipitation. <68>

Most wells in the mountains yield less than 10 GPM. In fact, wells almost anywhere in the mountain area that will yield more than 10 GPM continuously for a week are considered "large-yield" wells. Because of the large drawdowns required to produce even moderate quantities of water, wells tapping the same ground water reservoir in the Paleozoic rocks should, if possible, be spaced a minimum of 1,000 feet apart. <68>

Sufficient quantities of ground water for limited domestic and non-irrigation farm uses generally are available from the Paleozoic rocks. Since yields from the Palezoic rocks seldom exceed 5 to 10 GPM, ground water should not be considered as a source of supply for municipal growth and economic development in the Ouachita Mountains portion of the basin. <68>

Until recently, the towns of Hatfield, Cove, Vandervoort-Hatton, Wickes, Grannis (Polk County), and Gillham (Sevier County) utilized water from the Paleozoic rocks for public supply but these wells were abandoned in favor of a surface water supply from the Gillham Regional Water District.

<u>Quality</u>

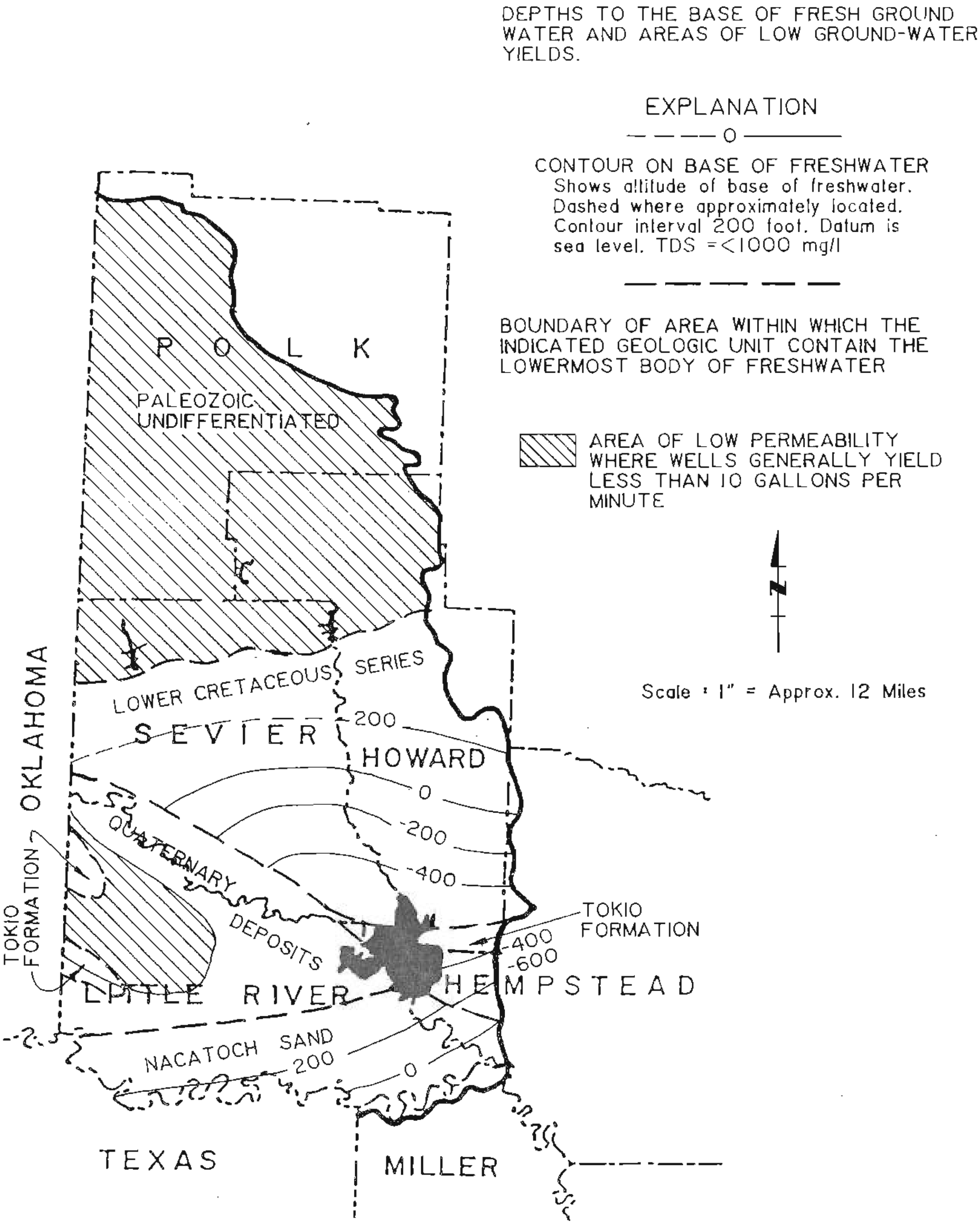
The quality of ground water from Paleozoic rocks is highly variable but generally is within recommended ranges for human consumption. The deeper wells usually have the poorest water quality because the water has been in contact with the rocks for a longer period of time. <69>

Water quality from Paleozoic rocks generally ranges from a bicarbonate to a sulfate type. Chemical analyses by U.S. Geolgical Survey of water samples taken from two wells in this formation revealed very limited information regarding water quality. The available data indicated levels of constituent concentrations well within secondary drinking water standards. <75>

Figure 4-4 shows the geohydrologic constraints associated with the various basin aquifers.

Figure 4-4

GEOHYDROLOGIC CONSTRAINTS



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

LEGAL AND INSTITUTIONAL SETTING

Ground Water in Federal Law

No comprehensive federal ground water law exists comparable to the legislation covering surface water or ocean pollution. This may reflect a federal view that ground water quality problems are susceptible to local or state resolution and do not affect "interstate commerce" as directly as do surface waters. Federal measures for the control of ground water pollution are listed in several different laws that are not primarily concerned with ground water. Each of the laws are discussed below.

Clean Water Act of 1977 - Congressionally delegated authority to the U.S. Environmental Protection Agency over surface water and ground water; however, the scope of EPA authority over ground water pollution has been ambiguous, partly because of the phrasing of Section 309 which refers to "navigable waters", which limits its applicability to ground water.

Safe Drinking Water Act of 1974 - The Act protects ground water through its Underground Injection Control Program; and sets limits on some substances that may occur in public water supplies.

> Section 1424(e) - The Gonzales Amendment - provides state agencies with a legal mechanism to protect the recharge zones of special or "sole source" aquifers. In such areas, federally assisted projects which are found to endanger the quality of the water as set forth in the maximum contaminant levels set by the Safe Drinking Water Act, could have their funding halted by EPA.
>
> Once designated as a "sole source" aquifer, sections 3004 and 4002 of the Resource Recovery and Conservation Act (1976) come into play which allows state agencies to prohibit facilities in the recharge areas. This act also requires a leachate monitoring system and design specification for landfills and surface impoundments, thus giving the state legal support in restricting or prohibiting waste facilities within the recharge zone.

Resource Conservation and Recovery Act of 1976 (RCRA) - through which the EPA recently promulgated regulations involving the classification, handling, testing, and disposal of hazardous substances. This act sets standards for the construction and monitoring of RCRA sites, including the drilling of monitoring wells.

Toxic Substances Control Act of 1976 (TOSCA) - which overlaps with RCRA in some respects, also deals with toxic substances, particularly polychlorinated biphenyls (PCBs).

Surface Mining Control and Reclamation Act of 1977 - which deals with the release and disposal of mine water.

National Environmental Policy Act - forces consideration of the effects of federal action on ground water in the writing of environmental impact statements. The federal reservation of water rights doctrine has been expanded to include ground waters (1 Harv. Env. L. Rev. 173).

In Cappaert v. United States (426 U.S. 128, 1976), the U.S. Supreme Court held that "since the implied reservation-of-water doctrine is based on the necessity of water for the purpose of the federal reservation....the United States can protect its water from subsequent diversity, whether the diversion is of surface or ground water." The court cited no cases to support this holding, relying instead on two National Water Commission publications and simple logic.

The federal government seems reluctant to tackle the socio/economic and technical problems involved in preparing a comprehensive ground water resource management policy, (there is no ground water legislation equivalent to the Clean Water Act). In September of 1984, EPA released its long awaited ground water protection strategy. Consistent with its past pronouncements on ground water, EPA's current strategy lays the burden of protection on the states. It calls upon them to build their ground water programs using existing appropriations. New funds are to be used mainly for "information gathering and planning," with implementation reserved for those states who have completed their basic planning.

To assist the states, EPA has recently set up a new office on ground water to coordinate programs. New regulations concerning the formerly unregulated underground storage tanks and surface impoundments will be promulgated along with further specifications for the protection and cleanup of aquifers.

Aquifers will be protected according to their "highest and best use", according to 3 classifications:

A. Special aquifers - those vulnerable to surface contamination, i.e., karst formations, sand and gravel aquifers. Those that are defined as ecologically vital, irreplaceable, or essential to the public.

B. Drinking water sources - currently used or potential sources.

C. All other aquifers.

Special aquifers will receive special attention; i.e., Superfund sites located over special aquifers will be cleaned up first. More stringent regulations for the storage and disposal of chemicals will be applied over special aquifers. A special casing will be needed for disposal wells drilled through them. Further rules for land applications of nutrients and for new facilities over these aquifers will be applied.

Drinking water sources will have the same protection now in place. If a contaminant enters an aquifer used as a source of drinking water, it will be cleaned up with the best available technology, or, if that is not possible, the contaminant plume will be monitored.

Aquifers too salty to be used as drinking water sources will be monitored so that as little contamination as possible escapes from them into cleaner aquifers that are, or could be, used as drinking water sources. EPA's recommendation for monitoring systems called for the utilization of monitoring already in place. They agreed some selected monitoring could be funded if it fit within the general framework of the state strategy for ground water. Monitoring that fell within the routine structure of the state system would not be eligible for funding.

Landfills, surface impoundments, and leaking storage tanks will be given special attention by EPA through programs designed to study the threat to ground water presented by these sources of contamination. The first study which addresses leaking underground storage tanks is presently (1986) underway, directed by the Office of Pesticides and Toxic Substances (OPTS).

Most of the actions to be taken by EPA involve the further use of existing regulations such as: FIFRA, the Federal Insecticide, Fungicide, and Rodenticide, Act., which will be used to control pesticides that may leach into the ground water, TOSCA, (Toxic Substances Control Act), guidelines will be used to regulate new chemicals.

Ground Water in State Law

Ground waters are generally subject to the same treatment given to watercourses, and it follows that the Arkansas position, with respect to ground waters, conforms to the riparian doctrine. Therefore, ground waters also come within the framework of the reasonable use theory as applied to watercourses. Disputes over water have generally been decided according to a reasonable use test which allows each owner to use the water for his own purposes having due regard for the effect of that use upon other riparian owners and on the public in general.

Arkansas Case Law

A leading case which deals with the questions of ground water use, Jones vs. Oz-Ark-Val Poultry Company, was a case of conflict between the industrial use of ground water and domestic wells. The court held that industry interference with the ground water was unreasonable and an injunction was issued to prevent excessive pumping by the industrial users. The court applied the "reasonable use doctrine" to resolve the conflict. The court recognized that under our law, the domestic use of ground water prevail. The court further stated that, where two or more tracts of separately-owned land join with a common underground reservoir, each owner has common and correlative right to the use of the water on his land if the common supply is sufficient. However, if the supply is limited and one use interferes with another use, then each person is limited to a reasonable share in order not to hamper the use of the other party.

The Arkansas Supreme Court has not rigidly defined reasonable use. The court has ruled "that we are not necessarily adopting all the interpretations given it be the decisions of other states, and that our own interpretation will be developed in the future as occasions arise."

[Harris vs. Brooks, 225 Ark. 436, 283 S.W. 2d 129 (1955)]. Clearly, the definition of reasonable use is evolving as the court addresses more complex water problems. The court recently reversed a previous ruling requiring riparian owners to use water on riparian lands and demonstrated a willingness to adapt to changing needs.

In Lingo vs. the City of Jacksonville, [258 Ark. 63, 522 S.W. 2d 403, 1975] the court ruled that the city of Jacksonville could legally buy land, drill wells, remove the water to a distant point and sell it to its customers. The Arkansas high court has consistently tried to guarantee maximum beneficial use of the State's water resources. The court concludes:

> "In all our consideration of the reasonable use theory, as we have attempted to explain it, we have accepted the view that the benefits accruing to society in general from a maximum utilization of our water resources should not be denied merely because of the difficulties which may arise in its application." [Harris vs. Brooks, 225 Ark. 436, 283 S.W. 2d 129, 1955].

Domestic use is preferred over other uses of ground and surface water. In times of scarcity, surface water use is allowed in the following order: (1) sustaining life, (2) maintaining health and (3) increasing wealth. The correlative rights rule (giving overlying owners a proportionate or prorated share) governs ground water use during times of scarcity.

The courts decide which uses are reasonable or unreasonable on a case by case basis as conflicts arise. The Arkansas high court has modified the common law on several occasions in order to allow maximum beneficial use of the state's water resources and seems willing to make further changes as needed.

To summarize, Arkansas water law is based on a riparian/reasonable use rule for both surface and ground water (whether percolating or flowing). Riparian owners are allowed to make reasonable beneficial use of the water "with due regard to the rights of others similarly situated."

Agency Regulations and Authority

A. Arkansas Department of Pollution Control and Ecology

1. Act 472 of 1949 as amended; Arkansas Water and Air Pollution Control Act.

   Under the authority of Act 472 of 1949, the ADPC&E has broad powers of regulation and enforcement over "waters of the state", both "surface and underground". Hence, it follows that all the kinds of monitoring, classifying, and regulating that have been done for surface water, can be done for ground waters (given, of course, the physical limitation imposed by geology).

2. Regulation #1, ADPC&E November 1, 1958.

   The regulation was for the Prevention of Pollution by Saltwater and Other Field Wastes Produced by Wells in New Fields or Pools.

   This attempted to prevent brine from the oil fields from polluting the "waters of the state". It applied only to wells established after July 1, 1957. It provided for underground injection whenever possible and outlawed holding ponds over porous or gravelly soils and was supplemented by Safe Drinking Water Act's Underground Injection Control Program.

3. Regulation #2, ADPC&E as amended, September, 1981. Arkansas Water Quality Standards.

   The regulation deals mostly with surface water, but refers occasionally to ground water protection, as in Section 4, Part E (2C) as related to ephemeral and intermittent streams. There is not any legal reason why the classification of ground water could not be included within this framework in the same comprehensive manner surface water is addressed.

4. Regulation #3 Underground Injection Control Code, March, 1982.

   The regulation adopts by reference, most of the federal regulations dealing with the construction and control of injection wells.

5. Act 134 of 1979 as amended by Act 647 of 1979.

   The program, in regard to ground water, consists of a permit system which would allow for the assessment of the effect a mining activity might have on the ground water resources, either quality or quantity. Again, this is accomplished on a case by case basis, only in the areas of proposed activity. The Department does have authority to prevent a given activity if adverse impacts warrant such action.

B. Arkansas Soil and Water Conservation Commission.

1. Act 217 of 1969 authorized the Commission to develop the Arkansas State Water Plan which would serve as the state water policy for the development of water and related land resources in the state. All reports, studies, and related planning activities were required to take the State Water Plan into consideration. In 1975, the first State Water Plan was published. In 1980, work on revising the 1975 plan began.

2. Act 1051 of 1985 outlined many variables that needed to be quantified or delineated and included in the State Water Plan, expected to be released by late 1987. Some requirements of the Act were: (a) current and projected needs of public water supplies, industry, and agriculture, (b) define and quantify the safe yield of all streams, reservoirs and aquifers, (c) quantify requirements of fish and wildlife, navigation, riparian rights and minimum stream flows. In addition, the act authorized interbasin transfer and nonriparian use contingent upon guideline development by the Commission and required all ground water users to report the quantity of ground water withdrawn on an annual basis. The Commission will now collect and compile ground water use data in addition to surface water use data authorized by Act 180 of 1969.

3. Act 417 of 1985 provided incentives for construction of surface water reservoirs in the form of a state tax credit not to exceed 50 percent of the total construction cost or a maximum of $33,000 over an 11-year period. Any applicant who converts to surface water from ground water sources may receive a tax credit equal to 10 percent of the total conversion cost. Persons seeking eligibility for the tax breaks must apply to Arkansas Soil and Water Conservation Commission for evaluation and acceptance.

C. Arkansas Geological Commission - Act 16 of 1963. This act charges the Commission with the collection and dissemination of data regarding water and other natural resources. This Act also states that the Commission will engage in cooperative agreements with the U.S. Geological Survey to perform investigations concerning water resources, which includes quantitative and qualitative analysis of ground water.

D. Arkansas Oil and Gas Commission - Act 105 of 1939. This program consists of a permitting system for the underground injection of any industrial waste into existing aquifers. The permits are considered on a case by case basis in regard to means and level of injection, quality of water injected, use of ground water in area, etc. An informal agreement exits between this Commission and the Department of Pollution Control and Ecology which indicates the Commission will deal with all impacts from the well head down and the Department of Pollution Control and Ecology will deal with problems related to surface water pollution (in execution of the Department Reg. 1). The Department of Pollution Control and Ecology will, in instances of hazardous waste inspections, work with potential subsurface impacts.

E. Arkansas Health Department - Act 402 of 1977. The program pertains primarily to the permitting of waste treatment systems for individual dwellings, with the limitation being the quantity of wastewater treated. Permits are considered on a case by case basis with the exception being that certain requirements are particularly applied to certain areas of the state to protect ground water sources, specifically. The Department has authority to prevent and/or stop ground water contamination sources by declaring them "public health nuisances". The Department is also authorized by Act 71 of 1973 to control septic tank pumpers and the disposal of sludge. Septic tank installers are also permitted by the Health Department. The Department not only considers septic tanks but any accepted method of waste treatment. Numerous alternatives are available and considered by the Health Department whenever physical conditions and economic justifications warrant.

F. University of Arkansas - Act 737 of 1977. The Act calls for research funds to be appropriated for septic tank design at the University's Agricultural Experiment Farms. The research is ongoing and is currently funded as a line item in the University's budget.

G. Water Well Construction Committee - Act 641 of 1969. This act, as amended, gave the Committee the authority to issue water well drillers contractors licenses, test and register water well drillers, and register and issue rig permits.
The Committee insures that proper construction and abandonment standards are followed and investigates complaints against drillers. The Committee maintains files of well completion reports submitted by drillers.

H. Related Legislation

Mining Legislation:

The Arkansas Open Cut Land Reclamation Act, Act 336 of 1977, as amended by Act 824, regulates reclamation of land disturbed by open cut mining; requires a permit for open cut mining.

The Arkansas Surface Coal Mining and Reclamation Act, Act 134 of 1979, as amended by Act 647, establishes a program for coal mining and reclamation of mining areas.

Solid Waste Legislation:

Arkansas Solid Waste Management Act, Act 237 of 1971, requires proper and permitted disposal of solid waste management plans; authorizes county courts to provide solid waste management systems.

Solid Waste Facilities and Finance Authorization Act, Act 238 of 1971, authorizes counties and municipalities to use available revenues for establishment of solid waste disposal systems, to impose rates and discharges, to issue bonds, and to prescribe regulations for refuse disposal.

Arkansas Hazardous Waste Act, Act 406 of 1979, establishes a program of regulation over the generation, storage, transportation, treatment, and disposal of hazardous wastes.

Joint County and Municipal Solid Waste Disposal Act, Act 699, authorizes counties and municipalities to participate in the joint construction, operation, and maintenance of facilities for disposal of solid waste and authorizes the creation of sanitation authorities to issue bonds for financing costs of solid waste management systems.

GROUND WATER PROBLEMS

Major Aquifers

Quaternary Aquifer

Declining Water Levels

No major problems which relate to declining water levels presently exist in the Quaternary aquifer within the basin. Between 1975 and 1980, a water level decline rate of about 0.4 feet per year has been measured in one Little River County observation well. (See Table 4-7) During the 1980 to 1985 period, two Little River County observation wells showed an average annual rise in water levels of 0.4 and 0.21 feet per year. (Table 4-7) The ten year records from 1975 to 1985 indicate that water levels in the Quaternary remained essentially static. Figure 4-5 shows the aquifer hydrograph for one observation well completed in the Quaternary.

In summary, declining water levels are not a current significant problem in the basin Quaternary aquifer.

TABLE 4-7: WATER LEVEL CHANGES IN THE QUATERNARY DEPOSITS WITHIN THE BASIN (feet)

County	Number of Wells	1975-1980		1980-1985		1975-1985	
		Net	Annual	Net	Annual	Net	Annual
Little River	1	-1.78	-0.36	+1.07	+0.21	-0.71	-0.07
Little River	1	1/	1/	+2.02	+0.40	1/	1/

1/ Data not available.

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975-1985 <71>

Quality Degradation

Water from the Quaternary aquifer is a calcium bicarbonate type and is generally suitable for irrigation at the present time. Because of the high degree of hardness and iron content however, the water is not suitable for most municipal and industrial uses without treatment. Chemical analyses of the alluvial aquifer show that hardness content averages about 385 mg/l. <75> (A hardness content exceeding 180 mg/l is considered hard water) In addition, water from the Quaternary aquifer averages about 2.3 mg/l of iron concentration which far exceeds the U.S. Environmental Protection Agency's national secondary drinking water maximum of 0.3 mg/l. <75>

Since water levels in the Quaternary aquifer are essentially static in the basin, water quality is not expected to greatly deteriorate beyond the present conditions. Continued treatment will be required for municipal and industrial uses and for most domestic uses.

Cretaceous Rocks (Nacatoch Sand)

Declining Water Levels

No significant problems relating to declining water levels presently exist in the Nacatoch Sand formation within the basin. This aquifer is not considered a principal source of ground water for use in the basin, yielding only a total of 0.3 MGD. From one observation well located in northern Miller County, the average annual water level decline was 0.19 feet during the period 1975 to 1985. (See Table 4-8) From 1980 to 1985, the average water level increased at the rate of 0.48 feet per year. For the ten year period 1975 to 1985, the water level increased an average of 0.14 feet per year. (Table 4-8) Figure 4-5 shows the aquifer hydrograph for one observation well completed in the Nacatoch Sand. Since basin ground water use from the Nacatoch Sand is not expected to significantly increase, declining water levels should not develop as a problem.

TABLE 4-8: WATER LEVEL CHANGES IN THE NACATOCH SAND WITHIN THE BASIN (feet)

County	Number of Wells	1975-1980		1980-1985		1975-1985	
		Net	Annual	Net	Annual	Net	Annual
Miller	1	-0.95	-0.19	+2.39	+0.48	+1.44	+0.14

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975-1985 <71>

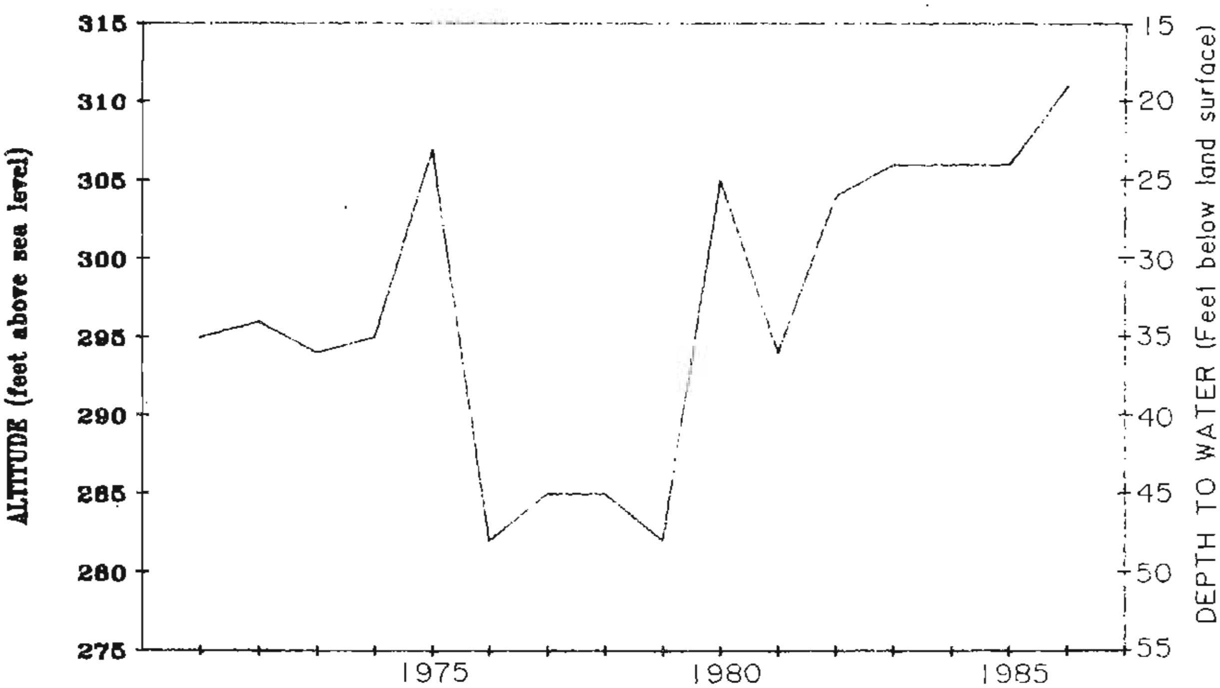
Quality Degradation

As previously stated, the Nactoch sand yields a moderately soft alkaline water with differing mineral content according to well location. The Nacatoch Sand yields water to wells in very limited areas of the basin, primarily in extreme southeast Little River County and northwest Miller County.

Isochlors contoured east and west of equal parts per million (ppm) of chloride for water from the Nacatoch Sand indicate that the water is generally too salty for most uses only a few miles downdip from the outcrop. The change between fresh water and salt water (250 ppm of chloride is the maximum for secondary drinking water) is often sharp, going from 100 ppm to 1,000 ppm of chloride in about four miles. However, the quality of presently available fresh water in the Nacatoch Sand is not likely to change significantly by continued use at the current rate.

Figure 4-5

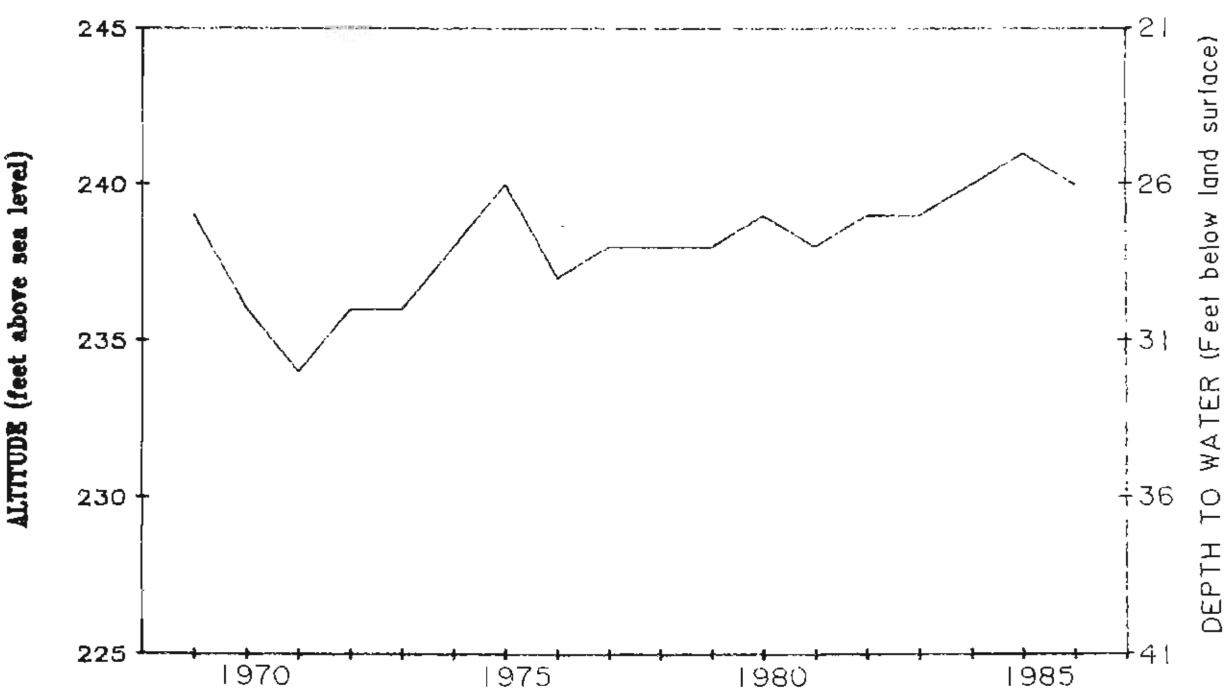
AQUIFER HYDROGRAPH FOR WELL COMPLETED IN THE QUATERNARY DEPOSIT



WELL NUMBER 13S29W05ABC LITTLE RIVER COUNTY

Source: U.S. Geological Survey, File Data.

AQUIFER HYDROGRAPH FOR WELL COMPLETED IN THE NACATOCH SAND



WELL NUMBER 14S28W13CCB MILLER COUNTY

Source: U.S. Geological Survey, File Data.

Cretaceous Rocks (Tokio Formation)

Declining Water Levels

The Tokio Formation yields about 1.5 MGD of ground water for use primarily in southeastern Sevier and Howard Counties. Total ground water use in the basin from the Tokio Formation increases at an average annual rate of about four percent. Since yields from this formation are limited, increased withdrawals will have some affect on the water levels. From two observation wells in Howard County, the average rate of water level decline from 1975 to 1980 was 0.06 feet per year. (See Table 4-9) The average rate of water level decline increased to 0.29 feet per year during the period 1980 to 1985. The average ten year water level decline from 1975 to 1985 was 0.18 feet per year. Figure 4-6 shows the aquifer hydrograph for one observation well completed in the Tokio Formation within the basin. Withdrawals from the Tokio Formation are not expected to increase at a rate high enough to develop severe declining water level problems in this basin.

TABLE 4-9: WATER LEVEL CHANGES IN THE
TOKIO FORMATION WITHIN THE BASIN
(feet)

County	Number of Wells	1975-1980		1980-1985		1975-1985	
		Net	Annual	Net	Annual	Net	Annual
Howard	2	-0.29	-0.06	-1.47	-0.29	-1.75	-0.18

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975-1985 <71>

Quality Degradation

The quality of water from the Tokio is fairly uniform. In general, it is soft water being moderately high in sodium bicarbonate and sodium sulfate. Isolated problems exist where iron content greatly exceeds the secondary drinking water standard. The chloride increases gradually downdip except for an area in southern Sevier County and northern Little River County where an abrupt rise in chlorides occur.

Since withdrawals from the Tokio are essentially self-limiting, water quality is not presently a serious problem nor is a serious problem expected to develop.

Cretaceous Rocks (Trinity Group Undifferentiated)

Declining Water Levels

From Table 4-10, water levels have increased during the period 1980 to 1985 in three observation wells. Although levels declined during the period 1975 to 1980 at an average rate of 0.89 feet per year, the ten year period, 1975 to 1985, shows an overall increase of water levels at an average rate of 0.1 feet per year. In 1980, the Trinity yielded 1.24 MGD for use in the basin. This represents an increase of 0.29 MGD over the use in 1975 or an average increase of about six percent per year.

Declining water levels of the Trinity are not considered a current problem in the basin nor is it expected to become a problem. Figure 4-6 shows the aquifer hydrograph for one well completed in the Trinity within the basin.

TABLE 4-10: WATER LEVEL CHANGES IN THE TRINITY GROUP WITHIN THE BASIN (feet)

County	Number of Wells	1975-1980		1980-1985		1975-1985	
		Net	Annual	Net	Annual	Net	Annual
Sevier	3	-4.43	-0.89	+5.46	+1.09	+1.03	+0.10

Source: U.S. Geological Survey, Ground Water Levels in Arkansas, 1975-1985 <71>

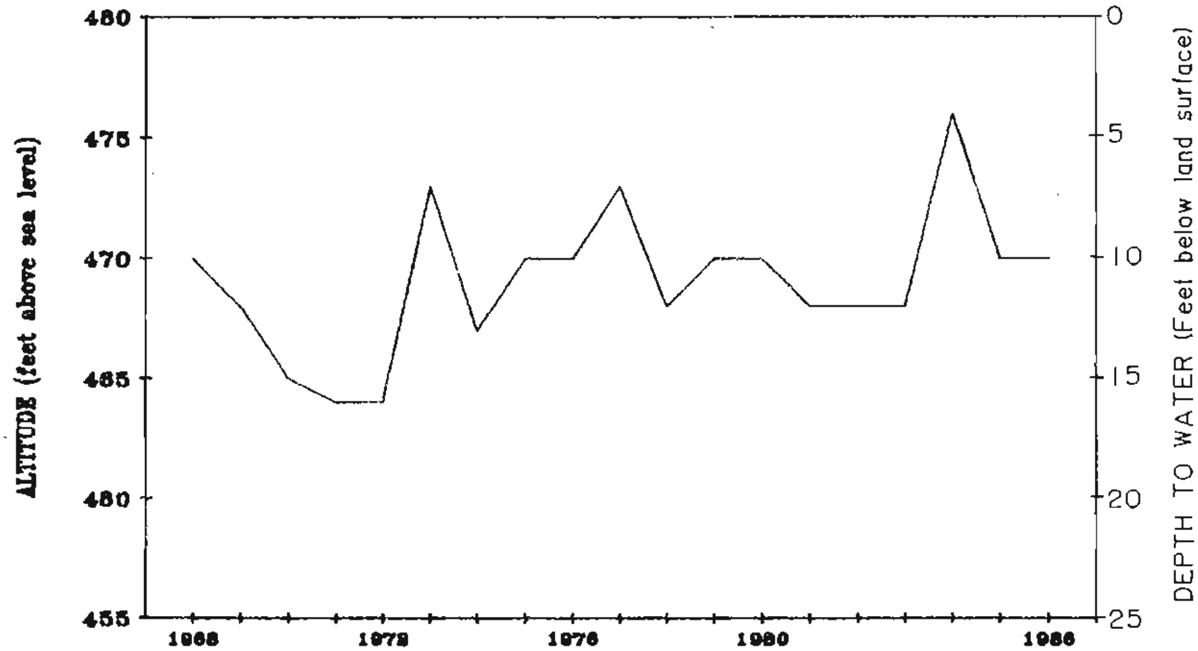
Quality Degradation

Some treatment of most of the ground water withdrawn from the Trinity Group is required for municipal and industrial use. The treatment required and the limited supply of ground water available from the Trinity has forced growing towns in the basin to develop, or plan to develop, surface water systems for public use.

During the period 1975 to 1980, use of ground water from the Trinity increased slightly for rural and domestic, and public supply. However, water quality did not appreciably deteriorate and quality degradation is not expected to develop as a more significant problem than currently exists.

Figure 4-6

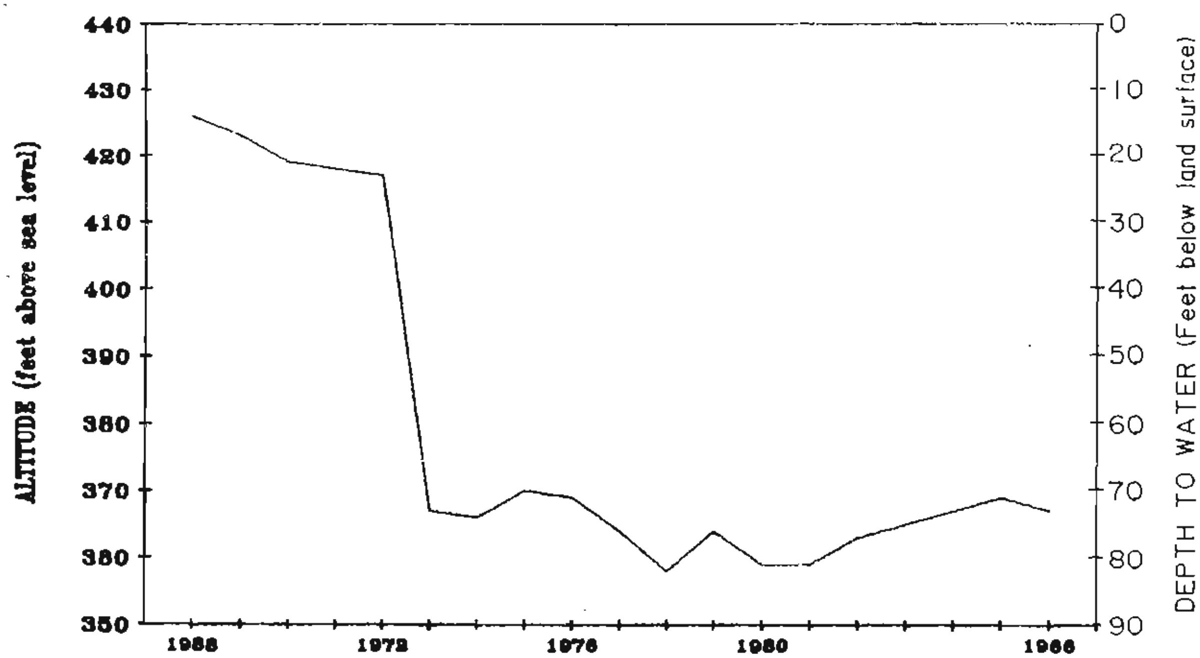
AQUIFER HYDROGRAPH FOR WELL COMPLETED
IN THE TOKIO FORMATION



WELL NUMBER 9S28W20DAC HOWARD COUNTY

Source: U.S. Geological Survey, File Data.

AQUIFER HYDROGRAPH FOR WELL COMPLETED
IN THE TRINITY FORMATION



WELL NUMBER 9S30W23BDD LOCKSBURG, SEVIER COUNTY

Source: U.S. Geological Survey, File Data.

Paleozoic Rocks

Ground water in the Paleozoic rocks is usually found in the sandstones and shales and solution openings in the limestones and dolomites. Although these rocks are locally important as a source of water for many rural homes in the basin, sufficient quantities to support M&I requirements are rarely found. Wells average about 150 feet in depth and generally yield less than 10 GPM. It is possible to drill 1,000 feet or more in these rocks without obtaining a good supply of water.

There are no observation wells available in the Paleozoic rocks for determining changes in water levels. However, it is generally known by users of ground water of the Paleozoic that only limited supplies are available. Water from the Paleozeic rocks is primarily a mixed calcium and sodium bicarbonate type and chemically suitable for most rural and domestic purposes. There is not enough data available to conclude that water quality of the Paleozoic rocks is degrading within the basin.

Critical Use Areas

The criteria for critical ground water use areas for aquifers under water table conditions are: (1) water levels have been reduced such that 50 percent or less of the formation thickness is saturated; and/or (2) average annual water level declines of one foot or more occur the preceding five years; and/or (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.

The criteria for critical ground water use areas in artesian aquifers are: (1) potentiometric surface is below the top of the formation; and/or (2) average annual water level declines of one foot or more occur for the preceding five years; and/or (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.

The Quaternary aquifer and Paleozoic rocks are under water table conditions. The Tokio Formation, Nacatoch Sand and Trinity are under artesian conditions.

Observation wells and other data available in the basin indicate that none of the basin ground water groups or formations are critical areas based on water level declines exceeding defined limits.

The potentiometric surface is not below the top of the formation in the Quaternary aquifer or the Paleozoic rocks. Water levels have not been reduced to 50 percent or less of the formation thickness in the Tokio Formation, Nacatoch Sand or Trinity Group. <57>

There are no trends developing indicating that future water quality degradation will restrict the use of ground water to a greater extent than currently exists. Under present conditions, there are no critical areas of ground water in the basin.

POTENTIAL GROUND WATER PROBLEMS

Approximately 11 MGD was obtained from ground water in the basin during 1980. This represents about 12 percent of the total water used in the basin. About 30 percent of the total ground water used was withdrawn from the Quaternary aquifer for irrigation in Little River County in the Red River vicinity. The remaining 70 percent was used for rural, domestic, and limited public supply. Generally, in this basin, if quantities of ground water needed exceeds 50,000 gallons per day, the potential user will be restricted to developing surface water supplies. If the amount of ground water required is less than 50,000 gallons per day, and the user can tolerate the raw water or pay for treatment, then ground water should be considered a potential source of supply.

Most large established communities and towns in the basin have abandoned the use of wells as a primary source of public supply and are using or planning to use surface water. Since ground water supplies are known to be limited in the basin, potential developers can initially seek alternative sources of water if necessary.

The most serious potential problem for ground water in the basin is contamination from several sources. Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground water system. Therefore, the potential for contamination is closely related to the recharge rate. <49> Generalized recharge zones and potential ground water contamination sources are delineated on Figure 4-7.

Sources of high potential ground water contamination in the basin include landfills, hazardous waste, improperly constructed and abandoned wells, and surface impoundments (waste holding). Additional sources of potential ground water contamination include storage tanks, septic tanks, waste injection wells, and wastes spilled during transport.

Landfills

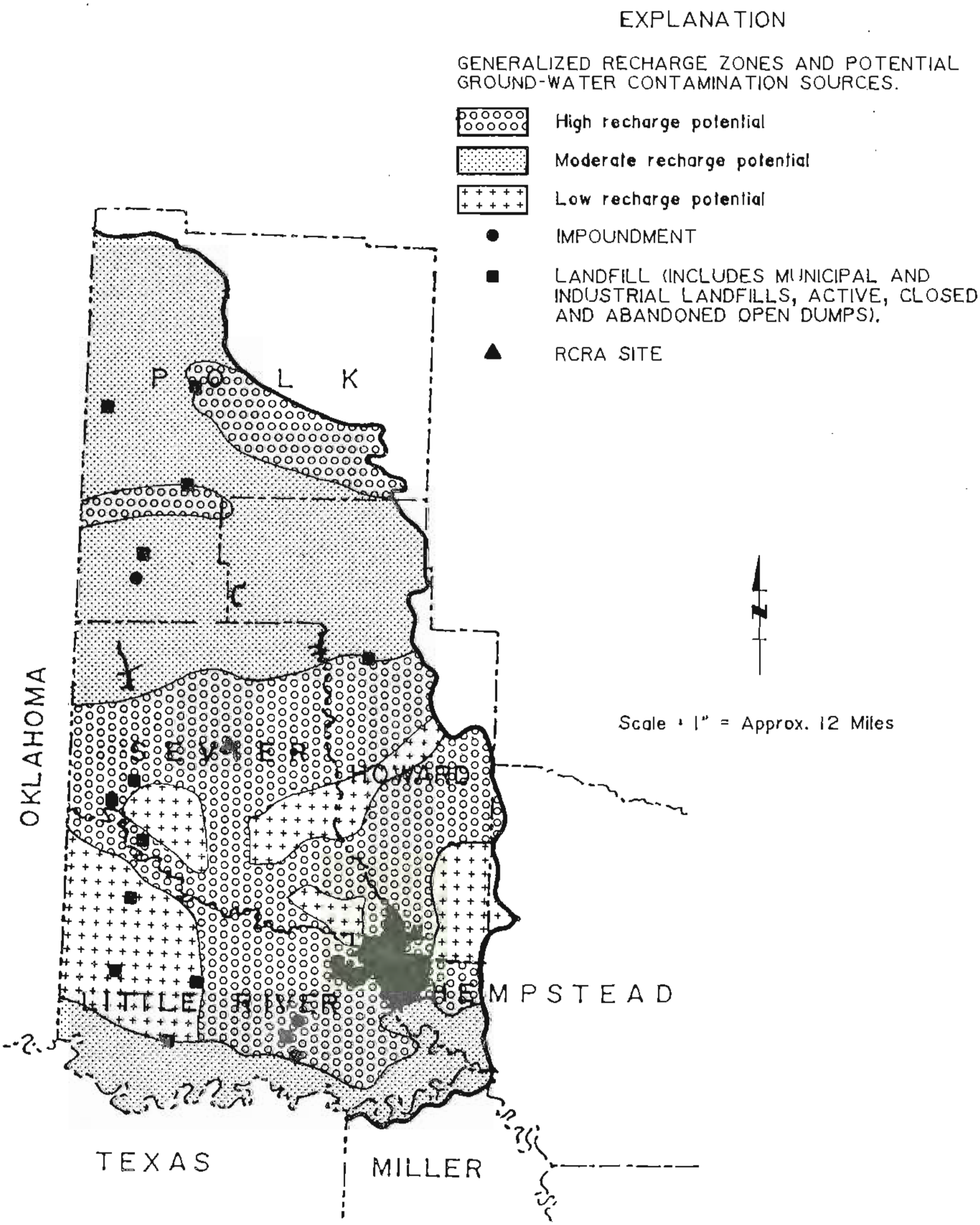
Many open landfills and dumps exist in the basin. The contents of many of these fills are basically unknown. Some have remained as open dumps while others are sanitary landfills. Hazardous materials that could eventually percolate into the aquifer may be stored in these areas. <49> Known landfills are shown in Figure 4-7.

Hazardous Waste

Hazardous materials generated or stored in the Red River Basin above Fulton exceeded 100 tons in 1982. <57> There are more than 340 landfills in Arkansas of which 13 are located in the Red River Basin above Fulton. Some landfills are covered by the Resource Conservation and Recovery Act (RCRA). RCRA sites are those where hazardous wastes are treated under authorization of regulatory agencies. These sites require permits to operate and, in some cases, ground water monitoring is required. There are 16 RCRA sites in Arkansas, one of which is located in the basin near DeQueen in central Sevier County. <49>

Figure 4-7

POTENTIAL GROUND WATER PROBLEMS



Source : USGS - modified from C. T. Bryant, A. H. Ludwig, and E. E. Morris, <49>

Improper Well Construction and Abandonment

No known producing oil and gas wells exist in this basin.

The authority to regulate the construction of water wells is vested in the Water Well Construction Committee. The Committee licenses water well contractors, provides drilling rig permits, and tests and registers water well drillers. The Committee also conducts hearings on well drillers' complaints concerning improper construction practices.

The problems center around enforcement of existing legislation concerning proper construction techniques and changing the law to address and alleviate current and potential problems. All well drillers are required to submit a construction report within 30 days after the completion of a well. It has been estimated that approximately one half of all wells drilled in certain areas of the state do not have construction reports on file.

The Committee has a staff of two people to maintain files, investigate complaints, inspect or enforce regulations, and perform necessary administrative functions required of a state committee. Lack of time and funds hinders the enforcement of well construction regulations and is creating resentment among contractors who are finding it difficult to compete with contractors who are cutting corners.

The escalating incidence of heat pump installation by drillers is a potential problem of unknown proportions. To date, this type of installation is not controlled by the Water Well Construction Committee. The variety of different heat pump systems aggravates the problem. Some systems use a single water well for withdrawing water to be circulated through a heat exchanger and then discharge the water out on the ground; others use 2 wells, 1 for withdrawal and 1 for injection. Other variations include closed loop systems where ground water circulates through field lines or a heat exchanger down in the well itself. Since the potential for contamination of ground water exists from these systems, regulations to insure that the well construction phase of installation is conducted properly are necessary.

Surface Impoundments (Waste Holding)

Regulatory control over impoundments receiving waste materials in Arkansas is primarily vested in the Arkansas Department of Pollution Control and Ecology. The Department of Pollution Control and Ecology operates under authority of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended), which confers broad powers of regulation and enforcement to the agency. The Arkansas Hazardous Waste Management Act (Act 406 of 1979) has direct applicability to surface impoundments holding toxic wastes but brine is not considered to be hazardous. This Act, which is to be enforced through the ADPC&E, requires permits for the construction, alteration and operation of hazardous waste treatment or disposal facilities or the storage of hazardous wastes.

The best available source of information on pits, ponds, and lagoons in the Red River Basin above Fulton is the Surface Impoundment Assessment (SIA) funded by ADPC&E and conducted in Arkansas in 1978 and 1979 by the Arkansas Soil and Water Conservation Commission and the Soil Conservation Service.

The study found 7,640 impoundments at 872 sites in the state of which three sites are located in the Red River Basin above Fulton. ADPC&E then selected 506 impoundments for assessment of pollution potential. <16> About 10 percent of the industrial sites have monitoring wells and less than 2 percent of the municipal sites assessed have monitoring wells. The fact that 95% of the sites on which information was available have no monitoring wells attests to the need for a strategy for developing a statewide monitoring system. <16>

Surface impoundments have been constructed in localities throughout the state and many where ground water is not protected by an impermeable surface layer. Some unlined ponds have been constructed at sites which apparently are potentially hazardous because of the lack of natural protection. A more detailed investigation at each site would be required to quantify the validity of this concern. About 78 percent of the impoundments surveyed reported no liner, 95 percent have no monitoring wells, and 32 percent are within 1 mile of a well used for drinking water. <16>

The lack of attention to ground water protection is reflected in the few state and federal programs which regulate construction and modification of waste holding impoundments in the state. Several state agencies are empowered to issue and enforce orders to abate pollution, and in the past, such orders have been issued in cases of reported ground water pollution, but effective preventive programs have not been developed. To prevent pollution of ground water from waste holding impoundments a unified program is needed which includes ground water quality management practices, proper siting and construction requirements, and site surveilance of ground water.

LEGAL AND INSTITUTIONAL PROBLEMS

Public Supply Systems

Many Arkansas communities have water supply systems which are improperly maintained and operated. The 1980 drought caused a vast majority of the State's public water systems to reach record demands. The heavy consumption placed an unexpected strain on existing sources, pumps, treatment facilities and distribution systems. Many customers experienced service interruptions due to an inadequate source, pump failure, single well systems, inadequately trained personnel and systems with undersized pipes. During this time period, five water systems in the state were forced to haul water to meet demands, and the Arkansas Department of Health issued boiling orders for water systems suspected of contamination when pressure losses occurred.

In addition, many water systems managers had to impose voluntary or mandatory water conservation practices. The extreme climatic conditions of the summer of 1980 focused attention on the importance of proper planning, operation, and maintenance of water systems. Due to a lack of sufficient funds, many small water systems have only a part-time operator and excessive personnel turnover is a common problem. Needed operation and maintenance is minimally performed, resulting in costly water projects having a shortened operational life.

Many of the public water supply systems do not have backup wells for use during periods when repairs are being made on their equipment. In addition, there is insufficient storage to supply the sustaining needs of their customers. There are 10 public water supply systems in the basin, most of which are one well systems. <14>

Ground Water Use Data

Various state and federal agencies have limited authority over ground water. This has resulted in several different ground water data bases, each slightly different in nature, and reflecting the authority and interest of the individual agency. The problems stem from various sources, including conflicting data and estimation methodology that has to be utilized in lieu of legislation that would require ground water users to report their actual use on an annual basis. The best source for data on the quantity of ground water withdrawn is from the U.S. Geological Survey and the Arkansas Geological Commission. Heavy reliance on many agencies, organizations, industry and individuals to report their use of data causes delays in compilation, adjustments, and interpretation of these data.

Consequently, the U.S. Geological Survey publications on water use run approximately two years behind. In order for current issues to be addressed properly, data of ground water must be made available with much less time lag between actual use and published use reports.

Ground Water Quality Data

For ground water quality data, one of the best sources is the Chemical Data, 1982, released by the Arkansas Health Department about every two years. It includes chemical analysis of samples submitted every three years by cities or communities using public water supplies. Similar chemical analyses are done by the University of Arkansas Cooperative Extension Service for farmers who provide irrigation well samples to their county agents.

A computer printout of these analyses is available from the University of Arkansas Extension Office. Additional chemical data from the sampling stations of the U.S. Geological Survey is presented in the publication entitled Water Resources Data for Arkansas, 1981, published annually. These analyses are also placed in the Federal computer system and STORET.

Another data source on the quantity and quality of ground water in the state is in the ADPC&E publication, Nonpoint Source Pollution Assessment Summaries, 1979, for each of the five major river basins in the state. This can be supplemented with the ground water section of ADPC&E's, Arkansas Water Quality Inventory Report, 1982, which also summarizes recent reports issued by the Soil and Water Commission, the United States Geological Survey and the ADPC&E. The State Water Plan of 1975, produced by the Arkansas Soil and Water Commission contains much information on municipal supplies.

In addition, valuable ground water use and quality data are scattered throughout the numerous reports published by the U.S. Geological Survey and the Arkansas Geological Commission. The Arkansas Water Resources Research Center also publishes studies dealing with all aspects of ground water.

Problems associated with gathering information on gound water stem mainly from data accessibility. Data entry commonly runs far behind data gathering. Many data bases are not compatible from agency to agency. In-house terminal link-ups, or a central data base system to share information are needed among ADPC&E, U.S. Geological Survey, and Arkansas Department of Health. Efforts are underway to have all the quality data from state and federal agencies centrally located at U.S. Geological Survey offices in Little Rock.

The time and effort required to secure the needed information from scattered files seems prohibitive and not cost effective. These sources possess valid, reliable and accurate data but the data is currently not directly accessible by enough state and federal agencies.

GROUND WATER PROBLEMS, SOLUTIONS, AND RECOMMENDATIONS

Problems

Although ground water levels are not declining in most aquifers, ground water supplies are limited throughout the Red River Basin above Fulton due primarily to natural geologic constraint. Towns, industries, and rapidly growing communities with ground water quantity demands exceeding 50,000 gallons per day have been forced to seek alternative water supply sources. Several suitable reservoirs and streams located in the basin have available storage or discharge for use as water supply sources. Some towns have been able to finance the transporting and treatment of surface water for use as a public water source while other towns as yet cannot afford the large initial cost.

Quality of ground water varies in the basin but in many areas presents a problem for users. The Quaternary aquifer yields water that is soft to very hard and has a high concentration of iron. The water can generally be used for irrigation but must be treated for human consumption.

Ground water yields from the Tokio Formation and Nacatoch Sand aquifer are of fair quality but chloride concentrations increase abruptly from 2 to 20 miles downdip of the outcrop precluding further use of the water.

Solutions and Recommendations

Nonstructural solutions for the conservation of ground water and improvement of water quality include: (A) Conservation; (B) Best Management Practices; (C) Incentives; (D) Research; (E) Ground Water Use Data; and (F) Reduced Aquifer Contamination Potential.

(A) Conservation: Many studies in other parts of the United States have documented up to 40 percent savings in efficiency and reduction of losses and waste by utilizing data obtained from studies of various application techniques, pumping plant efficiency tests and soil moisture monitoring. Additional monitoring of ground water levels in wells and more data on stream-aquifer connections are needed to develop ground water conservation programs.

(B) Best Management Practices (BMP): B.M.P.'s as outlined in the surface water chapter will also conserve the quantity and quality of ground water available in the basin. Surface water and ground water systems are interconnected and what happens on the land surface will affect, if not determine, ground water availability and quality.

(C) Incentives: Although not a current serious problem in this basin, ground water overdraft was addressed in the 1985 General Legislative Session with passage of Act 417, 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 were not available in sufficient quantities and quality 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 use.

Tax credits cannot exceed 50 percent of the actual construction costs for impoundments or $3,000 annually for a period of 11 years. The impoundment or water control structure must store a minimum of 20 acre-feet and be used for the production of food and fiber as a business or for industrial purposes. This would include rice, wheat, soybeans, cotton, corn, milo, fruit, and vegetable crops and domestic uses. The Arkansas Soil and Water Conservation Commission will administer the program within the existing Dam Safety and Water Rights Division. All plans, designs, and specifications must be submitted to the Commission for approval. If acceptable, a "certificate of tax credit approval" will be issued as proof of eligibility.

Conservation Credits are limited to 10 percent of the actual cost of abandoning or reducing the extraction of ground water and utilizing surface water as an alternative. Applicants must furnish proof to the Commission that ground water was being used previously and eligible equipment and construction costs will directly reduce the quantity of ground water withdrawn. The specific rules and regulations for eligibility in both programs can be obtained from the Arkansas Soil and Water Conservation Commission.

(D) Research: In 1985, Act 816 was passed which provided $200,000 for water related research. The money will be made available for a 2-year period ending June 30, 1987. An amount of $60,000 annually will be used to contract for modeling and continuing research on conjunctive use of ground water and surface water. The results and techniques developed from this research will be made available to water users.

(E) Ground water Use Data: The problems of time lag with ground water use data could be lessened with the passage of Act 1051 of 1985. The mandatory reporting of all ground water use by quantity, location, type of use and name of user on an annual basis is now state law. The exceptions are wells of 5" or less inside diameter or those used for domestic purposes.

Reporting of use will be on the same form and time frame as Surface Water Diversion Registration is today. Inaccurate reporting of ground water use can be avoided by the use of flowmeters made available through the Eastern Arkansas Water Conservation Project. Users can have their pumping plants rated at 1/4, 1/2, 3/4, and full throttle (diesel units) and keep records of the time that a particular rate of flow occurred. Electric bills can be used to determine flow rates for electric powered pumps. The use of flowmeters to rate pumps, such as tailwater recovery pumps, powered by internal combustion engines, will also reduce the error in reporting surface water use.

(F) Reduced Aquifer Contamination Potential: In 1982, a report was published by the Wright-Pierce Engineering Firm of Topsham, Maine. The report established criteria for siting impoundments and landfills of hazardous and non-hazardous waste and indicated areas highly vulnerable due to permeability and posing a significant threat to ground water quality. The report outlines in detail, the siting criteria that should be required by ADPC&E. The nature of unconsolidated lensed formations in the basin requires each site to be physically inspected and adequately evaluated.

Adequate staffing to inspect these sites and analyze the soils underneath would prevent ADPC&E from relying on reports supplied by firms applying for the permits. The Wright Pierce Report should be adopted as the official criteria for impoundments and hazardous and non-hazardous waste disposal.

Under the RCRA Program, all open dumps should be upgraded to sanitary landfills. This upgrading would provide a data base for further control. Impoundments holding hazardous waste could be controlled by the permit process of site evaluation. If the program was properly administered, the danger of ground water contamination from hazardous wastes should no longer be a significant threat in the State. Although it will be several years before the program is fully implemented, the "interim status" requirements for permit applicants will provide some control on the impoundments as the program progresses.

For impoundments containing non-hazardous materials, the state still must exercise some initiative in developing programs of control but can request funds in support of such projects through the Solid Waste Management Program of RCRA or the Water Quality Management Program under the Clean Water Act. All such impoundments should be permitted. This program could be used to contribute to the overall protection of ground water by limiting the quantities of brine held in surface impoundments in the basin. ADPC&E is currently updating information on the location and nature of surface holding impoundments in the basin.

Programs that could result in increased ground water protection are hindered by inadequate funding and staffing of state offices. The addition of any new commitments to ground water protection will require increased staffing and considerable financial, legislative, and public support.

The major emphasis in the past has been on surface water contamination and the result has been Federal Legislation to control the nature and extent of same. Commonly, ground water protection has occurred as a spinoff of surface water pollution regulations. This approach is inadequate to protect ground water resources. The requirements for ground water protection that do exist are too easily ignored and underfunded when they are secondary components of larger programs. Accountability for ground water protection is too easily hidden among plans for protection of surface waters.

Legal and Institutional

Public Supply Systems

Act 406 of 1985 was passed to make an appropriation to the Arkansas Soil and Water Conservation Commission to contract with the Arkansas Rural Water Association to provide technical assistance and training to the water systems operators in the state. For the biennial period ending June 30, 1987, $50,000 will be available to provide an additional circuit rider to investigate complaints, problems, or inspect water systems. The Circuit rider will be an experienced, licensed operator that can assist with accounting procedures, inventory, maintenance, and management problems. This program will complement the Arkansas Department of Health's training and licensing program for water system operators. The Health Department's training and short courses have approximately 2,000 to 3,000 graduates a year. Training of water system operators is essential but the value of a circuit rider to help operators with specific on-site problems is invaluable. These programs by the Arkansas Soil and Water Conservation Commission and the Arkansas Department of Health will hopefully aid in reducing costly errors in operations, maintenance and management of rural and municipal water supply systems.

Improperly Constructed and Abandoned Wells

In the 1985 legislative session, new laws were passed that will help alleviate some of the problems concerning improperly constructed and abandoned wells.

Water Wells

The objective of Act 783 of 1985 was to amend section 14 of Act 641 of 1979 to increase certain fees levied and to provide funds for the administration of the Water Well Construction Act by the Water Well Construction Committee. New fees are as follows: (A) Certificate of registration - $70, (B) Contractors license - $200 and (C) rig permits - $80. Additional funding provided by this Act will offset costs due to inflation, expanded duties by the committee and pay increases to personnel.

Act 822 of 1985 addressed heat pump well construction practices. The objective of the law was to provide the Water Well Construction Committee with regulatory control for wells drilled for the purpose of ground water source heat pump installations. The definition of "water well" in Act 641 of 1969 was amended to include excavations made for the purpose of exchanging geothermal energy found in the earth, termed heat pump wells.

Heat pump wells were defined as any excavation that is drilled, redrilled, cored, bored, washed, driven, dug, jetted or otherwise artifically constructed for the purpose of obtaining or exchanging geothermal energy for use with ground water source air conditioning or heat pump systems. The excavation may have pipes installed inside the excavation to circulate or discharge various fluids and the well may or may not be backfilled after excavation.

This Act will regulate the heat pump well drillers to the same degree as water well drillers. The same construction and abandonment procedures will apply to wells for heat pump sources as those wells for water supply. This should reduce the potential for contamination from heat pump systems that has been previously unregulated.

DEFINITIONS

ALLUVIUM: Earth, sand, gravel, and other transported matter which has been deposited by rivers. Usually a good, porous storage medium for ground water.

AQUIFER: A water-bearing layer of rock that will yield water in a usable quantity to a well or spring.

BEDROCK: A general term for the consolidated (solid) rock that underlies soils or other unconsolidated surficial material.

BEST MANAGEMENT PRACTICE (BMP): A practice or practices that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

CONE OF DEPRESSION (Or drawdown cone): A conical concavity (or dimple) in the potentiometric surface around a pumping well caused by the withdrawal of water.

CONFINED (or artesian) AQUIFER: An aquifer that is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

CONFINING BED: A body of "imperishable" material stratigraphically adjacent to one or more aquifers, the hydraulic conductivity of which may range from nearly zero to some value distinctly lower than that of the aquifer. Synonyms: aquitard; aquiclude; and aquifuge.

CONSUMPTIVE USE: Use of water in a manner that makes it unavailable for use by others because of absorption, evaporation, transpiration or incorporation in a manufactured product. In some instances, when water is returned to a stream at a distance downstream from the point of diversion, the use may be consumptive as to users immediately below the point of diversion but nonconsumptive as to users below the point where the water is returned.

CRITICAL GROUND WATER AREAS

Water Table Condition: Water levels have been reduced such that 50 percent of the thickness of the formation, or less, is saturated; and/or average annual declines of one foot or more have occurred for the preceding five years; and/or 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 Condition: Potentiometric surface has declined below the top of the formation; and/or average annual declines of one foot or more have occurred for the preceding five years; and/or groundwater 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.

CRITICAL SURFACE WATER AREA: 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.

DATUM PLANE: An arbitrary surface (or plane) used in the measurement of ground water heads. The datum most commonly used is the National Geodetic Vertical Datum of 1929, which closely approximates sea level.

DEPENDABLE WATER SUPPLY: The amount of water of desired quality that can be expected to be available at a given point a stated percentage of the time.

DISCHARGE: Outflow of water from a drainage basin, reservoir of other facility through a channel, pipe or other outlet, including the release of polluted water into a stream or waterbody. Also, the rate of discharge measured in units of volume per unit of time, either for an entire outlet or for a specified cross-sectional area of the outlet.

DRAWDOWN IN A WELL: The vertical drop of the water level in a well caused by pumping.

EROSION: The wearing away of the land surface by the detachment and transport of soil materials through the action of moving water, wind or other geological agent.

EVAPOTRANSPIRATION: Evaporation from water surfaces, plus transpiration from plants.

EXCESS STREAMFLOW: 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.

FAULT: A fracture in the Earth's crust accompanied by displacement of one side of the fracture with respect to the other.

FRACTURE: A break in rock that may be caused by compressional or tensional forces.

GROUND WATER: Water in the saturated zone that is under a pressure equal to or greater than atmospheric pressure.

GROUND WATER, CONFINED: Ground water which is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

GROUND WATER, PERCHED: Unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table.

GROUND WATER, UNCONFINED: Water in an aquifer under atmospheric pressure that has a water table and is free to rise and fall.

HEAD (or static head): The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.

HYDRAULIC CONDUCTIVITY: The capacity of a rock to transmit water. It is expressed as the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

HYDRAULIC GRADIENT: The change in static head per unit of distance in a given direction. If not specified, the direction generally is understood to be that of the maximum rate of decrease in head.

HYDROLOGIC CYCLE: The constant movement of water in the atmosphere and on and beneath the earth's surface.

INFILTRATION: The movement of water from the earth's surface into the soil zone.

INSTREAM FLOW REQUIREMENTS: The flow regime which will best meet 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 irrigatlon, municipal and industrial water supply, and cooling water.

INTERBASIN TRANSFER: The physical conveyance of water from one watershed to another.

IRRIGATION SCHEDULING: The process that enables an irrigator to apply irrigation water in the proper amounts and at the proper time to efficiently alleviate moisture shortages.

MINIMUM STREAMFLOW: The lowest daily mean discharge that will satisfy minimum instream flow requirements. The minimum streamflow represents the discharge at which all withdrawals from the stream will cease.

NONCONSUMPTIVE USE: Use of water with return to the stream or waterbody of substantially the same amount of water as withdrawn. A use in which only insignificant amounts of water are lost by evapotranspiration or incorporation in a manufactured product.

NONPOINT SOURCE: The entry of a pollutant into a body of water in a diffuse manner with no definite point of entry and where the source is not readily discernable.

PERCOLATION: Movement under hydrostatic pressure of water through the openings of rock or soil, except movement through large openings such as caves.

PERMEABILITY: A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient.

pH: A measure of the relative acidity of water. Below 7 is increasingly acid, 7.0 is neutral, and above 7 is increasingly alkaline (basic).

POINT SOURCE: The release of a pollutant from a pipe or discrete conveyance into a body of water or a watercourse leading to a body of water.

POROSITY: The voids or openings in a rock. Porosity may be expressed quantitatively as the ratio of the volume of openings in a rock to the total volume of the rock.

POTENTIOMETRIC SURFACE: A surface that represents the total head in an aquifer; that is, it represents the height above a datum plane at which the water level stands in tightly cased wells that penetrate the aquifer.

PRIME FARMLAND: Land well-suited to the production of food and fiber. Prime farmland has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when managed according to acceptable farming methods.

RCRA SITES: Resource Conservation and Recovery Act sites where hazardous wastes are treated under authorization of regulatory agencies.

RECHARGE: The entry into the saturated zone of water made available at the water table surface; together with the associated flow away from the water table within the saturated zone.

RECHARGE AREA OR ZONE: That position of a drainage basin in which the net saturated flow of ground water is directed away from the water table.

RECHARGE, ARTIFICIAL: The addition of water to the ground water by activities of man at a recharge rate greater than normal.

RIPARIAN DOCTRINE: The system of law in which owners of lands along the banks of a stream or waterbody have the right to reasonable use of the waters and a correlative right protecting against unreasonable use by others that substantially diminishes the quantity or quality of water. The right is appurtenant to the land and does not depend upon prior use.

RIPARIAN RIGHTS: The rights accompanying ownership of land along the bank of a stream or lake under the riparian doctrine.

RUNOFF: (1) That portion of precipitation which does not return to the atmosphere through evapotranspiration nor infiltrate the soil to recharge ground water, but leaves the hydrologic system as streamflow; also (2) that portion of precipitation delivered to streams as overland flow to tributary channels.

ROCK: Any naturally formed, consolidated or unconsolidated material (but not soil) consisting of two or more minerals.

SAFE YIELD:

Surface Water: The safe yield of a stream or river is the amount of water that is available on a dependable basis which could be used as a surface water supply. The safe yield 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 low flow season (July-October).

Ground Water: The safe yield of an aquifer is roughly equal to the recharge rate to the system. Due to the temporal and spatial variability of recharge, the safe yield can most easily be expressed as the quantity of ground water that can be withdrawn while maintaining static water levels over the long term.

SALTWATER INTRUSION (Seawater intrusion): The migration of saltwater into freshwater aquifers under the influence of ground water development (pumping).

SATURATED ZONE: The subsurface zone occurring below the water table where the soil pores are filled with water, and the moisture content equals the porosity.

SHEET AND RILL EROSION: A combined process caused by runoff water, that removes a fairly uniform layer of soil from the land surface and forms many small channels in the land surface.

SOIL: The layer of material at the land surface that supports plant growth.

SPECIFIC CAPACITY: The discharge from a pumping well (the pumping rate) divided by the drawdown in the well; it is a measure of the productivity of a well.

SPECIFIC RETENTION: The ratio of (1) the volume of water which the rock or soil, after being saturated, will retain against the pull of gravity to (2) the volume of rock or salt.

SPECIFIC YIELD: The ratio of (1) volume of water which the rock or soil, after being saturated, will yield by gravity to (2) the volume of the rock or soil.

STORAGE COEFFICIENT: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In an unconfined aquifer, the storage coefficient is equal to the specific yield.

STRATIFICATION: The layered structure of sedimentary rocks.

TRANSMISSIVITY: The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the aquifer thickness.

UNCONFINED AQUIFER: An aquifer in which the upper surface of the saturated zone is free to rise and fall.

UNSATURATED ZONE: The subsurface zone, usually starting at the land surface, that contains both water and air.

WATER TABLE: The level in the saturated zone at which the pressure is equal to the atmospheric pressure.

WATERSHED: The area of contribution to a surface water body or a central discharge point. It is defined by topographic high points.

WATERSHED PROTECTION: Establishing land treatment measures within a particular watershed to reduce erosion, sediment, and/or runoff.

REFERENCES CITED

<1> Arkansas Conservation District File Data, Resource Conservation Act (RCA) Worksheet No. 1, Resource Concerns and Problems, 1978.

<2> Arkansas Department of Health, Division of Engineering, Arkansas Community Water Supplies Chemical Data, 1986.

<3> Arkansas Department of Pollution Control and Ecology, Arkansas Water Quality Management Plan, Chapter 1, May 1979.

<4> Arkansas Department of Pollution Control and Ecology, Arkansas Water Quality Inventory Report, 1984.

<5> Arkansas Department of Pollution Control and Ecology, Arkansas Water Quality Inventory Report, 1986.

<6> Arkansas Employment Security Division, Office of Research and Analysis.

<7> Arkansas Geological Commission, Water Resources Summary No. 7, 1972, Use of Water in Arkansas, 1970.

<8> Bedinger, M. S., and Reed, J. E., 1961, Arkansas Geological Commission Water Resources Circular No. 6, Geology and Groundwater Resources of Desha and Lincoln Counties, Arkansas.

<9> Arkansas Geological Commission, Water Resources Summary No. 9, 1977, Use of Water in Arkansas, 1975.

<10> Halbert, H. N., and Stephens, J. W., 1961, Arkansas Geological Commission, Special Groundwater Report No. 4, Use of Water in Arkansas, 1960.

<11> Halbert, H. N., 1966, Arkansas Geological Commission, Water Resources Summary No. 5, Use of Water in Arkansas, 1965.

<12> Holland, T. W., and Ludwig, A. H., 1981, Arkansas Geological Commission, Water Resources Summary No. 14, Use of Water in Arkansas, 1980.

<13> Arkansas Oil and Gas Commission, Annual Oil and Gas Report, 1977.

<14> Arkansas Soil and Water Conservation Commission, Arkansas State Water Plan, Appendix E, Public Water Supply Inventory, 1978.

<15> Arkansas Soil and Water Conservation Commission, Arkansas Water Law, June 1981.

<16> Chesney, Clay, 1979, Arkansas Soil and Water Conservation Commission, Surface Impoundment Assessment, Arkansas

<17> Arkansas Soil and Water Conservation Commission, Lakes of Arkansas, August 1981 (Revised).

<18> Arkansas Soil and Water Conservation Commission, Nonpoint Source Pollution Assessment Summaries for Red River Basin, Arkansas, June 1979.

<19> Arkansas Waterways Commission, A Report to the Governor and General Assembly, January 1, 1983, to December 31, 1984.

<20> Arkansas-White-Red Basins Water Resources Activities Report, 1986. Prepared for members of AWRBIAC by the Exchange of Program Information Program Committee.

<21> Baker, R. C., and Others, 1948, Groundwater Resources of the El Dorado Area, Union County, Arkansas: University of Arkansas Research Series No. 14.

<22> Filipek, S., Keith, W. E., and Giese, J., 1985, Arkansas Game and Fish Commission, Instream Flow Requirements for Fisheries, Lower Ouachita River Basin, Arkansas, Unpublished Report.

<23> Klein, Howard, Baker, R. C., and Billingsley, G. A., 1950, University of Arkansas Research Series No. 19, Groundwater Resources of Jefferson County, Arkansas.

<24> Oklahoma Water Resources Board, Oklahoma Comprehensive Water Plan, Publication 94, 1980.

<25> Red River Compact Commission, 1984 Report of the Red River Compact Commission, July 1985.

<26> United States Department of Agriculture, Arkansas Agriculture Statistics Service, Arkansas County Estimates.

<27> United States Department of Agriculture, Soil Conservation Service, Arkansas Bulletin No. AR 40-0-6.

<28> United States Department of Agriculture, Soil Conservation Service, Arkansas Statewide Study, Base Report, 1981.

<29> United States Department of Agriculture, Soil Conservation Service, Arkansas Statewide Study - Phase V, June 1983.

<30> United States Department of Agriculture, Soil Conservation Service, Arkansas Watershed Data Listing and Hydrologic Unit Data, 1982.

<31> United States Department of Agriculture, Soil Conservation Service, Arkansas Water Use Study for 50 Arkansas Counties (Special Report), 1980.

<32> United States Department of Agriculture, Soil Conservation Service, Confined Animal Waste Inventory, 1983.

<33> United States Department of Agriculture, Soil Conservation Service, General Soil Map of Arkansas, 1982.

<34> United States Department of Agriculture, Soil Conservation Service, Multipurpose Inventory Instruction Manual, 1981-1982.

<35> United States Department of Agriculture, Soil Conservation Service, National Resources Inventory (NRl) Statistical Tables, 1982.

<36> United States Department of Agriculture, Soil Conservation Service, National Watershed Manual, 1984.

<37> United States Department of Agriculture, Soil Conservation Service, Prime Farmland Map of Arkansas, 1985, Unpublished.

<38> United States Department of Agriculture, Soil Conservation Service, Resource Information Data System (RIDS) File Data, 1977.

<39> United States Army Corps of Engineers, Shreveport Area Office, Red River Construction Contracts in Arkansas, 1980-1986, Correspondence, February 24, 1986.

<40> United States Army Corps of Engineers, Southwestern Division, Water Resources Development in Arkansas, 1981.

<41> United States Department of Commerce, Bureau of the Census, 1980 Census of Population and Housing.

<42> United States Department of Commerce, Bureau of the Census, General Social and Economic Characteristics, Arkansas, 1980.

<43> Climatological Data, Annual Summary, Arkansas, 1984, Volume 89, Number 13.

<44> Climatography of the United States, No. 81 in Arkansas, Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1941-1970, August 1973.

<45> United States Environmental Protection Agency, 1985, Personal Communications: Kenton Kirkpatrick, Deputy Director, Water Management Division.

<46> United States Department of Interior, Bureau of Land Management, 1979, Lakewood, Colorado, Instream Flow Guidelines.

<47> Albin, D. R., 1964, United States Geological Survey, Water-Supply Paper 1779-G, Geology and Groundwater Resources of Bradley, Calhoun, and Ouachita Counties, Arkansas.

<48> Broom, M. E., Kraemer, T. F., and Bush, W. V., 1984, United States Geological Survey, Water Resources Investigations Report 84-4012, A Reconnaissance Study of Saltwater Contaminations in the El Dorado Aquifer, Union County, Arkansas.

<49> Bryant, C. T., Ludwig, A. H., and Morris, E. E., 1985, United States Geological Survey, Water Resources Investigations Report 85-4010, Groundwater Problems in Arkansas.

<50> United States Fish and Wildlife Service, Circular 39, Wetlands of the United States, 1956.

<51> United States Geological Survey, Groundwater Levels in Arkansas, spring 1982, Open File Report 82-852.

<52> United States Geological Survey, Hydrologic Unit Map of Arkansas, 1974.

<53> United States Geological Survey, Quadrangle Sheets.

<54> United States Geological Survey, Water Resources Data Reports, Various Years and States.

<55> Haley, Boyd R., and others, United States Geological Survey, Geologic Map of Arkansas, 1976.

<56> Hunrichs, R. A., United States Geological Survey, Water Resources Investigations Report 83-4063, 1983, Identification and Classification of Perennial Streams of Arkansas.

<57> Ludwig, A. H., 1986, United States Geological Survey, Personal Communication.

<58> Ludwig, A. H., United States Geological Survey Water Supply Paper 1998, Water Resources of Hempstead, Lafayette, Little River, Miller, and Nevada Counties, Arkansas, 1972.

<59> Payne, J. N., 1968, United States Geological Survey Professional Paper 569-A, Hydrologic Significance of the Lithofacies of the Sparta Sand in Arkansas, Louisiana, Mississippi, and Texas.

<60> Riggs, H. C., 1972, United States Geological Survey, Techniques of Water Resources Investigations, Book 4.

<61> Searcy, J. K., 1959, United States Geological Survey Water Supply Paper, 1542-A, 33 P., Flow Duration Curves, Part 2, Low Flow Techniques.

<62> Speer, P. R., Hines, M. S., Calandro, A. J., and others, 1966, United States Geological Survey Professional Paper 448-G, Low Flow Characteristics of Streams in the Mississippi Embayment in Southern Arkansas, Northern Louisiana, and Northeastern Texas.

<63> Tennant, D. L., 1975, United States Fish and Wildlife Service, Billings, Montana, Instream Flow Regimens for Fish, Wildlife, Recreation, and Related Environmental Resources.

<64> Hines, M. S., 1975, Flow-Duration and Low Flow Frequency Determinations of Selected Arkansas Streams; Arkansas Geological Commission Water Resources Circular No. 12.

<65> Tait, D. B., and others, 1953, The Groundwater Resources of Columbia County, Arkansas, A Reconnaissance, United States Geological Survey Circular 241.

<66> University of Arkansas at Little Rock, Research and Public Services, Total Population by Counties, 1890-1960 and 1970-1980.

<67> Counts, H. B., and others, Water Resources Circular No. 2, Groundwater Resources in a part of southwestern Arkansas, Arkansas Geological Commission, 1955.

<68> Albin, Donald R., United States Geological Survey Water Supply Paper 1809-J, Water Resources Reconnaissance of the Ouachita Mountains, Arkansas, Department of the Interior, United States Geological Survey, 1965.

<69> Halberg, H. N., and others, 1968, Water Resources of Grant and Hot Springs Counties, Arkansas, United States Geological Survey Water Supply Paper 1857.

<70> Representatives Shaver, Mahony, McGinnis, and Glover, Act 1051, 1985, State of Arkansas 75th General Assemby, Regular Session, 1985.

<71> United States Corps of Engineers, Lake Regulation Manuals for DeQueen Lake (1976), Dierks Lake (1975), Millwood Lake (1973), and Gillham Lake (1980).

<72> Arkansas State Department of Pollution Control and Ecology, Regulation Number 2, as amended, Regulation Establishing Water Quality Standards for Surface Waters for the State of Arkansas, March 1985.

<73> United States Department of Agriculture, Handbook No. 60, Diagnosis and Improvement of Saline and Alkali Soils, February 1954.

<74> United States Geological Survey, Ground Water Levels in Arkansas, Files, 1975-1985.

<75> United States Geological Survey Water Quality Computer Files, Multiple Station Analyses.

APPENDIX A

Draft Report Comments

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

PHONE: (501) 562-7444

September 11, 1986

Soil Conservation Service
700 West Capitol Avenue
Little Rock, AR 72201

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 - Red River above Fulton 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 groundwater section of 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. 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.

REC'D	ROUTE
Sullivan	
Murphy	
ASTC (O)	
★ Dennis	✓
Fultz	
Peters	
Williams	
SAO	
File	C.F.
★ Action by	

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. An additional source of data which is available concerning groundwater quality is the RCRA industrial monitoring data available through STORET. Specifically, monitor-well data is available from the DeQueen 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 of the driest months of the year, (i.e., July, August, September and October). This minimum streamflow, hereafter referred to as SWC plan, is proposed to supply all instream flow needs, including fish and wildlife, during all seasons of the year. This 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 remains no effective mechanism to control diversions above this 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.

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.

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.

We fail to find the rationale or justification for the SWC plan for establishing minimum streamflows (i.e., 10 percent of historical flows of July through October). We are also convinced that these 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.

Sincerely,

Phyllis Garnett

Phyllis Garnett, Ph.D.
Director

PG/sy

cc: J. Randy Young
Soil & Water Conservation Commission

ARKANSAS NATURAL HERITAGE COMMISSION

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

Harold K. Grimmett
Director

Bill Clinton
Governor

Date: September 19, 1986
Subject: Red River Basin above Fulton
ANHC Job #SWCC-5
Dated August 18, 1986
Received August 25, 1986

REC'D	ROUTE
Sullivan	
Murphy	
ASTC (O)	
* Dennis	
Fultz	
Peters	
Williams	
SAO	
File	Dennis
* Action	

Mr. Gene Sullivan, State Conservationist
Soil Conservation Service
700 West Capitol Avenue
Little Rock, Arkansas 72201

re: State Water Plan, Red River above Fulton

Dear Mr. Sullivan:

The staff of the Arkansas Natural Heritage Commission has reviewed the draft state water plan for the Red River Basin above Fulton. For reasons that will be outlined below, we have serious reservations about the potential impacts of plan implementation on fish and wildlife.

The discussion of minimum streamflow that begins on 4050H(39) fails to offer any documentation or clear statement of justification for the conclusions reached. The fact that "the minimum daily stream flow in Bayou Bartholomew required for fish and wildlife [presumably based on the Arkansas method] was exceeded during most months of the year" certainly is no reason to "adopt an alternative method for establishing minimum stream flow requirements." What is important is the minimum flow requirement itself, and if this requirement is exceeded, so much the better.

The ASWCC method does not account for "the seasonal variability of stream flow." The "method" results in a straight, horizontal line that is precisely the same no matter what the season. The only way the ASWCC method accounts for seasonal variability is to insure that the minimum streamflow figure will nearly always be exceeded. This is what one would expect when the figure used is ten percent of the mean summer discharge.

Third, the discussion leaves an impression that the ASWCC method was created by fiat. No mention is made of any biological justification for choosing ten percent of low flow as the minimum required for fish and wildlife, and no supporting data is presented. Absent any documentation to the contrary, it might be presumed that the method developed by the ASWCC was arrived at subjectively.

Finally, the statements regarding discharge records for the Little River and the Red River--"stream flow exceeded minimum instream flow requirements for fish and wildlife throughout the year under current stream flow conditions"--are plainly begging the question. Using ten percent of the mean discharge rate during the period of lowest flow to establish a "requirement," one would expect streamflow to exceed that figure all or most of the time.

It is highly likely that many aquatic species will be affected adversely if flows of basin streams are reduced to the point that would be permitted by implementation of the AWSCC standard. Reproduction and growth of fishes and aquatic invertebrates, cleansing of aquatic habitats, and recharge of ground-water tables all depend upon substantial flows of water, flows that exceed the Arkansas Soil and Water Conservation Commission's (ASWCC) minimum instream flow recommendation. Even Tennant's short-term survival figure of ten percent of the average annual flow is inadequate as a minimum standard for wildlife, except from July to October, when normal seasonal low flows in Arkansas coincide closely with his figure.

The Arkansas method is superior to the methods of both Tennant and the ASWCC because it follows the natural hydrographs of the state's streams and gives greater consideration to the biological needs of fish and wildlife. Some margin for error also is built into the seasonal percentages of the Arkansas method. The bare survival figure of ten percent flow, on the other hand, does not permit any "cushion" at all. Given the unpredictability of Arkansas weather, lack of stream gaging stations, poor existing flow data, etc., a considerable margin for error should be included in any method used to determine minimum instream flows.

Much more could be said in favor of the Arkansas method over that of the ASWCC, but we will wait until the executive summary of the basin reports is prepared to provide additional comments. In the meantime, we will point out that the Red River Basin above Fulton provides habitat for no less than thirteen aquatic species of federal and/or state concern. These are as follows:

Lampsilis orbiculata	pink mucket	Endangered (USFWS)
Percina pantherina	leopard darter	Threatened (USFWS)
Arkansia wheeleri	Ouachita rock pocketbook	Candidate for federal listing (Category 2)
Ammocrypta clara	western sand darter	Candidate for federal listing (Category 2)
Etheostoma fusiforme	swamp darter	
Nerodia cyclopion cyclopion	green water snake	
Notropis atrocaudalis	blackspot shiner	
Notropis hubbsi	bluehead shiner	
Notropis snelsoni	Ouachita Mountain shiner	Recently described endemic

(continued on next page)

Percina phoxocephala	slenderhead darter
Regina rigida sinicola	gulf crayfish snake
Sternotherus carinatus	razorback musk turtle
Gomphus ozarkensis	Ozark clubtail dragonfly

Of these, the fish and mussel species are most likely to be affected adversely by extremely low flows. If additional information regarding these species or our comments in general is desired, please do not hesitate to contact me.

Sincerely,

Harold K. Grimmett
Executive Director

cc: Craig Uyeda
John Giese

Dennis
Please see me
about comments
Robert C

Arkansas Game & Fish Commission

2 Natural Resources Drive Little Rock, Arkansas 72205

REC'D	ROUTE
Sullivan	✓
Murphy	✓ ℛ
Dennis	
Brown	
Fultz	
Peters	
Williams	
Wolfe	
File	C.F.
*Action by	

* ✓ ROBT C.

November 28, 1986

Mr. Gene Sullivan
State Conservationist
U.S.D.A. Soil Conservation Service
700 West Capital Avenue
Little Rock, AR 72201

Dear Mr. Sullivan:

This letter is in response to a memorandum sent to the Arkansas Game and Fish Commission (AGFC) by the Arkansas Soil and Water Conservation Commission (ASWCC) notifying interested agencies of the Draft Red River Basin above Fulton Report produced by the Soil Conservation Service (SCS). Please forgive us for the lateness of this letter (comment deadline September 22, 1986), but the personnel responsible for reviewing this information did not receive the document until after the deadline date. Mr. Charles Herndon of your agency was contacted by Steve Filipek, Fisheries Research Biologist with AGFC, about this matter and Mr. Herndon assured us he understood the situation and late submission of AGFC's comments would be permissible.

In reference to the Upper River Basin (URB) report, it appears it was drafted along the same lines as the Lower Red Basin (LRB) report by SCS and before your agency received our comments on that basin draft report (letter of July 21, 1986 to State Conservationist of SCS from Steve Wilson, Director, of AGFC). Since the URB report is basically a reflection of the LRB report in respect to instream flow matters, the AGFC would like to re-emphasize the concerns stated in its response to the LRB draft report (correspondence dated July 21, 1986). There are, however, additional comments we would like to make specific to the URB draft report and other comments of enough importance that we will reiterate them in this response. Again, since there are no page numbers in the report, our responses will generally progress from the beginning of the draft to its end.

Due to several of the rivers in this basin being regulated by dams, the extent of low flows are often dampened in respect to historic flows. Therefore, for all practical purposes, low flows occur from July through September (infrequently October) and not from June through December as stated in the report.

It is stated in the report that recharge requirements of ground water resources in the basin are unknown. If sufficient data on aquifer recharge in the basin is not available, more study and work needs to be conducted since this is an important component of the state's water resource. Use of the Arkansas Method of instream flow reservation would likely allow for adequate stream flow and timing of this stream flow to accomplish this recharge (Filipek et al. 1985).

Comparison of the Arkansas Method of instream flow reservation against daily discharge measurements for the basin rivers is illogicaly and inconsistent with procedures already diagrammed in the report. Instream flow requirements for fish and wildlife (and any other instream use) cannot be realistically set on a daily basis because of the inherent daily variation in discharge in the majority of Arkansas streams. In contrast, by using monthly mean flows to compute instream needs, much of the variation is taken into account. In this way, a monthly instream flow can be computed, check stations set-up (present gauging stations), and an acceptable variance about the computed instream flow arrived at (e.g flow "+" or "-" 10%). Water users would be allowed to pump water from a stream even when actual river water levels may be slightly lower than instream needs. This would take into account daily discharge variances, which can be high, as long as overall monthly means are similar to historic flows for that month, which should more often than not be the case.

Using the Arkansas Method, there are times when water diversion from surface waters may need to be postponed due to critical low flows and/or a substitute water source (ground water) will need to be utilized. However, this is the pragmatic side of surface water regulation. ASWCC's minimum flow philosophy is basically to allow diversion of surface water down to drought conditions so that no controversial regulation plan for surface water will have to be implemented. For example, ASWCC's "method" (and evidently SCS's) when used on rivers in the URB would reserve "fish and wildlife flows" that are less than the 7-day Q10. Use of the 7-day Q10 as a fisheries instream flow has been shown to be unacceptable and totally inadequate in previous studies (Tennant 1975). The flow duration curve for the Little River near Horatio indicates the ASWCC's (and SCS's) "fish and wildlife" value is exceeded 100% of the time at that site. This is basically non-regulation of one of our state's most valuable resources. At the same site in August (lowest flow month of year), use of the Arkansas Method would recommend a fish and wildlife instream flow of 568 cfs. This flow is exceeded 82% of the time and allows regulation of the surface water resource within reasonable limits. Using the Arkansas Method, instream flows were computed for other rivers in the URB as follows:

River and Site	Month	Discharge	% of Time Exceeded
Red River @ Index	August	2,306 cfs	85%
Cossatot River near Vandervoort	August	15 cfs	89%

ASWCC and SCS's "methods" appear to be subjectively arrived at with no biological backing. Its only advantage (?) appears to be that it will never have to be administered by the regulatory agency (ASWCC), which is also its originator. This type of "non-regulation" may be desirable from an enforcement agency's standpoint, but it is certainly not desirable to the majority of Arkansans who rely on surface water for many of their everyday activities.

Under "Surface Water Resources Problems", along with agriculture, forestry, mining and industry, recreation is a major activity in the basin that produces dollars towards the diverse economic base of the URB.

Given the present condition of agriculture in the state and the nation as a whole, the prediction that the URB has the potential to expand from 5,497 acres of irrigated cropland in 1980 to 100,710 acres in 2030 seems inflated. In fact, the argument that flows reserved by the Arkansas Method for the basin's fish and wildlife resources will detect from agricultural irrigation in the basin is not founded. Water use registration in the basin with the ASWCC in 1984 for irrigation was approximately 1,111 acre-feet. In this same basin, surface water stored in impoundments equaled in excess of 32,800 acre-feet.

Under "Surface Water Quality Problems", presently, fecal coliform bacterial levels exceed state standards for primary contact use in the Red River during low flow periods. While this is currently an infrequent occurrence, dewatering of the basin's streams past levels recommended by the Arkansas Method can only worsen this problem. This is especially true since the report admits that the impact of confined animals on the basin's water quality has not been adequately studied.

Under "Determining Instream Flow Requirements", the Arkansas Method is a modification of an accepted methodology, the Tennant Method. This method has been used on hundreds of streams throughout the U.S. and is certainly not a theoretical method. Also, work conducted on the L'Anguille River by personnel from AGFC, ASWCC, and USGS using IFIM (Instream Flow Incremental Methodology) showed much closer agreement with the recommendations of the Arkansas Method than the ASWCC "method".

There has been a misunderstanding that the Arkansas Method represents flow requirements for "excellent" fisheries habitat. ASWCC and SCS have confused the Arkansas Method with the Tennant or Montana Method. Flows recommended by the Arkansas Method maintain excellent conditions in streams with excellent fisheries, which our state has many, and fair conditions in streams with fair fisheries. In other words, the status quo is maintained.

While there is not a defined critical use area in the URB, the AGFC strongly agrees with SCS for stating that construction of on-farm storage reservoirs would be of considerable benefit to basin farmers. The word needs to be spread on this water conservation measure so that farmers will follow through on this progressive, yet tested technique.

These same measures and water reuse systems should be emphasized in assistance to self-supplied industries which are major water users in the basin. AGFC echoes SCS's statement on the need for additional gauging stations on basin streams such as Mountain Fork, Walnut Creek, and Mine Creek.

As mentioned before in this previous correspondence, one IFIM study has been completed which reflects favorably on the Arkansas Method. Additional IFIM work is contingent on applicable results, adequate funding and agencies interests.

Under ground water solutions and recommendations, declining water levels in the basin's major aquifers are, in fact, partly due to lack of regulation. These decreasing ground water levels can be stabilized by recharges from streams and other surface water sources. Since the URB report states that surface water and ground water are interconnected, regulation of surface waters in the state at this time is a necessity. The time for surface water regulation is now since "what happens to surface water resources will affect, if not determine, ground water availability and quality".

Finally, the AGFC would like to reiterate the concern over the numerous enlarged, threatened or rare aquatic biota found in URB by the Arkansas Natural Heritage Commission. They list no less than 13 species that qualify for the above classifications. AGFC would like to add to this list the paddlefish (Polyodon spatula), which is presently being exploited at higher rates than ever before in the state. AGFC is initiating work on this primitive fish to evaluate abundance, life history information, and spawning site location. Two of the primary requirements for spawning of paddlefish include substantial flow increases and adequate river depths for upstream migrations.

In order to keep paddlefish and other species dependent on stream systems at acceptable levels, wise water management in the URB is of paramount interest to AGFC and other conservation agencies and groups in Arkansas. For this reason, we will continue to work with the SCS and other agencies on this aspect of the state water plan.

Cordially,

Steve N. Wilson
Director

SNW:SF:jmc

Heckbart —

REC'D | ROUTE
Murphy
ASTC (O)
* Dennis
Fultz
Peters
Williams
SAO
File
Action by:

SEP 19 1986

DEPARTMENT OF THE ARMY
LITTLE ROCK DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 867
LITTLE ROCK, ARKANSAS 72203-0867

REPLY TO
ATTENTION OF

September 18, 1986

Planning Division
Special Studies

Mr. Gene Sullivan, State Conservationist
Soil Conservation Service
Room 5423 Federal Office Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

Dear Mr. Sullivan:

We have reviewed the draft of the State Water Plan concerning the Red River River Above Fulton Basin. The major comment that we have is in regard to Surface Water Availability Solutions. There are additional quantities of water available in three Corps of Engineers reservoirs which can be utilized. In Lakes Gillham, Dierks and DeQueen, the municipal and industrial water supply storage has not been totally contracted. The uncommitted volumes of water are available to a responsible entity upon execution of a mutually agreed to contract.

If we could be of further assistance, please contact us.

Sincerely

David L. Burrough

David L. Burrough
Chief, Planning Division

United States Department of the Interior

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

September 24, 1986

Mr. J. Randy Young, Director
Arkansas Soil and Water
Conservation Commission
#1 Capitol Mall, Suite 2D
Little Rock, Arkansas 72201

Dear Mr. Young:

The report "Arkansas State Water Plan, Red River above Fulton Basin" was reviewed in our office by Gus Ludwig, Braxtel Neely, Eddie Morris and Jim Petersen. All of their comments are noted in the text.

We appreciate the opportunity to review the report. The subject matter is very important to all residents of Arkansas.

Sincerely,

E. E. Gann
District Chief

Enclosures

BLN:bll

USDA SOIL CONSERVATION SERVICE

LIST OF PREPARERS

NAME	TITLE
GARY STEIGMAN	CIVIL ENGINEER
CHARLES HERNDON	CIVIL ENGINEER
RAY LINDER	BIOLOGIST
JIMMY ARRINGTON	GEOLOGIST

THE NATURAL STATE ®
Arkansas