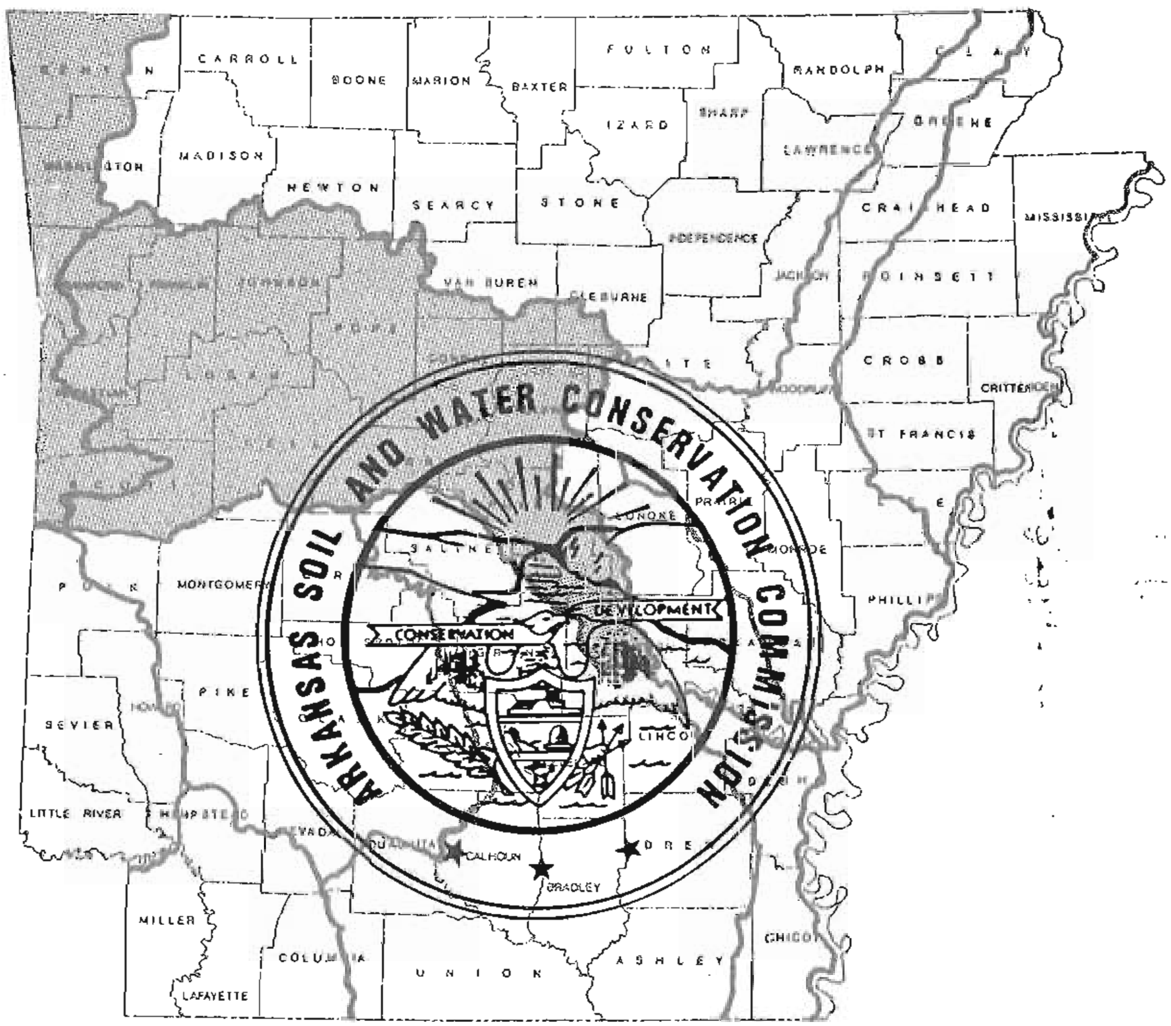
ARKANSAS STATE WATER PLAN

ARKANSAS RIVER BASIN



Prepared for
Arkansas Soil and Water Conservation Commission
by

U.S. Army Corps of Engineers
Little Rock District

PREFACE

Act 217 of 1969 gave the Arkansas Soil and Water Conservation Commission the specific authority to be the state agency responsible for water resource planning. 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 resoources in the State of Arkansas

The first State Water Plan was published in 1975 with 5 appendices that addressed specific problems and needs in the state. As more data has become abvailable, 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 revisionsto the State Water Plan are necessary for the document to remain valid.

Reports in the State Water Plan series are:

Beouf-Tensas Basin Report	August 1984
Lower Ouachita Basin Report	February 1987
Upper Ouachita Basin Report	October 1987
Red River Above Fulton Basin Report	April 1987
Red River Below Fulton Basin Report	April 1987
Upper White River Basin	March 1988
Arkansas River Basin	March 1988
Upper Arkansas River Basin	(included with Arkansas River Basin)
Bayou Meto Basin Report	(included with the Lower White)
Lower White River Basin Report	(unpublished)
St. Francis River Basin Report	(included with the Lower White)

The Arkansas River Basin Report was prepared by the U.S. Army Corps of Engineers in cooperation with the Arkansas Soil and Water Conservation Commission. The authority for preparing this report is Section 22 of the Water Resources Development Act of 1974, as amended. Section 22 authorizes the Chief of Engineers to cooperate with states in the preparation of comprehensive plans for the development, utilization, and conservation of the water and related land resources of drainage basins located within the boundaries of the states.

ACKNOWLEDGEMENTS

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

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ABSTRACT

The Arkansas River Basin is located in the west central part of the state and covers approximately 6.7 million acres. The land use of the basin is 3,729,184 acres of forest land, 2,074,823 acres of grassland, 433,230 acres of cropland, 218,536 acres of urban and built-up and 204,907 acres of other land uses.

The basin is predominately rolling hills and mountainous terrain with flat alluvial areas adjacent to the Arkansas River and downstream of Little Rock.

Water use in the area totaled 28,742 million gallons per day (mgd) or 32.2 million acre-feet in 1980. The major portion or 28,217 mgd was used for electrical energy production. The second largest use of water in the Arkansas River Basin was irrigation. The use of water is projected to increase to 185,000 mgd by 2030. The main reason for the large projected use of water is the development of hydropower facilities in the basin especially on the Arkansas River.

The principal streams in the basin are the Arkansas River, Lee Creek, Poteau River, Mulberry River Illinois Bayou, Sixmile Creek Big Piney Creek, Petit Jean River, Fourche Lafave River, Cadron Creek, Maumelle River, and Plum Bayou. These streams have steep gradients in their upper reaches and in their lower reaches have a flat gradient with meandering channels.

There are about 36,900 water impoundments in the Arkansas River Basin which store an estimated 1.4 million acre-feet. The major impoundments in the basin are Nimrod Lake, Blue Mountain Lake, Dardanelle Lake, Ozark Lake, Lake Maumelle, and Lake Conway. These impoundments are used for flood control, power generation, navigation, recreation, water supply, and conservation.

The combined yield of the streams of the Arkansas River basin is 29.8 million acre-feet. Streamflow in the basin is adequate, on an average annual basis, to satisfy existing water needs in the basin. However, due to natural streamflow variability, the majority of flow is available during the winter and spring months of the year. Considerably less water is available during the growing season when water use is highest. It is estimated that 2.7 million acre-feet of excess streamflow is available on an average annual basis for other uses, such as interbasin transfer.

Water quality of the streams and lakes in the Arkansas River Basin is generally good. There are instances where water quality parameters do not meet standards established by the Arkansas Department of Pollution Control and Ecology and the Arkansas Department of Health. Parameters which frequently do not meet the standards are fecal coliform bacteria, turbidity, and agricultural pesticides.

No streams in the Arkansas River Basin were designated as critical surface water areas based on quantity or quality problems. Shortages of water usually exist on streams during the summer and fall due to natural streamflow variability. Water quality problems do exist in the basin but the problems are generally localized and do not cause a significant shortage of useful water.

Solutions which are recommended for surface water problems in the Arkansas River Basin are development of alternate water sources, such as construction of water storage reservoirs, implementation of best management practices for nonpoint sources of pollution, and enforcement of pollution control laws for point source polluters.

Ground water is also a major source of water in the Arkansas River Basin. Rural domestic uses rely solely on ground for their source of water. Also, irrigators in the alluvial reaches of the basin rely heavily on ground water to irrigate rice as well as other crops.

The major ground water source based on areal coverage in the basin is the Rocks of Paleozoic age. The yield of this ground water source is limited generally to less than 10 gallons per minute (gpm) due to limited storage in the consolidated units.

Deposits of Quaternary age are the major source of groundwater in the basin. The yield of this formation can range as high as 2,500 gpm but the average is 1,000 gpm.

Another important source of ground water in the Arkansas River Basin is the Sparta Sand found in Pulaski and Jefferson Counties. The yield of the Sparta Sand varies from a few hundred gallons per minute to over 2,000 gpm.

Groundwater withdrawals in the study area in 1980 averaged 300 mgd or totalled 336,000 acre-feet. Approximately, 67 percent of the groundwater withdrawn was used for irrigation. The groundwater use in the basin increased 640 percent during the period 1960 to 1985, but the ground water use has declined 15 percent since 1980. Ground water use in the basin accounted for 7 percent of the groundwater use statewide.

Water quality of the ground water is generally good, but there are isolated areas which have water quality problems. Water from the Sparta aquifer is soft, sodium bicarbonate water of good quality which is suitable for most uses without treatment. Excessive hardness, locally high concentration of nitrate, iron, chloride, sulfate, and dissolved solids are water quality problems found in water from the Quaternary deposits. Rocks of Paleozoic age yields a hard to very hard, calcium bicarbonate water which is generally suitable for most uses.

No areas in the Arkansas River Basin have been designated as critical groundwater use areas. Even though the water level of the Sparta Sand in the vicinity of Pine Bluff has recorded a significant decline over the years but the decline is not severe enough to deserve a critical designation.

The most common ground water problems in the basin are low yields and poor water quality both of which are inherent in the formations. Therefore, no solutions exist for these problems.

Potential hazards to groundwater in the basin include landfills, surface impoundments, hazardous waste operations, storage tanks, septic tanks, and saline water intrusion. Legislation is already in place for controlling or denying construction of liquid waste holding impoundments. Proper administration of the Resource Conservation and Recovery Act program should contribute to the control of ground water contamination from hazardous wastes.

CHAPTER 1

GENERAL DESCRIPTION

GENERAL DESCRIPTION

Location and Size

The Arkansas River Basin in Arkansas, as shown in Figure 1-1, is an area of 10,409 square miles or 6,660,680 acres. Originally, for State Water Plan purposes, the Arkansas River Basin consisted of 8,353 square miles or 5,346,098 acres located primarily in the west-central and central part of the state. At the request of the Arkansas Soil and Water Conservation Commission, the Arkansas River Basin area was expanded to include the Upper Arkansas River Basin. The Upper Arkansas River Basin is located along the west side of the state, extending from the northwest corner to the west central part of the state, consisting of 2,056 square miles or 1,314,582 acres. Portions of 27 counties are located in the basin.

The streams in the Upper Arkansas River Basin originate in Arkansas and flow into Oklahoma before entering the Arkansas River.

The main water course is a 267 mile reach of the Arkansas River, from the Arkansas-Oklahoma state line to below Lock and Dam No. 4 near Pine Bluff. Some of the major tributaries of the Arkansas River in the study area are Lee Creek, Mulberry River, Petit Jean River and Fourche LaFave River.

There are eight major impoundments located in the basin including Lake Ozark and Lake Dardanelle on the Arkansas River; Blue Mountain Lake on Petit Jean River; Nimrod Lake on Fourche LaFave River; Harris Brake on a tributary of Fourche LaFave River; Brewer Lake on Cypress Creek (Conway County); Lake Conway on Palarm Creek (Faulkner County) and Lake Maumelle on the Maumelle River.

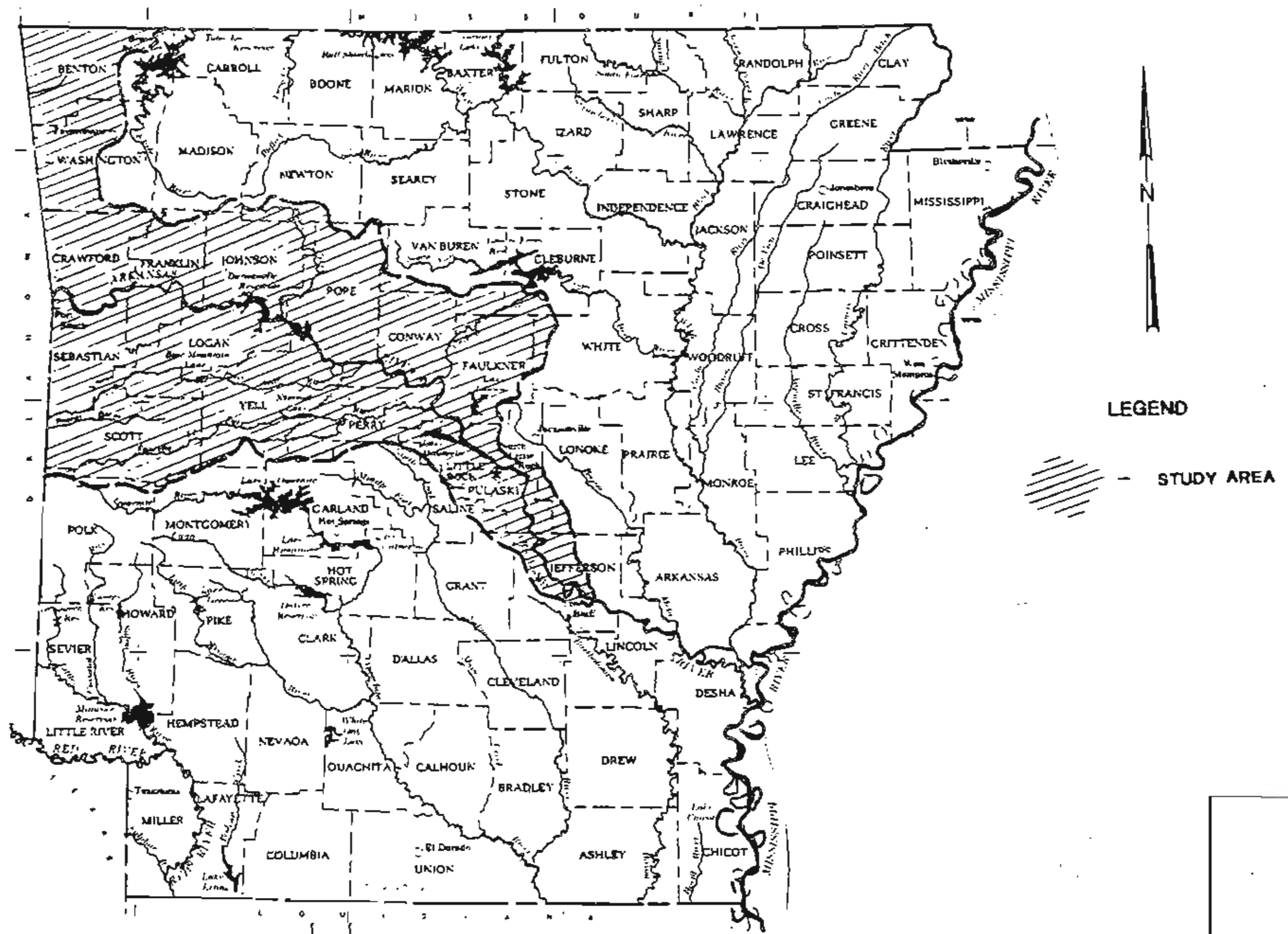
Topography

The major topographic region of the study area is the Arkansas Valley physiographic region. The Arkansas Valley is a broad synclinorium lying between the Ozark Plateaus and Ouachita Mountains anticlinorium. The folds on the north limb of the synclinorium are rather broad and nearly symmetrical, most have a general east-west strike. As the southern part of the valley is approached, the intensity of the folding increases and the general strike remains the same. Development of a marked asymmetry of the folds is present in the southern part of the valley; the northern limbs are much steeper than the southern limbs.

Faults are common in the Arkansas Valley, and for the most part, are parallel to the regional structure. As in folding, there is a contrast in the types of faults. Normal faults, downthrown on the south, are common north of the Arkansas River. South of the Arkansas River most large faults are reverse faults with upthrust sides on the south.

Arkansas River Valley soils are dominantly shallow and steep but are deep on gently sloping benches, terraces and hilltops; medium (sandy loam) textured; and developed from sandstone and shale.

The study area also includes the Ozark Plateaus. The Ozark Plateaus province of Arkansas is a part of a large structural dome which centers in the St. Francis Mountains of Missouri. Rock formations in the northern part of the Arkansas River Basin lie on the south flank of the dome. The beds have a regional dip to the south of one degree to three degrees near the Missouri boundary and become progressively steeper toward the south. Minor folds of



ARKANSAS RIVER BASIN
STUDY AREA

FIGURE 1-1

limited extent are superimposed on the regional dome. The folds increase in intensity from north to south. In the northern part of the region, the structures usually are synclines and basins, or monoclines and broad, domelike anticlines; whereas in the southern part of the area, the folds are strongly developed. Coincident with an increase in folding is an increase in the regional dip.

Faulting is common in the Ozark Plateau. These faults are normal, usually downthrown on the south, sometimes producing graben structures.

Ozark Plateaus soils are of two associations which are the Ozark Highlands and the Boston Mountains Soil Associations. The Ozark Highlands are comprised chiefly of limestone hills and valleys. The soil developed mainly from limestone and ranges from deep to shallow and is rapidly to slowly permeable. Surface textures are mainly silt loam and very cherty silt loam. The most productive soils occur on level to nearly level plateaus and narrow stream valleys and are used for orchards, pasture, and rowcrops. The more mountainous areas have slopes that range from moderately sloping to steep. Some of the less sloping areas are used for pasture production with steeper areas remaining in hardwood timber.

The Boston Mountains soils are remnants of an old plateau in the northern part of the state bordering the Ozark Highlands area. The mountains are capped by sandstone. Soils formed from interbedded sandstone and shale on the steep mountainsides and are deep to shallow and rapidly permeable to very slowly permeable. Surface textures are mainly sandy loam, gravelly sandy loam or stony sandy loam. Most of this area is in woodland. Narrow valleys and ridgetops have been cleared and are used mainly for pastureland. This association consists of moderately sloping hilltops and rolling hills and moderately sloping to steep hillsides and mountainsides (Arkansas Resource Base Report, 1981).

Climate

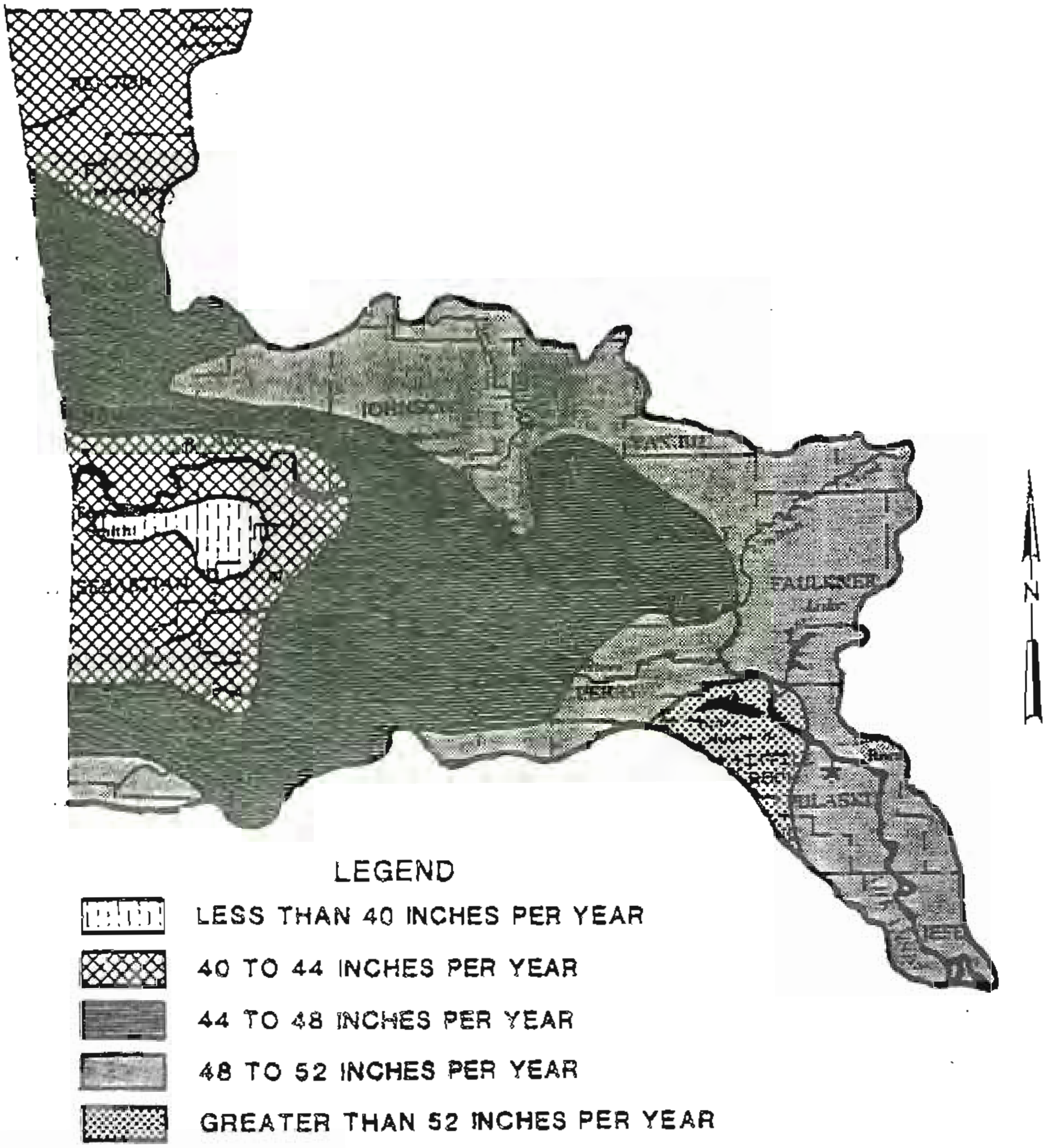
The Arkansas River Basin lies in a semi-humid region characterized by long summers, relatively short winters, and a wide range of temperatures. Extremes in air temperatures may vary from winter lows around 0 degrees Fahrenheit, usually caused by Canadian air masses to summer highs above 100 degrees Fahrenheit. Extreme temperatures may occur for short periods of time at any location within the study area. The growing season averages 244 days per year.

The average pan evaporation is about 54.9 inches for the Arkansas River Basin. Lake evaporation averages about 69 percent of the class A pan evaporation.

Precipitation is well distributed throughout the year with the driest periods occurring during the late summer and early fall. Mean annual precipitation in the study area ranges from less than 40 inches per year to greater than 52 inches per year as shown in Figure 1-2.

Population and Economy

Only 15 counties (Benton, Conway, Crawford, Faulkner, Franklin, Jefferson, Johnson, Logan, Perry, Pope, Pulaski, Scott, Sebastian, Washington, and Yell) were selected to make up the study area for this report even though



ARKANSAS RIVER BASIN
MEAN ANNUAL PRECIPITATION

SOURCE: FREIWALD, U.S.G.S., 1985

Figure 1-2

there are parts of 27 counties located within the boundary of the basin. (See Figure 1-1) The remaining 12 counties were omitted from the study area because of the small area that they contribute to the basin and the fact that the 1980 census of population does not subdivide population data by hydrologic boundaries. Any trends, projections, or conclusions that would be drawn, based on the data for the entire 27 county region, could be misleading.

The total 1980 population of the 15 counties in the study area was 932,953 (Table 1-1). This figure represents an increase from the 1970 census of about 24 percent or 180,913 people. Eight of the 15 counties increased in population from 1900 to 1980. See Figure 1-3 for the population trend in the study area since 1900.

The generally accepted measure of the individual level of welfare in an area is its per capita personal income. It is determined by dividing the total personal income in an area by its total population. The 1980 per capita personal income for this area ranged from a low of $6,032 in Scott County to a high of $10,368 in Pulaski County. This compares to $8,041 for the state and $10,495 nationally. Per capita incomes of the individual counties in the study area are compared to the state and the national values in Figure 1-4.

In Table 1-2, poverty level statistics are shown. Poverty level is based on income, age of householder, and number of children under 18 in a household. The poverty level, in 1979, for a single person under age 65 is $3,774. For families, the poverty level ranges from $3,858 for 2 adults with no children to $14,024 for a family of 9 or more persons with 8 or more children.

TABLE 1-2
INCOME AND POVERTY CHARACTERISTICS
IN THE STUDY AREA

	Above Poverty Level	Below Poverty Level
Total Number of Persons	786,479	146,474
Percent of Persons	84.3	15.7
Total Number of Families	221,031	31,287
Percent of Families	87.6	12.4

SOURCE: U.S. Bureau of Census, 1980

TABLE 1-1 POPULATION BY COUNTY FOR THE ARKANSAS RIVER BASIN (1900 to 1980)

COUNTIES	YEARS								
	1900	1910	1920	1930	1940	1950	1960	1970	1980
BENTON	31611	33389	36253	35253	36148	38076	36272	50476	78115
CONWAY	19772	22729	22578	21949	21536	18137	15430	16805	19505
CRAWFORD	21270	23942	25739	22549	23920	22727	21318	25677	36892
FAULKNER	20780	23708	27681	28381	25880	25289	24303	31572	46192
FRANKLIN	17395	20638	19364	15762	15683	12358	10213	11301	14705
JEFFERSON	40972	52734	60330	64154	65101	76075	81373	85329	90718
JOHNSON	17448	19698	21062	19289	18795	16135	12421	13630	17423
LOGAN	20563	26350	25866	24110	25967	20260	15957	16798	20144
PERRY	7294	9402	9905	7695	8392	5978	4927	5634	7266
POPE	21715	24527	27153	26547	25682	23291	21177	28607	39003
PULASKI	63179	86751	109464	137727	156085	196688	242980	287189	340613
SCOTT	13183	14302	13232	11803	13300	10057	7297	8207	9685
SEBASTIAN	36935	52278	56739	54426	62809	64202	66685	79237	95172
WASHINGTON	34256	33889	35468	39255	41114	49979	55797	77370	100494
YELL	22750	26323	25655	21313	20970	14057	11940	14208	17026
TOTAL	389123	470660	516489	530213	561382	593309	628090	752040	932953

Source: U.S. Bureau of Census

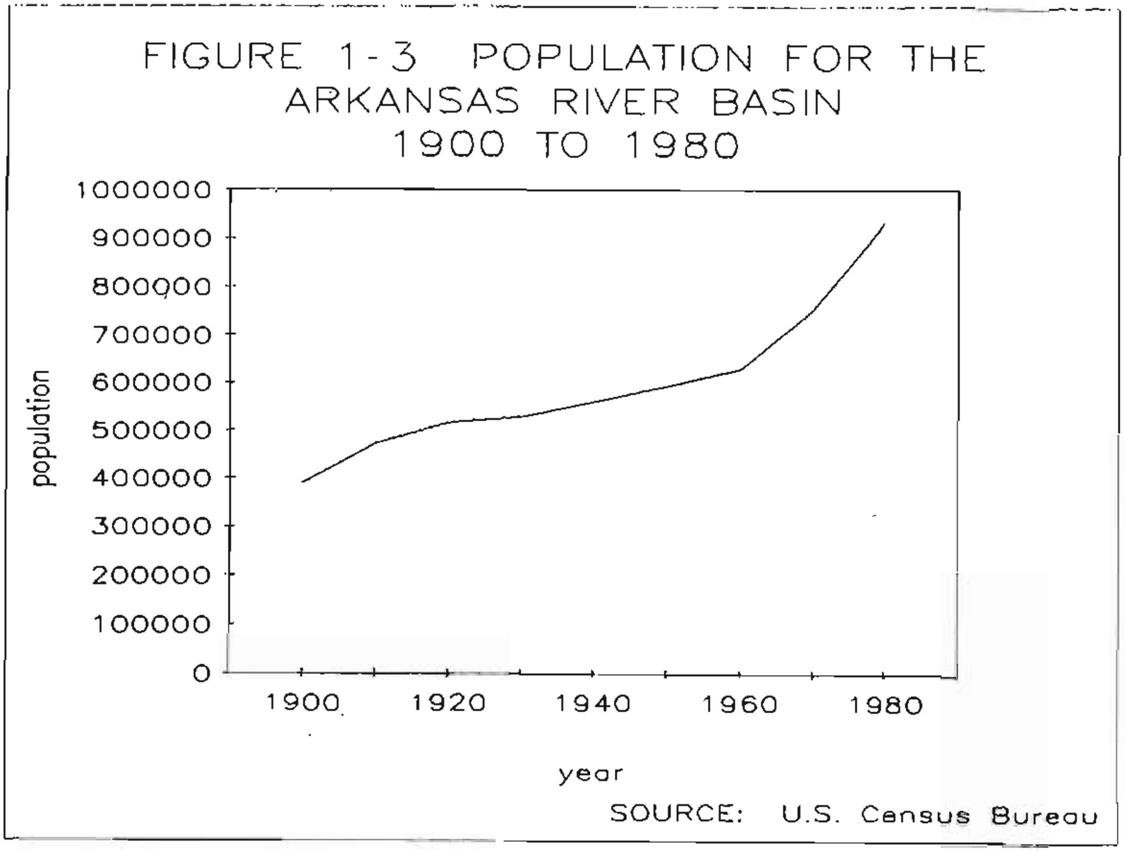


FIGURE 1-3 POPULATION FOR THE
ARKANSAS RIVER BASIN
1900 TO 1980
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
population
1900
1920
1940
1960
1980
year
SOURCE: U.S. Census Bureau

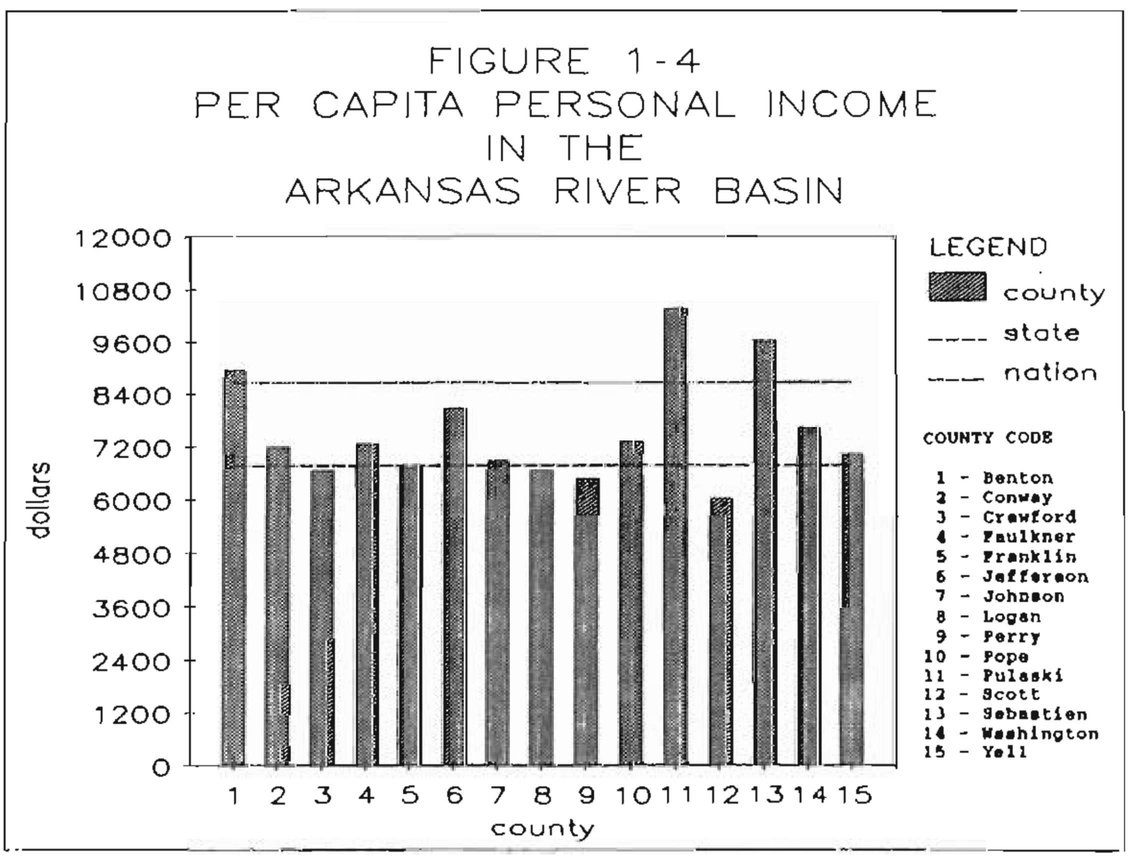


FIGURE 1-4
PER CAPITA PERSONAL INCOME
IN THE
ARKANSAS RIVER BASIN
12000
10800
9600
8400
7200
6000
4800
3600
2400
1200
0
dollars
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
county
LEGEND
county
state
nation
COUNTY CODE
1 - Benton
2 - Conway
3 - Crawford
4 - Faulkner
5 - Franklin
6 - Jefferson
7 - Johnson
8 - Logan
9 - Perry
10 - Pope
11 - Pulaski
12 - Scott
13 - Sebastien
14 - Washington
15 - Yell

CHAPTER 2

LAND RESOURCES INVENTORY

LAND RESOURCES INVENTORY

Current Land Use

Most of the land in the Arkansas River Basin is composed of forest land. Of the total 6,660,680 acres, forest land accounts for 3,729,184 acres or 56.0 percent. Grassland represents 2,074,823 acres or 31.2 percent. Cropland covers 433,230 acres or 6.5 percent. Urban and built-up land accounts for 218,536 acres, or 3.1 percent and water and other lands account for the remaining 204,907 acres, or 3.1 percent. (See Figure 2-1.) Land use by county is shown in Table 2-1.

Crops grown on cropland are as follows: 64 percent (277,267 acres) soybeans; 16 percent (69,317 acres) cotton; 7 percent (30,326 acres) rice; 8 percent (34,658 acres) hayland; and the remaining 5 percent (21,662) in a variety of other crops. Most of these crops are grown in the Arkansas River Valley, the Mississippi Valley Alluvium and the valleys of the larger tributary streams.

Forest land is the land use which comprises the greatest area in the Arkansas River Basin. Of the total acreage of 6,660,680, forest land accounts for 3,729,184 acres or 56 percent. In table 2-2, it can be seen that the dominant forest type is oak-pine, closely followed by oak-hickory. Table 2-3 shows forest land acreage by ownership and Table 2-4 compares commercial and non-commercial acreage.

TABLE 2-2 FOREST LAND BY FOREST TYPE

FOREST TYPE	ACRES	PERCENT
Loblolly-Shortleaf Pine	663,795	17.8
Oak-Pine	1,592,362	42.7
Oak-Hickory	1,275,381	34.2
Oak-Gum-Cypress	145,438	3.9
Elm-Ash	44,750	1.2
Cedar	7,458	0.2

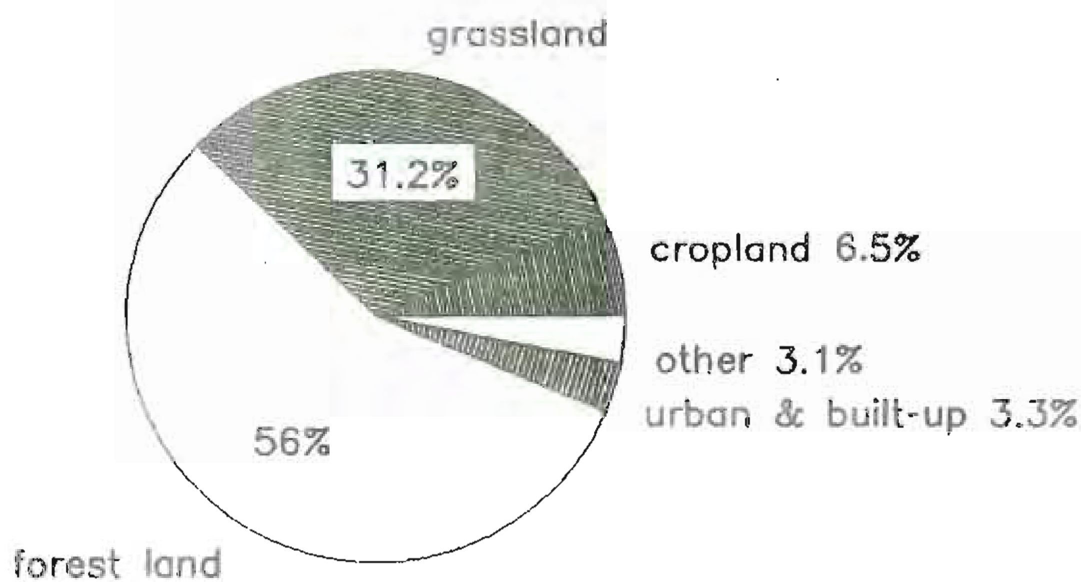
Source: Resource Inventory Data System, 1977

TABLE 2-3 FOREST LAND BY OWNERSHIP

OWNERSHIP	ACRES	PERCENT
Federal	1,629,654	43.7
State	37,292	1.0
Forest Industry	350,543	9.4
Misc.-Private	1,711,695	45.9

Source: Resource Inventory Data System, 1977

FIGURE 2-1 PRESENT LAND USE IN THE ARKANSAS RIVER BASIN BY COUNTY



SOURCE: Resource Inventory Data System, 1977

TABLE 2-1 PRESENT LANDUSE IN THE ARKANSAS RIVER BASIN BY COUNTY

COUNTY	LANDUSE (acres) CROPLAND	GRASSLAND	FORESTLAND	URBAN AND BUILT-UP	OTHER	TOTAL ACRES IN BASIN
Benton	17655	260373	133209	10101	21021	442359
Cleburne	2155	28126	30336	0	0	60617
Conway	42997	133261	159362	4233	18519	358372
Crawford	21520	105912	223950	18228	18733	388343
Faulkner	39469	157933	161452	18216	4777	381847
Franklin	7069	195896	171321	2710	9312	386308
Garland	0	0	860	0	0	860
Grant	0	0	11981	0	0	11981
Jefferson	87196	8688	70804	8136	1907	176731
Johnson	10214	88111	326628	2911	7336	435200
Logan	19469	194986	232451	7760	13814	468480
Lonoke	31625	3503	3503	0	0	38631
Madison	0	0	25936	0	0	25936
Montgomery	0	1466	1465	0	0	2931
Newton	0	5166	87001	0	0	92167
Perry	17442	43775	281698	2746	8401	354062
Polk	0	0	20151	0	0	20151
Pope	18890	135151	331419	14815	12794	513069
Pulaski	62868	35264	197654	65955	40527	402268
Saline	0	7918	52054	8781	3203	71956
Scott	0	121008	452938	0	0	573946
Searcy	0	1766	2648	0	0	4414
Sebastian	19652	143178	130917	37694	12239	343680
Van Buren	0	53467	70610	0	0	124077
Washington	10217	170946	178019	16250	13919	389351
White	0	28392	5678	0	0	34070
Yell	24792	150537	365139	0	18405	558873
Total	433230	2074823	3729184	218536	204907	6660680

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

TABLE 2-4 COMMERCIAL AND NON-COMMERCIAL FOREST LAND

ITEM	COMMERCIAL	NON-COMMERCIAL	TOTAL
Percent in Basin	97.1	2.9	100.0
Acres	3,621,038	108,146	3,729,184

Source: Resource Inventory Data System, 1977

Urban and built-up areas are defined as including cities, villages, and other built-up areas of more than 10 acres; industrial sites; railroad yards; cemeteries; airports; golf courses; shooting ranges; institutional and public administrative sites and sililar types of areas; and road and railroad rights-of-way. Urban and built-up acreage in the Arkansas River Basin is 218,536.

A group of various land uses are combined under the "Other" category. Land uses included in the "Other" category are orchards, vineyards, extractive, construction, animal feedlots, bodies of water and homesteads. The urban and built-up category has 204,907 acres and accounts for 3.1 percent of the area.

A detailed listing of land use acreages by county is shown in Table 2-1.

Prime Farmland

Prime farmlands are those lands having the capability to produce sustained yields of crops, economically, year after year. These lands are not flooded twice or more during any one growing season. Prime farmland is Class I, Class II or Class III land. According to the U.S.D.A., National Resource Inventory of 1982, about 1,840,300 acres of land within the Arkansas River Basin are classified as prime. Figure 2-2 shows the distribution of prime farmland throughout the basin.

Projected Land Use

There are no major land use changes predicted for the Arkansas River Basin; however, small changes are expected. Cropland will continue to be converted to urban and built-up, as will forestland.

A greater percentage of the cropland will be irrigated in the future. By the year 2030, irrigated acres are projected to increase from 70,744 in 1980 (R.I.D.S., 1977) to 140,000. The reason for the increased use of irrigation is the more efficient use of the available cropland. The limiting factor in using irrigation in a large part of the basin is the lack of a readily available and dependable water source. A second limiting factor is the high investment cost of irrigation systems.

Wetlands

An important classification of land is wetlands. Wetlands are low land areas which remain saturated with water for extended periods of time including wet meadows, freshwater marshes and bottomland hardwood wetlands. Wetlands

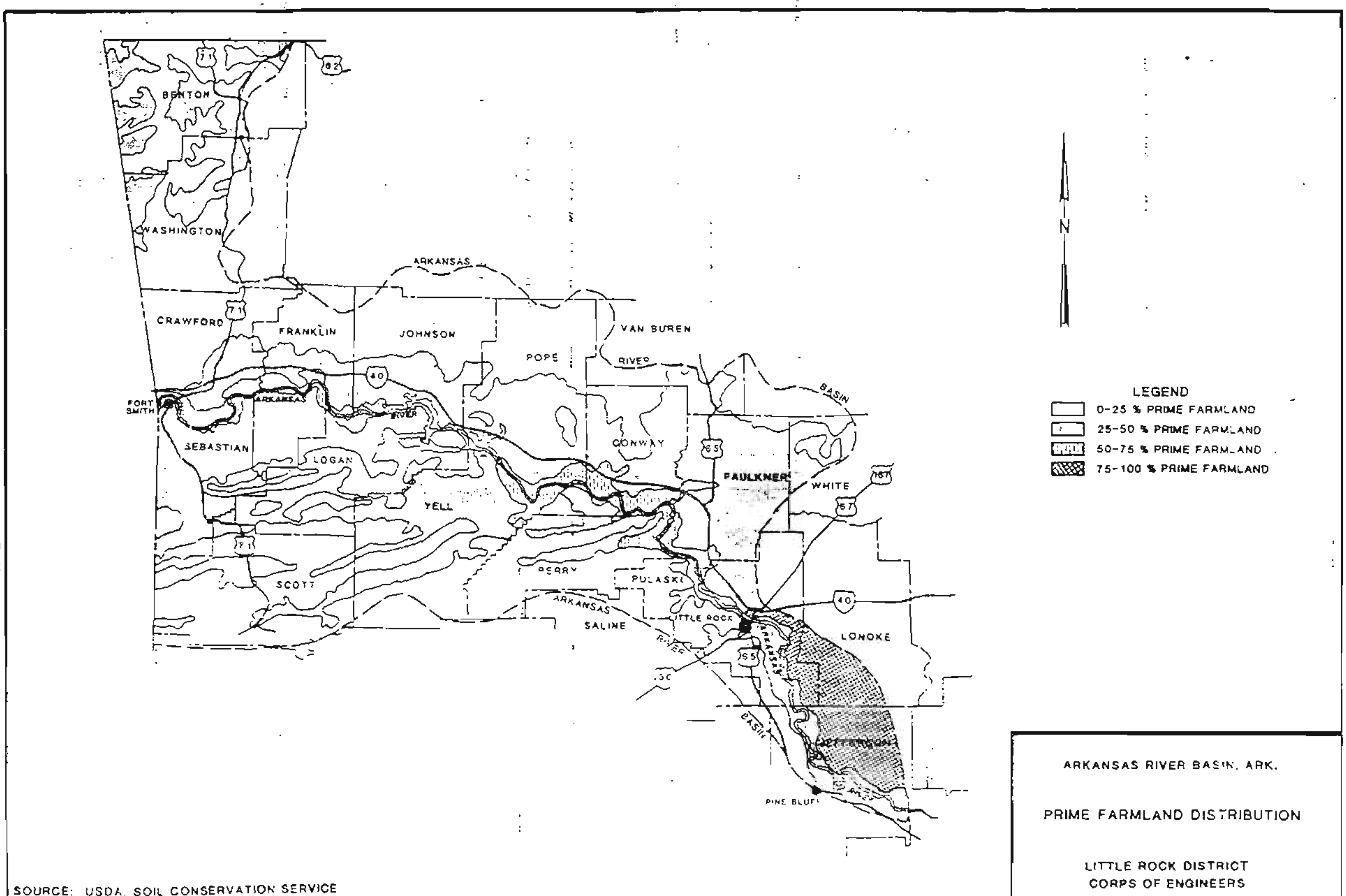

BENTON
WASHINGTON
CRAWFORD
FRANKLIN
JOHNSON
POPE
VAN BUREN
ARKANSAS
RIVER
BASIN
FORT SMITH
SEBASTIAN
LOGAN
YELL
CONWAY
FAULKNER
WHITE
SCOTT
PERRY
PULASKI
SALINE
LITTLE ROCK
LONOKE
JEFFERSON
PINE BLUFF
N
LEGEND
0-25 % PRIME FARMLAND
25-50 % PRIME FARMLAND
50-75 % PRIME FARMLAND
75-100 % PRIME FARMLAND
ARKANSAS RIVER BASIN, ARK.
PRIME FARMLAND DISTRIBUTION
LITTLE ROCK DISTRICT
CORPS OF ENGINEERS
SOURCE: USDA, SOIL CONSERVATION SERVICE

Figure 2-2

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

Wetlands have numerous functional values. Major functions of wetlands are food and cover for fish and wildlife, water quality improvement, ground water recharge, soil enrichment, erosion control and downstream fishery benefits.

Natural wetland acreage in the Arkansas River Basin has been reduced by modern farming, urban development, and other uses such as highways, airports, etc., to approximately 50,000 acres in the basin (Arkansas Resource Base Report).

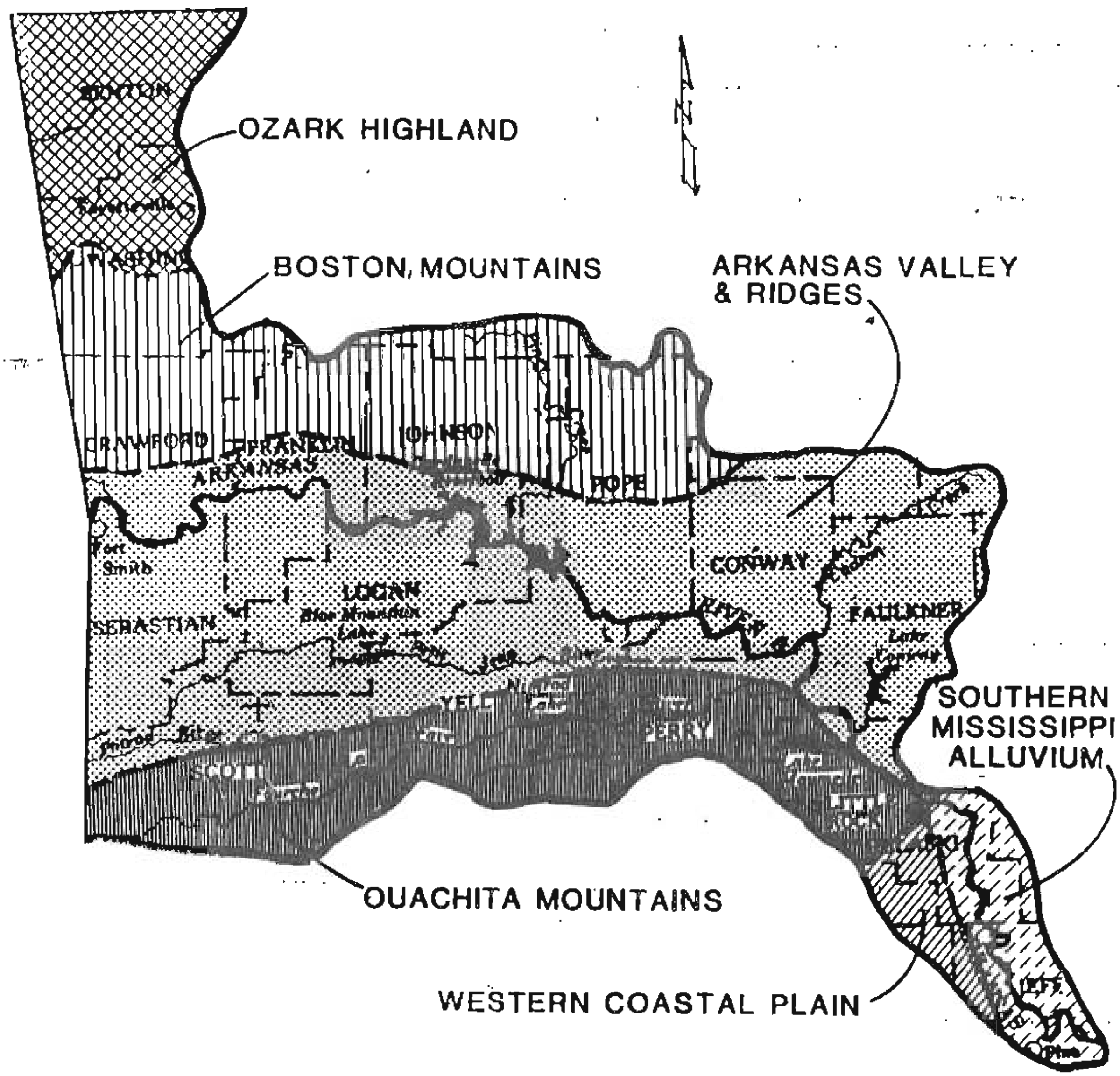
Soil Resources (Arkansas Resource Base Report, 1981)

1. Major Land Resource Areas (MLRA's). There are six major land resource areas in the Arkansas River Basin (Figure 2-3). Their names and general soil descriptions follow:

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

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

c. ARKANSAS VALLEY AND RIDGES. This area is comprised of broad valleys, narrow ridges, and high flat-topped mountains in the central portion of the state. Elevations of the valley floor range from 300 to 500 feet, with mountains protruding from 1,200 feet to 2,800 feet above sea level. Soils developed from sandstone and shale. Soils are deep to shallow and are rapidly permeable to very slowly permeable. Surface



MAJOR LAND RESOURCE AREAS
IN THE
ARKANSAS RIVER BASIN

Figure 2-3

textures are mainly sandy loam, gravelly sandy loam, or stony sandy loam. Slopes in the valleys and on ridgetops are level to gently sloping and hillsides and mountainsides are moderately sloping to steep. The valleys are mainly used for pasture production. The steeper areas remain in woodland.

d. OUACHITA MOUNTAINS. The Ouachita Mountains area consists 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 to 2,600 feet above sea level. Soils are deep to shallow and moderately permeable to slowly permeable. Surface textures are mainly sandy loam, silt loam or their cherty 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 this area is used for timber production. Some narrow valleys have been cleared and are used for pasture production.

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

f. WESTERN COASTAL PLAIN. The Coastal Plain area consists of rolling terrain broken by stream valleys. Soils developed from deep marine sediments. The soils are deep and rapidly permeable 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.

2. The different soil associations found in the various MLRA's are listed below.

a. Ozark Highland

Clarksville - Nixa - Noark

Gepp - Doniphan - Gassville - Agnos

Arkana - Moko

Captina - Nixa - Tonti

Eden - Newnata - Moko

b. Boston Mountains

Linker - Mountainburg - Sidon

Enders - Nella - Mountainburg - Steprock

c. Arkansas Valley and Ridges

Faulkner - Wrightsville

Leadvale - Taft

Enders - Mountainburg - Nella - Steprock

Spadra - Guthrie - Pickwick

Linker - Mountainburg

d. Ouachita Mountains

Carnasaw - Pirum - Clebit

Leadvale - Taft

Spadra - Pickwick

e. Bottomlands and Terraces

Perry - Portland

Crevasse - Bruno - Oklared

Roxana - Dardanelle - Bruno - Roellen

Rilla - Hebert

Muskogee - Wrightsville - Mckamie

f. Coastal Plain

Amy - Smithton - Pheba

Pheba - Amy - Savannah

Smithdale - Sacul - Savannah - Saffell

Sacul - Smithdale - Sawyer

Guyton - Ouachita - Sardis

g. Loessial Plains

Calloway - Henry - Grenada - Calhoun

General Soil Associations specific descriptions and locations can be obtained from the U.S.D.A., Soil Conservation Service offices in Little Rock and in every county of the state.

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

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

Nineteen of the soil surveys for the twenty-seven counties located within the Arkansas River Basin have been published. The counties, and the date of their publication are as follows: Benton (1977), Cleburne (1986), Conway (1971), Crawford (1980), Faulkner (1979), Franklin (1971), Jefferson (1980), Johnson (1977), Logan (1980), Lonoke (1981), Madison (1986), Perry (1982), Pope (1981), Pulaski (1975), Saline (1979), Sebastian (1975), Van Buren (1986), Washington (1969), and White (1981). Two of the remaining eight counties, Newton and Yell, are scheduled to be published in 1987. The six remaining counties in the basin (Garland, Grant, Montgomery, Polk, Scott, and Searcy) do not have a date set, at this time, for publication.

CHAPTER 3

SURFACE WATER

SURFACE WATER

Introduction

This chapter presents an inventory of the surface water resources of the Arkansas River Basin. Present water use and estimated future water needs are quantified. Problems are identified and solutions are recommended for the water resource concerns.

The surface water of the Arkansas River serves the nation and the world as a major artery for commercial navigation. The Arkansas River is also a major source of hydroelectric energy. Some of the tributaries are major recreational attractions to Arkansas residents. Endangered wildlife species inhabit the water and adjoining wetlands.

Rainfall in the basin ranges from 42 inches to 52 inches per year. Runoff from rainfall in the Arkansas River Basin ranges from 12 inches to 22 inches per year (Freiwald, 1985). Runoff from the Arkansas River Basin within Arkansas averages 17 inches per year.

Major tributaries of the Arkansas River in the study area are Lee Creek, Poteau River, Mulberry River, Illinois Bayou, Sixmile Creek, Big Piney Creek, Petit Jean River, Fourche LaFave River, Cadron Creek, Maumelle River, and Plum Bayou.

Stream runoff in the Arkansas River Basin is rapid in the mountainous perimeter areas but as the tributaries approach their major outlets the stream flow velocities decrease. Stream flow occurs predominately after rainfall with little base flow.

The major impoundments in the basin are nine Arkansas River Locks and Dams, Lake Maumelle on the Maumelle River, Brewer Lake on Cypress Creek, Lake Conway on Palaram Creek, Blue Mountain Lake on the Petit Jean River and Nimrod Lake on the Fourche LaFave River. The nine dams on the Arkansas River are for navigational purposes with two of the dams having limited additional storage for hydropower production. Lakes Maumelle and Brewer are for water supply storage.

The water quality of the Arkansas River Basin varies from point to point within the basin. The forested perimeter areas have the highest water quality with the water quality declining as the water flows through pastures and cropland. The Arkansas River has shown improved water quality in the past twenty years due to completion of the McClellan-Kerr Navigation System and the enforcement of stricter water pollution control laws. Based on current water quality data, the Arkansas River water meets the drinking water standard for chlorides and total dissolved solids (Water Quality Inventory Report, 1986).

SURFACE WATER INVENTORY

Surface Water Data Collection Network

Streamflow data are collected in the Arkansas River Basin primarily by the US Geological Survey and the U. S. Army Corps of Engineers. Locations of 17 streamflow data collection sites are shown in Figure 3-1. Table 3-1 lists pertinent data about the gaging stations.

LEGEND

✱ 07261000 U.S.G.S. GAGING STATIONS LOCATION

ARKANSAS RIVER BASIN

SLECTED U.S.G.S.
GAGING STATIONS

FEBRUARY 1988

Figure 3-1

TABLE 3-1 STREAMFLOW GAGING STATION DATA

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI)	STREAMFLOW PERIOD OF RECORD		DISCHARGES FOR PERIOD OF RECORD MAXIMUM	MINIMUM	AVERAGE
				CFS AND (DATE)		
07195800 Flint Creek at Springtown, AR	14	6/61	9/84	14,600 (6/74)	0	13
07196900 Baron Fork at Dutch Mills, AR	46	4/58	9/84	17,100 (7/72)	0	37
07247000 Poteau River at Cauthron, AR	203	2/39	9/84	32,200 (5/60)	0	214
07249400 James Fork near Hackett, AR	147	4/58	9/84	30,000 (5/68)	0	129
07250000 Lee Creek near Van Buren, AR	426	10/50	9/84	80,600 (5/60)	0	484
07250550 Arkansas River at Dam 13 near Van Buren, AR	150,547	10/27	10/84	850,000 (5/43)	0 (2/81)	30,790
07252000 Mulberry River near Mulberry, AR	373	5/38	9/84	70,200 (4/64)	0	531
07255000 Sixmile Creek at Caulksville, AR	104	1955	4/70	10,100 (5/61)	0	95
07256500 Spadra Creek at Clarksville, AR	61	1953	9/70	15,300 (4/57)	0	71
07257000 Big Piney Creek near Dover, AR	274	10/50	10/84	111,000 (12/82)	0	399
07258500 Petit Jean River near Booneville, AR	241	11/38	9/84	43,200 (4/39)	0 (10/78)	246
07260000 Dutch Creek at Waltreak, AR	61	1955	4/70	24,500 (7/69)	0	90

TABLE 3-1 STREAMFLOW GAGING STATION DATA (cont.)

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI)	STREAMFLOW PERIOD OF RECORD		DISCHARGES FOR PERIOD OF RECORD MAXIMUM	MINIMUM	AVERAGE
				CFS AND (DATE)		
07260500 Petit Jean River at Danville, AR	764	6/16	9/84	70,800 (4/39)	0	807
07261000 Cadron Creek near Guy, AR	169	10/54	10/84	24,200 (12/82)	0	283
07261500 Fourche LaFave River near Gravely, AR	410	2/39	9/84	162,000 (12/82)	0	528
07263000 South Fourche LaFave River near Hollis, AR	210	5/41	9/84	94,000 (12/82)	0	292
07263450 Arkansas River at Murray Lock and Dam, Little Rock, AR	158,030	9/27	9/84	536,000 (5/43)	14 (10/78)	40,270

TABLE 3-2 MEAN MONTHLY DISCHARGES AT SELECTED GAGING STATIONS

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOW PERIOD OF RECORD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT
07195800 Flint Creek at Springtown, AR	14	1969 - 84	9.8	16	14	12	13	18	20	14	16	3.0	5.3	7.9
07196900 Baron Fork at Dutch Mills, AR	46	1959 - 84	20	44	37	30	44	69	71	64	27	18	4.0	16
07247000 Poteau River at Cauthron, AR	203	1940 - 84	56	145	251	254	352	416	360	440	165	66	29	39
07249400 James Fork near Hackett, AR	147	1959 - 84	56	119	177	111	167	366	209	288	83	40	12	19
07250000 Lee Creek near Van Buren, AR	426	1931-37 ; 1951-84	195	417	453	475	626	961	989	938	434	140	49	160
07250550 Arkansas River at Dam 13 near Van Buren, AR	150,547	1970 - 84	19,030	34,530	27,180	21,820	27,380	45,840	52.240	55,630	54,490	26,430	11,930	12,460
07252000 Mulberry River near Mulberry, AR	373	1939 - 84	146	448	555	573	819	1,046	1,105	1,001	408	129	73	96
07255000 Sixmile Creek at Caulksville, AR	104	1955 - 69	28	68	108	88	124	197	163	234	60	42	15	16
07256500 Spadra Creek at Clarksville, AR	61	1953 - 70	13	43	68	75	112	145	161	151	45	19	16	8.4
07257000 Big Piney Creek near Dover, AR	274	1951 - 84	100	361	514	376	593	847	875	708	253	72	42	59
07258500 Petit Jean River near Booneville, AR	241	1940 - 84	63	183	278	296	398	520	446	491	145	67	34	47

SOURCE: USGS streamflow records.

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

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOW PERIOD OF RECORD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT
07260000 Dutch Creek at Waltreak, AR	61	1946 - 75	24	71	115	133	152	194	186	168	42	33	11	10
07260500 Petit Jean River at Danville, AR	764	1948 - 84	132	408	890	951	1247	1514	1326	1426	787	373	234	129
07261000 Cadron Creek near Guy, AR	169	1955 - 84	57	246	413	352	447	589	498	443	174	50	60	78
07261500 Fourche LaFave River near Gravelly, AR	410	1940 - 84	146	379	641	636	870	1095	960	980	373	138	45	91
07263000 South Fourche LaFave River near Hollis, AR	210	1942 - 84	57	190	421	408	498	658	520	459	158	48	37	64
07263450 Arkansas River at Murray Lock and Dam, Little Rock, AR	158,030	1970 - 84	20,190	41670	42,580	31,370	39,410	63,020	70,300	69,810	63,220	28,180	12,290	13,890

SOURCE: USGS streamflow records.

STREAM FLOW CHARACTERISTICS

Distribution of streamflow is dependent upon climate, physiography, geology, and land use in the basin. Basins where these conditions are similar may have similar streamflow characteristics. Generally, the distribution of high flows is governed largely by the climate, the physiography, and the plant cover of the basin. The distribution of low flows is controlled mainly by the basin geology. The variability is reduced by storage, either on the surface or in the ground.

In the Arkansas River Basin, streamflow is generally highest during November through June because of the large amount of precipitation during this period. Similarly, streamflow is generally lowest during July through October 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. Streamflow variability is shown in more detail by the streamflow distribution graphs in Figures 3-2a through 3-2f.

There are several streams in the Arkansas River Basin which are regulated by dams. Some of the regulated streams are the Arkansas River, Petit Jean River, Muddy Fork of the Illinois River, Little Clear Creek, Little Mulberry Creek, Galla Creek, Ouachita Creek, Tupelo Bayou, West Fork Point Remove Creek, East Fork Point Remover Creek, Fourche LaFave River, Upper Poteau River, Sixmile Creek, Cypress Creek (Conway County), Maumelle River, and Flat Rock Creek (Sebastian County).

Duration of flow for selected streams is listed in Table 3-3. The table shows that only the streams with larger drainage have flows a large percentage of the time.

A geologic feature which impacts streamflow is faults. A USGS study (Freiwald, 1987) found that faults can alter flows in a stream. The fault provides an access for groundwater to exit from an aquifer to the stream or for surface water to enter an aquifer depending on the surface elevations of the two sources. The exact effect of faults on streamflow can not be determined unless a detailed study is made of a stream (Freiwald, 1987).

Streamflow variability at several selected sites in the Arkansas River Basin, illustrated in Figures 3-2a through 3-2f, shows that the annual discharge is below average more times than the annual discharge exceeds the average.

Low Flow Characteristics

In the Arkansas River Basin, minimum streamflows generally occur during July through October of each year. Management and development of surface water supplies depend on the rate of sustained streamflow during these dry periods. Indices generally used to define low flow characteristics of streams are the lowest mean discharges for seven consecutive days having recurrence intervals of 2 and 10 years. For simplicity, these indices are referred to as the 7-day Q2 (7Q2) and 7-day Q10 (7Q10) discharges, respectively. These discharges are taken from a frequency curve of annual values of the lowest mean discharge for seven consecutive days. Low flow characteristics of selected streams are shown in Table 3-4. The 7Q2 and 7Q10 discharges per square mile are also shown in Table 3-4 for comparison purposes. The 7Q2 and 7Q10 values were determined using U. S. Geological Survey streamflow data and the log Pearson Type III probability distribution (Riggs, 1972). A computer

Figure 3-2a Streamflow Distribution Graph
Baron Fork at Dutch Mills, Arkansas
Period of Record 1959 - 1984

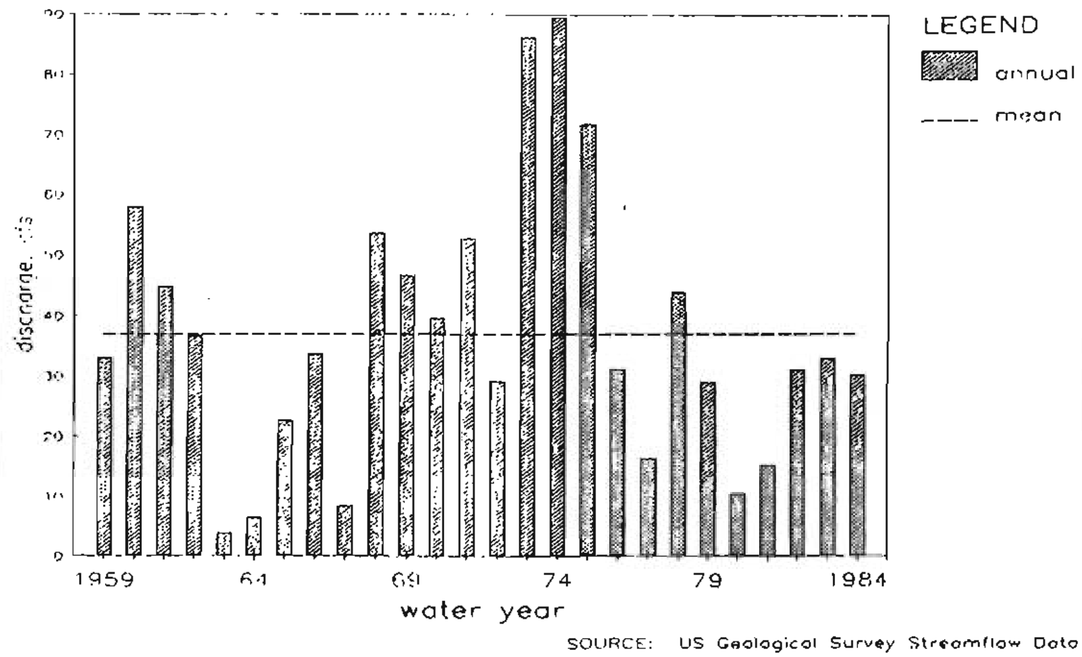


Figure 3-2b Streamflow Distribution Graph
Poteau River at Cauthron, Arkansas
Period of Record 1940 - 1984

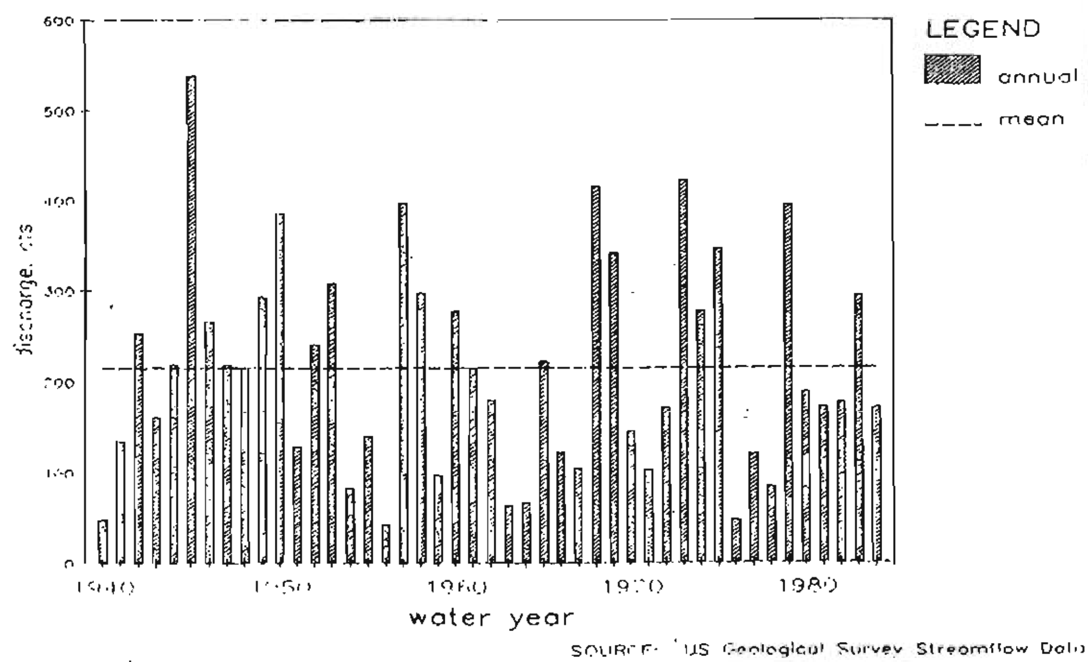


Figure 3-2c Streamflow Distribution Graph
Arkansas River near Van Buren, Arkansas
Period of Record 1970 - 1984

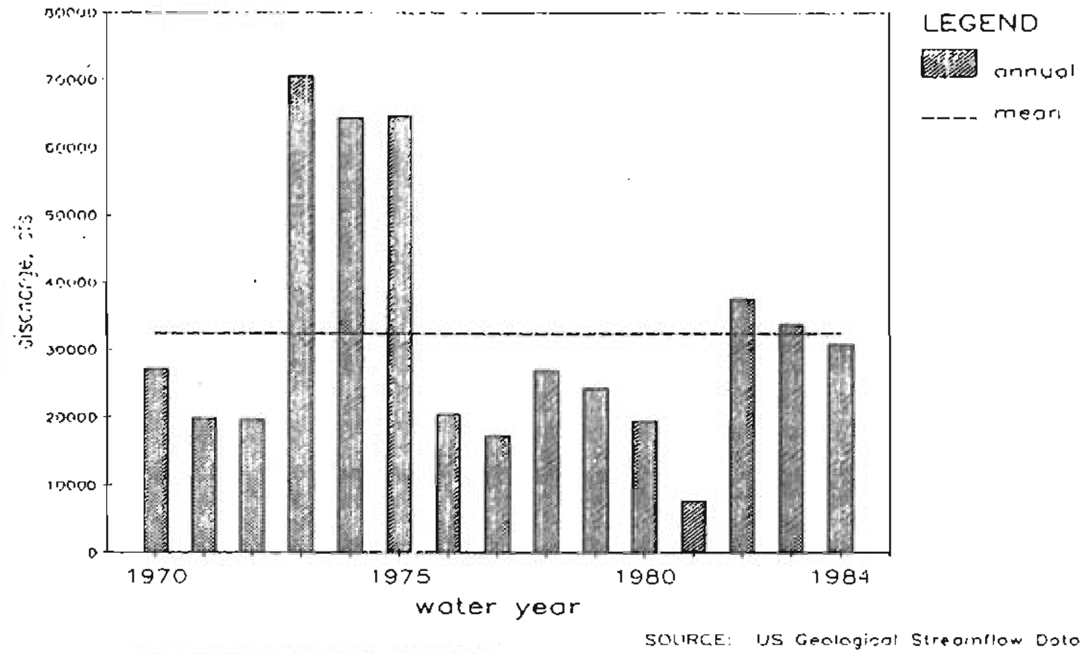


Figure 3-2d Streamflow Distribution Graph
Big Piney Creek near Dover, Arkansas
Period of Record 1951 - 1984

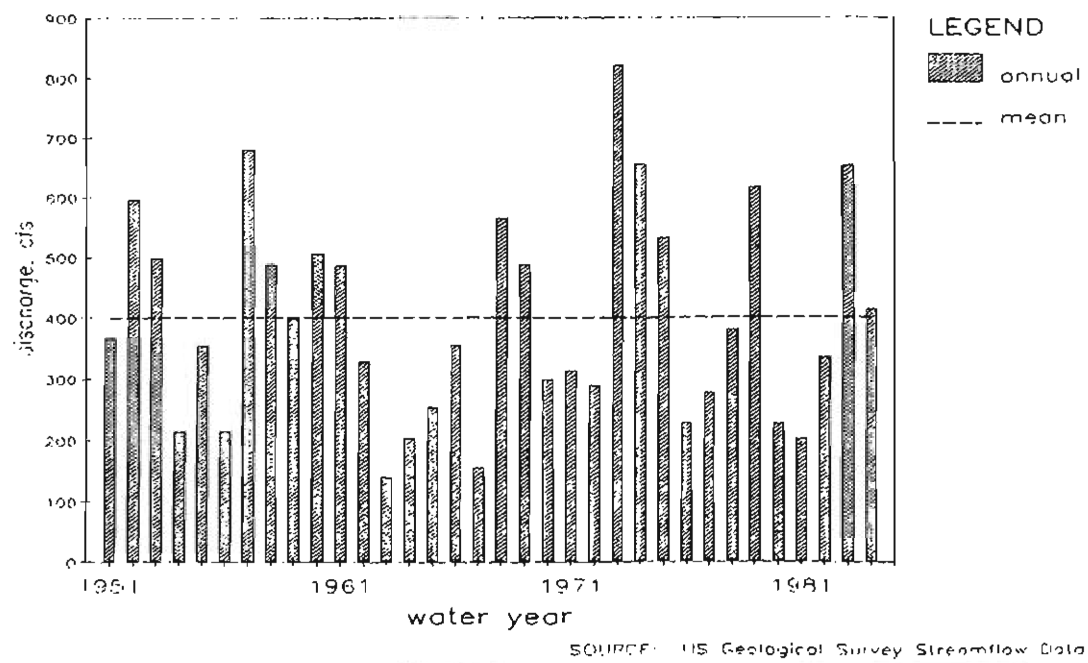
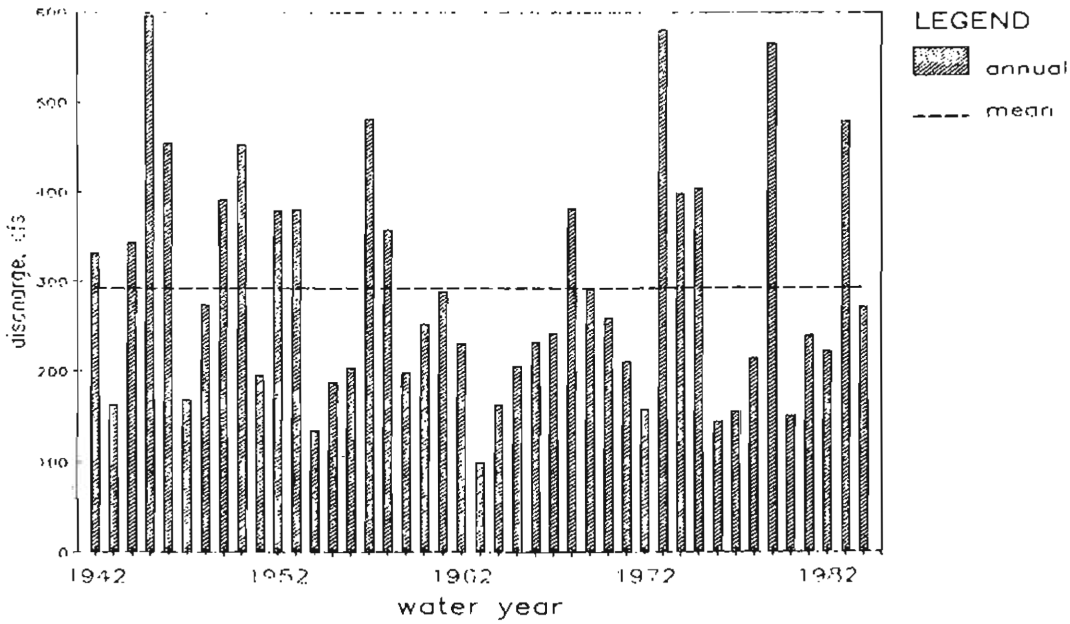
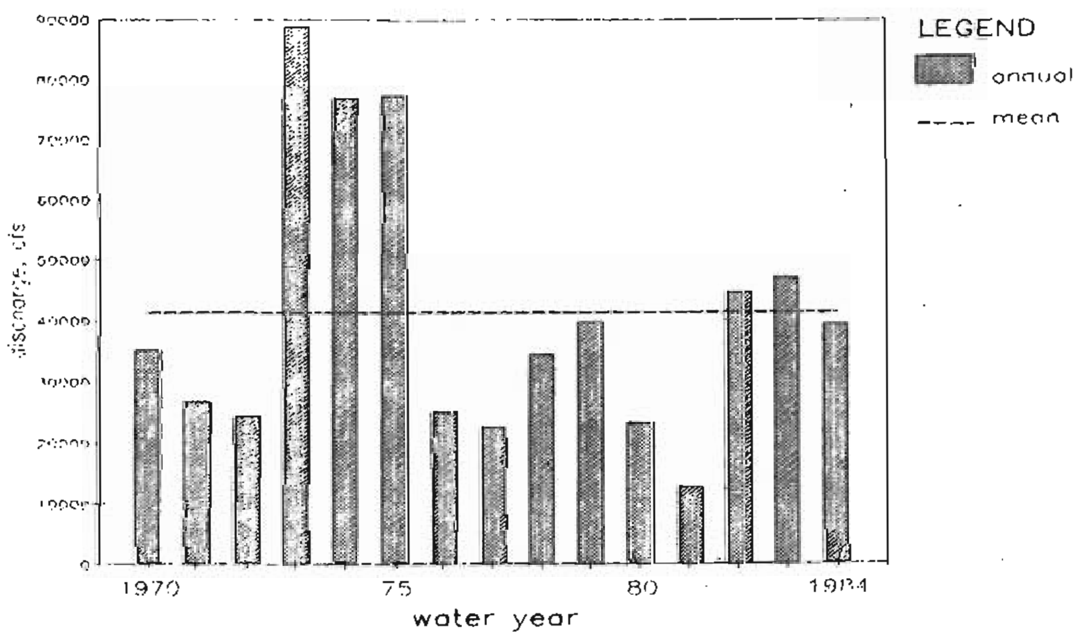


Figure 3-2e Streamflow Distribution Graph
South Fourche LaFave near Hollis, Arkansas
Period of Record 1942 - 1984



SOURCE US Geological Survey Streamflow Data

Figure 3-2f Streamflow Distribution Graph
Arkansas River near Little Rock, Arkansas
Period of Record 1970 - 1984



SOURCE: US Geological Survey Streamflow Data

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

U.S.G.S. GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOW PERIOD OF RECORD	DAILY MEAN FLOW, IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF THE TIME INDICATED IN COLUMN SUBHEADING																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	.5
07195800 Flint Creek at Springtown, AR	14	1969 - 84	.4	.8	1.2	1.3	2.3	2.8	3.8	4.7	5.1	7.3	8.3	12	16	26	37	58	39	140
07196900 Baron Fork at Dutch Mills, AR	46	1959 - 84	0	0	.1	.1	.3	.6	1.6	3	5.4	9.2	15	24	38	43	130	305	470	360
07247000 Poteau River at Cauthron, AR	203	1940 - 84	0	0	0	0	0	.4	2.3	5.2	17	33	55	105	185	430	830	1950	3200	4300
07249400 James Fork near Hackett, AR	147	1959 - 84	0	0	0	0	.3	.9	3.1	7	14	29	44	72	120	249	570	1150	1960	2850
07250000 Lee Creek near Van Buren, AR	426	1931-37 ; 1951-84	0	0	0	0	.1	1.7	10	27	54	114	218	335	560	1120	2050	3900	5800	9200
07250550 Arkansas River at Dam 13 near Van Buren, AR	150,547	1970 - 84	21	36	57	113	930	2400	6100	9500	13000	19500	27000	37000	52000	84000	118000	147000	164000	170000
07252000 Mulberry River near Mulberry, AR	373	1939 - 84	0	0	0	.1	.6	3.7	15	41	104	171	275	430	710	1300	1950	3750	5500	8600
07255000 Sixmile Creek at Caulksville, AR	104	1955 - 69	0	0	0	0	.1	.1	.5	2.1	4.6	12	26	51	102	258	420	770	1140	1630
07256500 Spadra Creek at Clarksville, AR	61	1953 - 70	0	0	0	0	.6	1.4	2.9	4.9	9.4	18	31	53	85	172	307	610	940	1375
07257000 Big Piney Creek near Dover, AR	274	1951 - 84	0	0	0	0	.5	2.8	11	28	62	120	193	310	530	938	1480	2800	4250	6300

SOURCE: US Geological Survey Streamflow Data

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

U.S.G.S. GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOW PERIOD OF RECORD	DAILY MEAN FLOW, IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR PERCENTAGE OF THE TIME INDICATED IN COLUMN SUBHEADING																	
			99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	.5
07258500 Petit Jean River near Booneville, AR	241	1940 - 84	0	0	0	0	0	.2	1.3	6.9	17	35	65	118	220	497	1000	2375	4100	6100
07260000 Dutch Creek at Waltreak, AR	61	1946 84	0	0	0	0	0	0	.8	3.8	9	18	30	51	92	187	385	830	1380	2150
07260500 Petit Jean River at Danville, AR	764	1948 - 84	.8	1.8	2.6	3.8	6.3	12	26	45	165	173	318	770	1700	2460	2950	3750	4800	6200
07261000 Cadron Creek near Guy, AR	169	1955 - 84	0	0	0	0	.3	2.2	13	24	50	98	157	228	345	669	1030	2050	3100	4900
07261500 Fourche LaFave River near Gravelly, AR	410	1940 - 84	0	0	0	0	.1	1.7	8.2	31	66	121	199	325	570	1140	2175	4400	6800	11000
07263000 South Fourche LaFave River near Hollis, AR	210	1942 - 84	0	0	0	0	0	.7	5.2	12	24	52	88	150	253	599	1140	2520	4400	6900
07263450 Arkansas River at Murray Lock and Dam, Little Rock, AR	158,030	1970 - 84	168	640	930	1400	2300	4050	7900	12300	16700	23500	33800	47000	65000	100000	132000	174000	198000	219000

SOURCE: US Geological Survey Streamflow Data

TABLE 3-4 LOW FLOW CHARACTERISTICS

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOWW PERIOD OF RECORD	7Q2 (cfs)	7Q2/SQ. MI. (cfsm)	7Q10 (cfs)	7Q10/SQ. MI. (cfsm)
07195800 Flint Creek at Springtown, AR	14	1963 - 84	2.8	.2	.9	.1
07196900 Baron Fork at Dutch Mills, AR	46	1960 - 84	.3	.006	0	0
07247000 Poteau River at Cauthron, AR	203	1941 - 84	.2	.001	0	0
07249400 James Fork near Hackett, AR	147	1960 - 9/84	.5	.003	0	0
07250000 Lee Creek near Van Buren, AR	426	1932-37 ; 1952-84	.5	.001	0	0
07250550 Arkansas River at Dam 13 near Van Buren, AR	150,547	1971 - 84	1882	.012	630	.004
07252000 Mulberry River near Mulberry, AR	373	1940 - 84	1.2	.003	0	0
07255000 Sixmile Creek at Caulksville, AR	104	1956 - 69	0	0	0	0
07256500 Spadra Creek at Clarksville, AR	61	1954 - 70	1.5	.024	0	0
07257000 Big Piney Creek near Dover, AR	274	1952 - 84	.9	.003	0	0
07258500 Petit Jean River near Booneville, AR	241	1941 - 84	<0.1	0	0	0
07260000 Dutch Creek at Waltreak, AR	61	1947 - 75	0	0	0	0

SOURCE: USGS Streamflow records.

TABLE 3-4 LOW FLOW CHARACTERISTICS (cont.)

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	STREAMFLOW PERIOD OF RECORD	7Q2 (cfs)	7Q2/SQ. MI. (cfsm)	7Q10 (cfs)	7Q10/SQ. MI. (cfsm)
07260500 Petit Jean River at Danville, AR	764	1949 - 84	7.2	.009	1.9	.002
07261000 Cadron Creek near Guy, AR	169	1956 - 84	.3	.002	0	0
07261500 Fourche LaFave River near Gravelly, AR	410	1941 - 84	.9	.002	0	0
07263000 South Fourche LaFave River near Hollis, AR	210	1943 - 84	<0.1	0	0	0
07263450 Arkansas River at Murray Lock and Dam, Little Rock, AR	158,030	1971 - 84	2685	.017	684	.004

SOURCE: USGS Streamflow records.

program mathematically fits the frequency curve to the discharge data, and the 7Q2 and 7Q10 values are then taken from the curve generated by the program. If a stream is dry during any part of the year, however, this procedure is not directly applicable and a graphical solution for determining the low flow characteristics must be used.

It should be noted that extrapolation of the 7Q2 and 7Q10 indices in Table 3-4 to other reaches on the streams or to other streams in the basin can be particularly dangerous if made without knowledge of the basin characteristics and without knowledge of the effects of man-made practices. For example, the diversion of water at many locations along a stream affects the low-flow characteristics throughout much of the stream reach. Also, the effects could be different if there are several large industrial and municipal effluent dischargers along a stream.

Table 3-4 shows that only two of the gaged streams at the gage originating in the Arkansas River Basin have a 7Q10 greater than zero. Flint Creek has a 7Q10 of 0.9 cfs which is due to the geology of the drainage area. The Petit Jean River at Danville has a 7Q10 of 1.9 cfs which is due to the stream being regulated by Blue Mountain Dam and the large drainage area 764 square miles.

INSTREAM FLOW REQUIREMENTS

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

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

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

Water Quality Requirements

One of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The 7Q10 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 ADPC&E monitors water-quality conditions in streams meeting or exceeding the 7Q10 discharge. The ADPC&E monitors point source discharges in streams when flows are less than the 7Q10 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. There are several streams listed in Table 3-4 which have a 7Q10 of zero. With this situation, discharge of wastes into streams have been limited about 10 percent of the time.

Regulated streams are examined individually by ADPC&E to determine instreamflow requirements for water quality. Streamflow records which represent the existing pattern of regulation were used in the determination of the 7Q10. If significant changes are made in the method of reservoir regulation in the Arkansas River Basin, the 7Q10 values should be recomputed. A list of modified streams is in the Flow Characteristics Section of this report.

Fish and Wildlife Requirements

Instream flow requirements for maintenance of fish and wildlife populations in the Arkansas River Basin are based on an unpublished Arkansas Game and Fish Commission report (Filipek, et. al., 1986). According to this report, several methods are presently available for determining instream flow requirements for fisheries. Some of these methods require considerable field work to characterize fish habitats in the basin. However, Tennant (1975) developed a method (sometimes referred to as the "Montana Method") which utilizes historic hydrologic records to estimate instream flow requirements for fish and other aquatic life. Results of Tennant's comprehensive study showed that: (1) 10% of the average annual streamflow is the minimum flow recommended for short-term survival of most aquatic forms, (2) 30% of the average annual streamflow is recommended to sustain a good survival habitat, and (3) 60% of the average annual streamflow is recommended to provide excellent to outstanding habitat for most aquatic life forms. Tennant also suggested that the flow regimens should be altered to fit different hydrologic cycles or to coincide with vital periods of the life cycle of fish.

Filipek and others (1986) 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. Table 3-5 describes the three physical/biological seasons used in the "Arkansas Method" and the flow recommended for maintenance of fisheries during each season. The instream flow requirements, as determined by the Arkansas Method, are those that apply to fish populations only. The "Arkansas 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 Arkansas River Basin. Instream flow requirements for fisheries were determined for several selected gaging stations and the results are shown in Table 3-5.

If instream flow requirements are needed at other ungaged locations on the stream and additional information about the basin is not available, the following procedure may be used. Mean monthly flows from the gaging station closest to, or most representative of, the point in interest can be adjusted based on a ratio of the drainage areas. The Arkansas Method may then be applied to these mean monthly flows to determine the instream flow requirements at the point in question. Because there are relatively few gaging stations with historic record in the Arkansas River Basin, this method does enable determination of mean monthly discharges and instream flow requirements at other points.

According to the report submitted to the Arkansas Soil and Water Conservation Commission by Filipek and others (1986), the recommended instream requirements as determined by the Arkansas method are "a practical and reasonable approach to protecting the state's fish, wildlife and other environmental resources" (Filipek et al, 1986). Therefore, to protect stream fisheries and to satisfy water needs for fish and wildlife in the Arkansas River Basin, the instream flow requirements as previously described for streams in this basin represent an amount of water that is unavailable for interbasin transfer.

Navigation Requirements

Streams in the Arkansas River Basin that are recognized by either state and/or Federal agencies as being partially or entirely navigable are the Arkansas River, Fourche Creek, Fourche LaFave River, Big Maumelle River, Petit Jean River, Little Maumelle River, Mulberry River, Illinois Bayou, Cadron River, and Plum Bayou. Most streams do not have a minimum flow requirement in order to maintain navigation. Also, the boating use of these streams, except for the Arkansas River, is limited to small recreational watercraft.

The Arkansas River is the only Federally maintained navigation system in the Arkansas River Basin. The entire Arkansas River navigation system stretches from the Mississippi River to Catossa, Oklahoma. Within the State

Table 3-5 Description of Physical/Biological Seasons in the Arkansas Method of Instream Flow Quantification

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

SOURCE: Filipek, et al, 1985

TABLE 3-6 MONTHLY FISH AND WILDLIFE REQUIREMENTS FOR SELECTED GAGING STATIONS

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	FISH AND WILDLIFE MONTHLY FLOW REQUIREMENTS (cfs)											
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT
07195800 Flint Creek at Springtown, AR	14	4.9	9.8	8.4	7.2	7.8	11	14	9.8	11	4	2.9	4
07196900 Baron Fork at Dutch Mills, AR	46	10	26	22	18	26	41	50	45	19	9	2	8
07247000 Poteau River at Cauthron, AR	203	28	87	151	152	211	250	252	308	116	33	15	20
07249400 James Fork near Hackett, AR	147	28	71	106	67	100	160	146	202	58	20	6	10
07250000 Lee Creek near Van Buren, AR	426	98	250	272	285	376	577	692	657	304	70	25	80
07250550 Arkansas River at Dam 13 near Van Buren, AR	150,547	9515	20718	16308	13092	16428	27504	36568	68941	36143	13215	6190	6230
07252000 Mulberry River near Mulberry, AR	373	73	269	333	344	491	628	774	701	286	64	37	48
07255000 Sixmile Creek at Caulksville, AR	104	14	41	65	53	74	118	114	164	42	132	58	44
07256500 Spadra Creek at Clarksville, AR	61	6.5	26	41	45	67	87	113	106	32	9.5	8	4.2
07257000 Big Piney Creek near Dover, AR	274	50	217	308	226	356	508	612	496	177	36	21	30
07258500 Petit Jean River near Booneville, AR	241	31	110	167	178	239	312	312	344	102	34	17	24
07260000 Dutch Creek at Waltreak, AR	61	12	43	69	80	91	116	130	118	29	17	5.5	5

TABLE 3-6 MONTHLY FISH AND WILDLIFE REQUIREMENTS FOR SELECTED GAGING STATIONS (cont.)

USGS GAGING STATION NUMBER AND LOCATION	DRAINAGE AREA (SQ. MI.)	FISH AND WILDLIFE MONTHLY FLOW REQUIREMENTS (cfs) OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT
07260500 Petit Jean River at Danville, AR	764	66	245	534	571	748	908	928	998	551	187	117	65
07261000 Cadron Creek near Guy, AR	169	29	148	248	211	268	353	349	310	122	25	30	39
07261500 Fourche LaFave River near Gravelly, AR	410	73	227	385	382	522	647	672	686	261	69	22	46
07263000 South Fourche LaFave River near Hollis, AR	210	29	114	253	245	299	395	364	314	111	24	19	32
07263450 Arkansas River at Murray Lock and Dam, Little Rock, AR	158,030	10095	25002	25548	18822	23646	37812	49210	48867	44254	14090	6655	6945

SOURCE: US Geological Survey Streamflow Data

of Arkansas, a series of twelve locks and dams have been constructed to provide a nine foot navigation channel from the Mississippi River to the Arkansas-Oklahoma state line.

The discharge to maintain navigation on the Arkansas River is currently quantified by the Little Rock District, U.S. Army Corps of Engineers to be 3,000 cubic feet per second (File Data). The original design of the navigation system required only flow to offset lockage requirements, seepage, and evapotranspiration, but additional flow is now needed to offset dam leakage in the system and limitations in controlling navigation pool levels.

For more information on the operation of the Arkansas River Navigation System see the Reservoir Regulation Section later in this chapter.

Interstate Compact Requirements

An interstate compact has been negotiated and signed by the states of Oklahoma and Arkansas. The area involved is: "the Arkansas River Basin immediately below the confluence of the Grand-Neosho River with the Arkansas River near Muskogee, Oklahoma, to a point immediately below the confluence of Lee Creek with the Arkansas River near Van Buren, Arkansas, together with the drainage basin of Spavinaw Creek in Arkansas, but excluding that portion of the drainage basin of the Canadian River above Eufaula Dam" (Arkansas River Compact) (See Figure 3-3).

As stated in Article I of the compact the purposes of the agreement are:

A. To promote interstate comity between the States of Arkansas and Oklahoma;

B. To provide for an equitable apportionment of the waters of the Arkansas River between the States of Arkansas and Oklahoma and to promote the orderly development thereof;

C. To provide an agency for administering the water apportionment agreed to herein;

D. To encourage the maintenance of an active pollution abatement program in each of the two States and to seek the further reduction of both natural and manmade pollution in the waters of the Arkansas River Basin; and

E. To facilitate the cooperation of the water administration agencies of the States of Arkansas and Oklahoma in the total development and management of the water resources of the Arkansas River Basin.

Apportionment of the waters of the Arkansas River Basin is defined in Article IV (Arkansas River Compact). The Article states:

A. The State of Arkansas shall have the right to develop and use the waters of the Spavinaw Creek Sub-basin subject to the limitation that the annual yield shall not be depleted by more than fifty percent (50%).

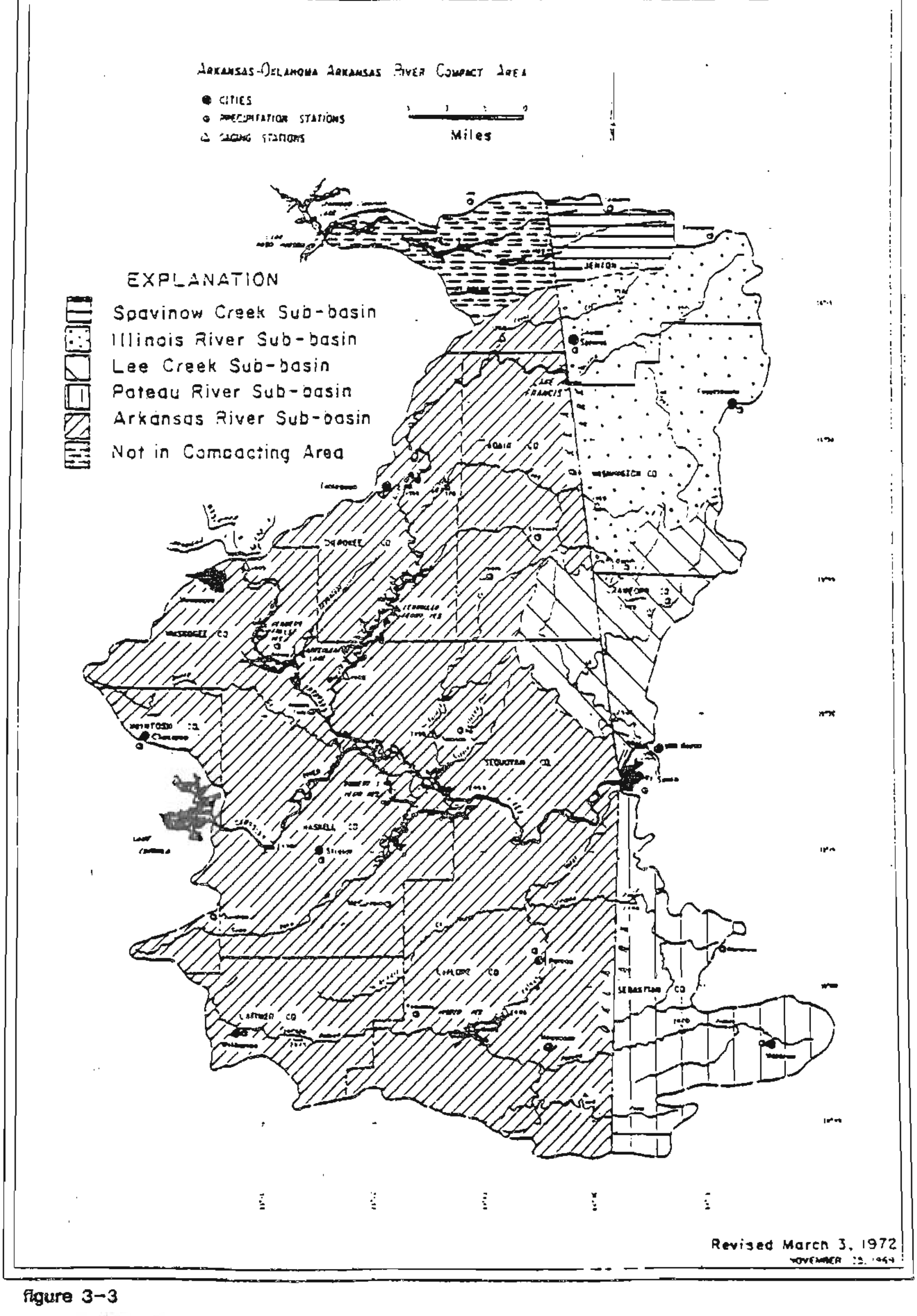

Arkansas-Oklahoma Arkansas River Compact Area
CITIES
PRECIPITATION STATIONS
GAGING STATIONS
Miles
EXPLANATION
Spavinow Creek Sub-basin
Illinois River Sub-basin
Lee Creek Sub-basin
Poteau River Sub-basin
Arkansas River Sub-basin
Not in Compacting Area
Revised March 3, 1972

figure 3–3

B. The State of Arkansas shall have the right to develop and use the waters of the Illinois River Sub-basin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

C. The State of Arkansas shall have the right to develop and use all waters originating within the Lee Creek Sub-basin in the State of Arkansas, or the equivalent thereof.

D. The State of Oklahoma shall have the right to develop and use all waters originating within the Lee Creek Sub-basin in the State of Oklahoma, or the equivalent thereof.

E. The State of Arkansas shall have the right to develop and use the waters of the Poteau River Sub-basin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

F. The State of Oklahoma shall have the right to develop and use the waters of the Arkansas River Sub-basin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

The annual yield of the interstate compact areas are to be determined by December 31 of each year. The Arkansas District of the Water Resources Division of the U.S. Geological Survey in cooperation with the Arkansas Soil and Water Conservation Commission computes the annual yield and deficiency of the subbasins.

The interstate compact flows are computed on an annual basis. If depletion of the flows is greater than that specified in the compact, steps shall be taken to assure that 60 percent of the current runoff be delivered to the downstream state (Arkansas River Compact). Table 3-7 lists the estimated interstate flow requirement based on mean annual flows. Also, Table 3-7 is based on the assumption that the flow of no stream will be significantly diverted. Depletion or accretions are not considered.

TABLE 3-7 Arkansas-Oklahoma Arkansas River Compact
Estimated Annual Depletion Allowances

Subbasin	Depletion (percent)	Mean Annual Flow (cfs)	Estimated Flow Requirement (cfs)
Spavinaw Cr.	50	108	54
Illinois River	60	688	275
Flint Creek at Springtown	60	13	5
Barren Fork at Dutch Mills	60	37	15
Lee Creek	100	546	0
Poteau River	60	527	211
James Fork nr Hackett	60	129	52
Poteau River at Cauthron	60	214	86
Arkansas River	60	21,597	8,639

Aquifer Recharge Requirements

Bedinger, et. al. (1963) estimated that the Arkansas River alluvial aquifer recharged at a rate of 10 inches per year or 130 mgd. The majority of recharge is attributed to rainfall. In addition, Bedinger, et. al. stated that during periods of high water in the Arkansas River there is water flow into the aquifer.

At the cities of Dardanelle and Ozark during 1960, it was determined that the cities' groundwater wells had reversed the aquifer's hydraulic gradient and were indirectly pumping water from the Arkansas River (Bedinger, et. al., 1963). Since 1960, Ozark has changed to surface water sources for municipal water supply.

Usually recharge has occurred before runoff enters the basin's principle stream system. The allocating of additional stream flows will not add greatly to the Arkansas River alluvium aquifer's water volume. Only during periods of high withdrawals from wells adjacent to the Arkansas River will the flow in the Arkansas River contribute to the groundwater supply.

An area of the Arkansas River Basin where groundwater recharge is especially important is the portion of the basin downstream of Little Rock. This area relies heavily on groundwater for agricultural and industrial purposes. Aquifer recharge from the Arkansas River decreases the farther downstream from Little Rock due the finer soil particles forming the channel. From an analysis of spring 1959 piezometric data, it was determined that the Arkansas River recharge the alluvial aquifer in Lincoln County at the rate of 1 mgd and the alluvial aquifer in Arkansas County at the rate of 8 mgd. From an analysis of fall 1959 piezometric data, it was determined that the Arkansas River recharge the alluvial aquifer in Lincoln County at the rate of 2 mgd and the alluvial aquifer in Arkansas County at the rate of 10 mgd (Bedinger and Jeffery, 1964).

Even though the information presented previously shows the Arkansas River to be a source of aquifer recharge, the river is also a gaining stream or outlet for aquifer discharge. Piezometric maps prepared by the U.S. Geological Survery have verified this to be true (Bedinger and Jeffery, 1964).

Riparian Use Requirements

The Arkansas Soil and Water Conservation Commission (AS&WCC) is required by Section 2 of Act 1051 of 1985 to determine riparian water needs of public water supplies, industry, and agriculture. Riparian water use has been registered with the AS&WCC since empowered by Arkansas Act 180 of 1957. In 1984, reported surface water use totalled approximately 1.04 million acre-feet of water in the Arkansas River Basin as determined from Arkansas Soil and Water Conservation Commission's records of registered diversions. Table 3-7 shows the amount of water diverted for the different uses representing the current riparian needs in the Arkansas River Basin. These quantities are probably low as it is difficult to monitor both the number of water users and quantity used.

TABLE 3-8

1984 ARKANSAS RIVER RIPARIAN WATER USE

Purpose	Quantity (acre-feet)
Irrigation	32,292
Industrial	8,030
Power (cooling)	966,169
Municipal	38,112
Miscellaneous	99
Total	1,044,710

Source: AS&WCC File Data

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

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

Aesthetic Requirements

Water based recreation is an important use of water in the Arkansas River Basin. There are many streams which, at times, have adequate flows to provide canoeists with favorable conditions. Fishermen are attracted to the many high quality "fishin' holes" that are available. Along the Arkansas River, the Corps of Engineers have developed many parks and campgrounds. State agencies have also developed many recreational areas within the basin.

Canoeists prefer the higher spring flows. Increased withdrawals in the springtime could adversely effect canoeists. The flow required by canoeists depends upon the canoeists' experience and daring. Determination of other instream flow requirements, especially fish and wildlife requirements have indirectly quantified the water needs for recreation.

Several streams in the Arkansas River Basin have special designations. The Mulberry River has been designated scenic by the Arkansas State Legislature. Designation of a scenic river is for the purpose of protection of natural and scenic beauty, water quality, and fish and wildlife of aquatic systems. Big Piney Creek and Cadron Creek are listed in the Arkansas Natural and Scenic River System. These special designations do not prohibit existing and future water withdrawals from designated scenic rivers. Instream flow requirements which have been established for water quality and fish and wildlife should protect the natural character of the streams in the basin.

In addition, there are 41 species in the Arkansas River Basin which are considered to threatened or endangered by federal and/or state concerns. The list, as furnished by the Arkansas Natural Heritage Commission, is as follows:

Anodonta suborbiculata	flat floater	
Amblyopsis rosae	Ozark cavefish	LT
Ambystoma annulatum	ringed salamander	
Caecidotea ancyla	isopod	
Cambarus causeyi	crayfish	
Cemophora coccinea copei	Northern scarlet snake	
Danella provonshai	mayfly	
Etheostoma cragini	Arkansas darter	
Etheostoma microperca	least darter	
Eurycea tynerensis	Oklahoma salamander	C2
Gomphus ozarkensis	Ozark clubtail dragonfly	
Heterodon nasicus gloydi	dusty hognose snake	
Hiodon alosoides	goldeye	
Hyla avivoca avivoca	bird-voiced tree frog	
Lampropeltis triangulum amaura	Louisiana milk snake	
Lirceus bicuspidatus	isopod	
Mesodon clenchi	calico rock oval	C2
Mesodon magazinensis	Magazine Mountain shagreen	C2
Moxostoma macrolepidotum	shorthead redhorse	
Nerodia cyclopion cyclopion	green water snake	
Notropis camurus	bluntface shiner	
Paravitrea aulacogyra	striate supercoil	
Percina phoxocephala	slenderhead darter	
Phenacobius mirabilis	suckermouth minnow	
Plethodon fourchensis	Fourche Mountain salamander	C2
Plethodon ouachitae	Rich Mountain salamander	
Plethodon serratus	Ouachita red-backed salamander	
Polyodon spathula	paddlefish	3C
Pseudosinella dubia	springtail	
Pseudacris streckeri streckeri	Strecker's chorus frog	
Rana areolata circulosa	Northern crawfish frog	
Rana sylvatica	wood frog	
Regina grahamii	Graham's crayfish snake	
Regina rigida sinicola	gulf crayfish snake	
Regina septemvittata	queen snake	
Rimulincola divalis	beetle	
Scaphiopus holbrookii hurterii	Hurter's spadefoot	
Sternotherus carinatus	razorback musk turtle	
Stygobromus elatus	elevated spring amphipod	
Stygobromus ozarkensis	Ozark cave amphipod	C2
Terrapene ornata ornata	ornate box turtle	

LT - Listed Threatened; the Fish and Wildlife Service (FWS) has listed these species as threatened.

C2 - Category 2; the FWS states that further biological research and field study will be necessary in order to determine if these species should be listed as threatened or endangered.

3C - These species have been reviewed by the FWS and the determination has been made that special designation is not warranted.

These species would be adversely impacted by low flow, since, they depend on surface water for their existence. All uses of surface water should be managed so that the negative affects on the species are minimized.

MINIMUM STREAMFLOW

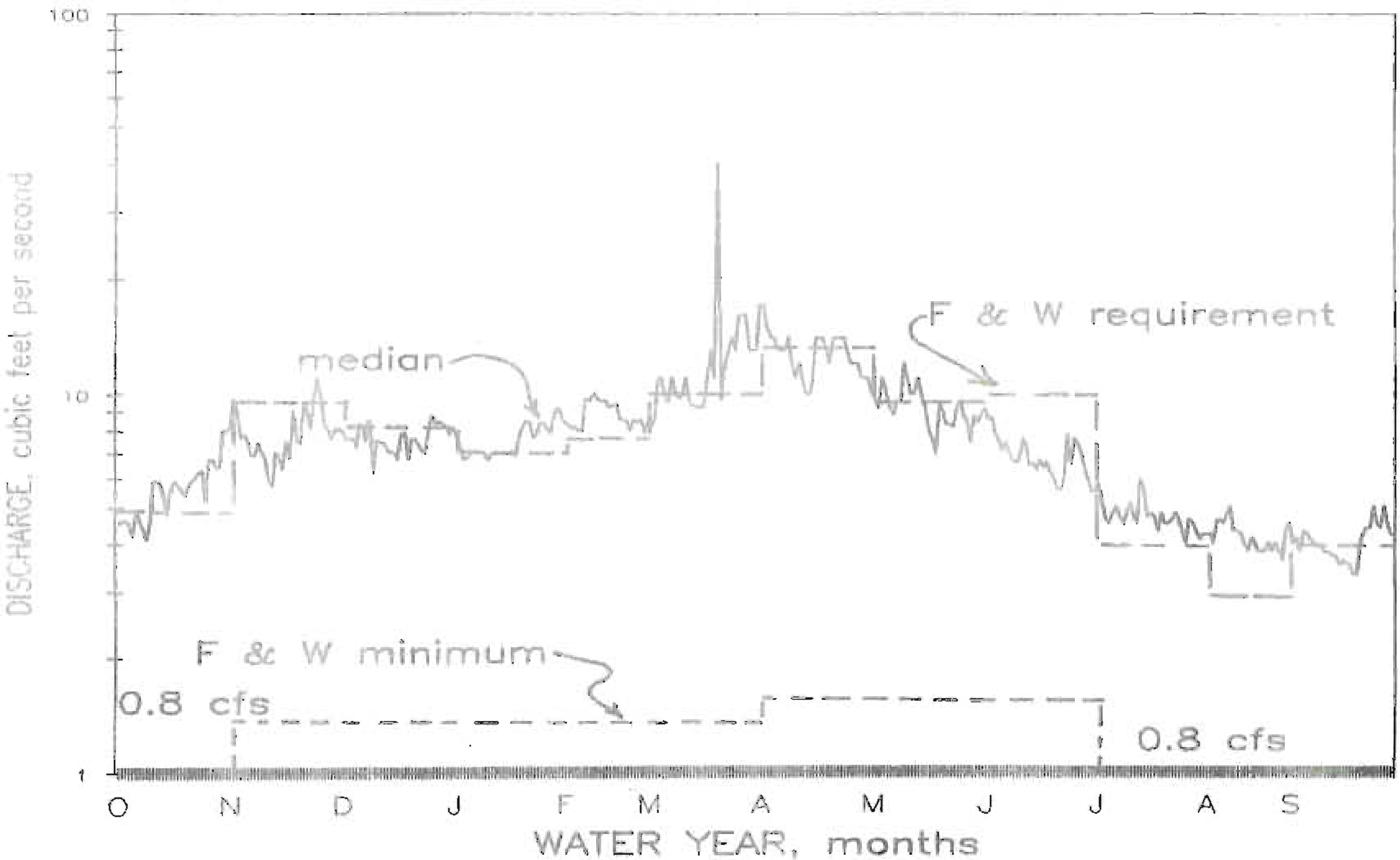
Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to establish minimum streamflows. Minimum streamflow is defined as the lowest daily mean discharge that will satisfy minimum instream flow requirements. Minimum streamflows are established for the purpose of protecting all instream flow needs during low-flow conditions which may occur naturally or during periods of significant water withdrawal from the streams. The minimum streamflow represents the point below which some instream flow need will not be met. This could be the instream flow requirements for water quality, fish and wildlife, navigation,interstate compact, aquifer recharge, riparian, or aesthetics. The minimum flow does not represent a target level or a flow that can be consistently maintained in a stream either seasonally or annually. Before the flow in a stream reaches the minimum flow, allocation of water based on the establishment of water use priorities should be in effect which would maintain streamflow at or above the established minimum discharge. When comparing the various recommendations for instream flow requirements, it was noted that the fish and wildlife recommendations at certain points were greater than some of the U.S. Geological Survey measured low flows. The flows recommended by the Arkansas Method are viewed as representing desirable conditions and not minimum instream flow needs.

The fish and wildlife requirement equals or exceeds the daily median flow at the four selected sites in Figure 3-3 within the Arkansas River Basin. Figures 3-3b and 3-3c are graphs of streams without base flow. Figures 3-3a and 3-3d have higher base flows due to geology and drainage area size, respectively. From these graphs, it is evident that the fish and wildlife recommendation did not provide for any excess flow.

In an attempt to define a more realistic stream flow, a revised fish and wildlife minimum was determined. As previously stated in the Instream Flow Requirements section, Tennant (1975) concluded from his study that 10 percent of the average annual streamflow is the minimum flow required for short-term survival of most aquatic life forms. Analysis of stream flow records for unregulated streams in the Arkansas River Basin showed that 10 percent of the average annual discharge was frequently higher than the daily median discharge during the summer months. (See Figures 3-3a through 3-3d.) High streamflows that generally occur during January through May increase the average annual discharge which causes the flow recommended by Tennant for short-term survival to exceed streamflow during the low-flow season.

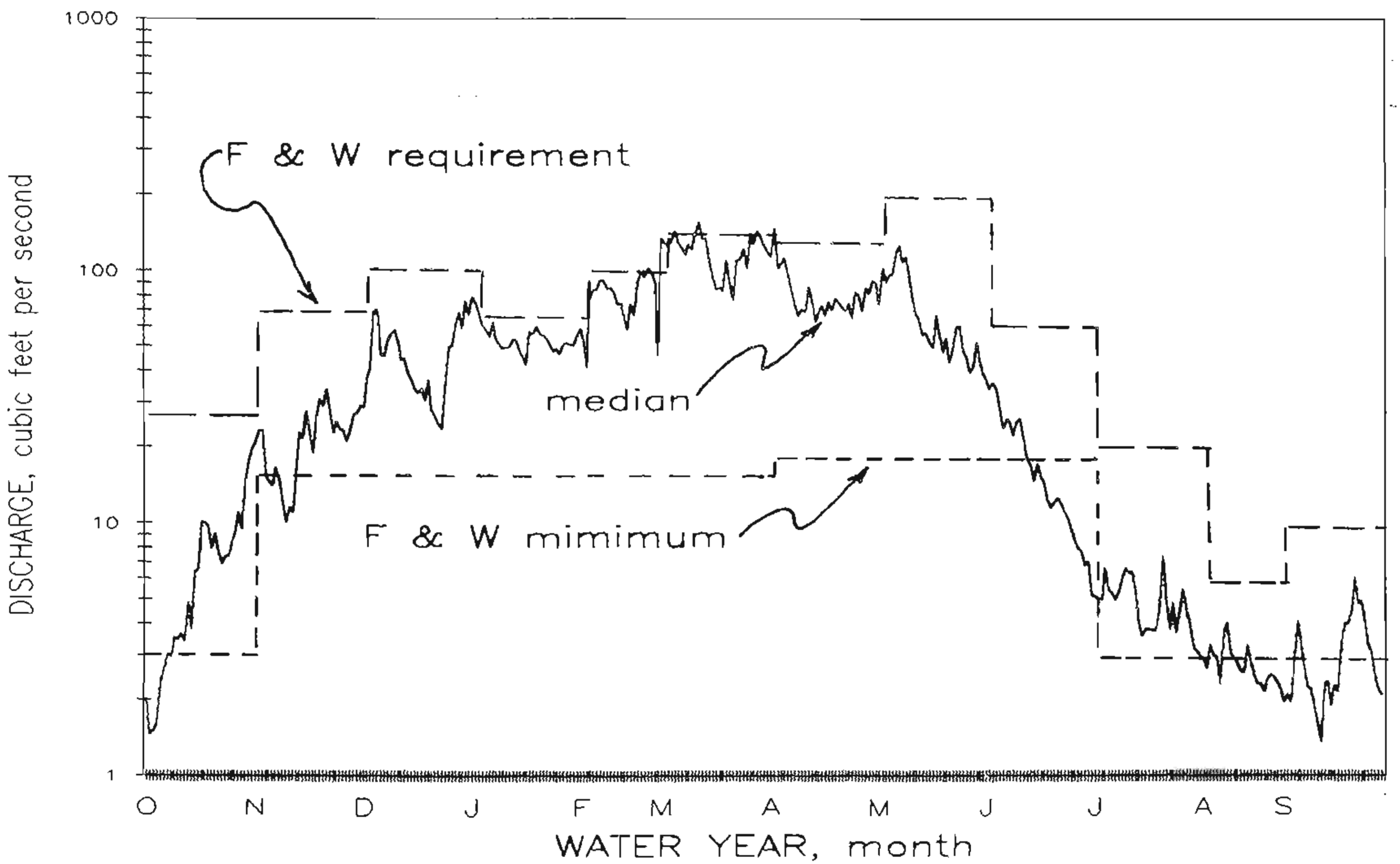
To account for the seasonal variability of streamflow in the basin, the year was divided into three seasons as identified in the Arkansas Method (Filipek et al, 1985). The seasons are based on physical processes that occur in the stream and the critical life stages of the fish and other aquatic organisms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

FIGURE 3-4a COMPARISON OF MEDIAN DAILY DISCHARGE AND SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE AT FLINT CREEK AT SPRINGTOWN, ARK.
Period of Record: 1962 to 1984.



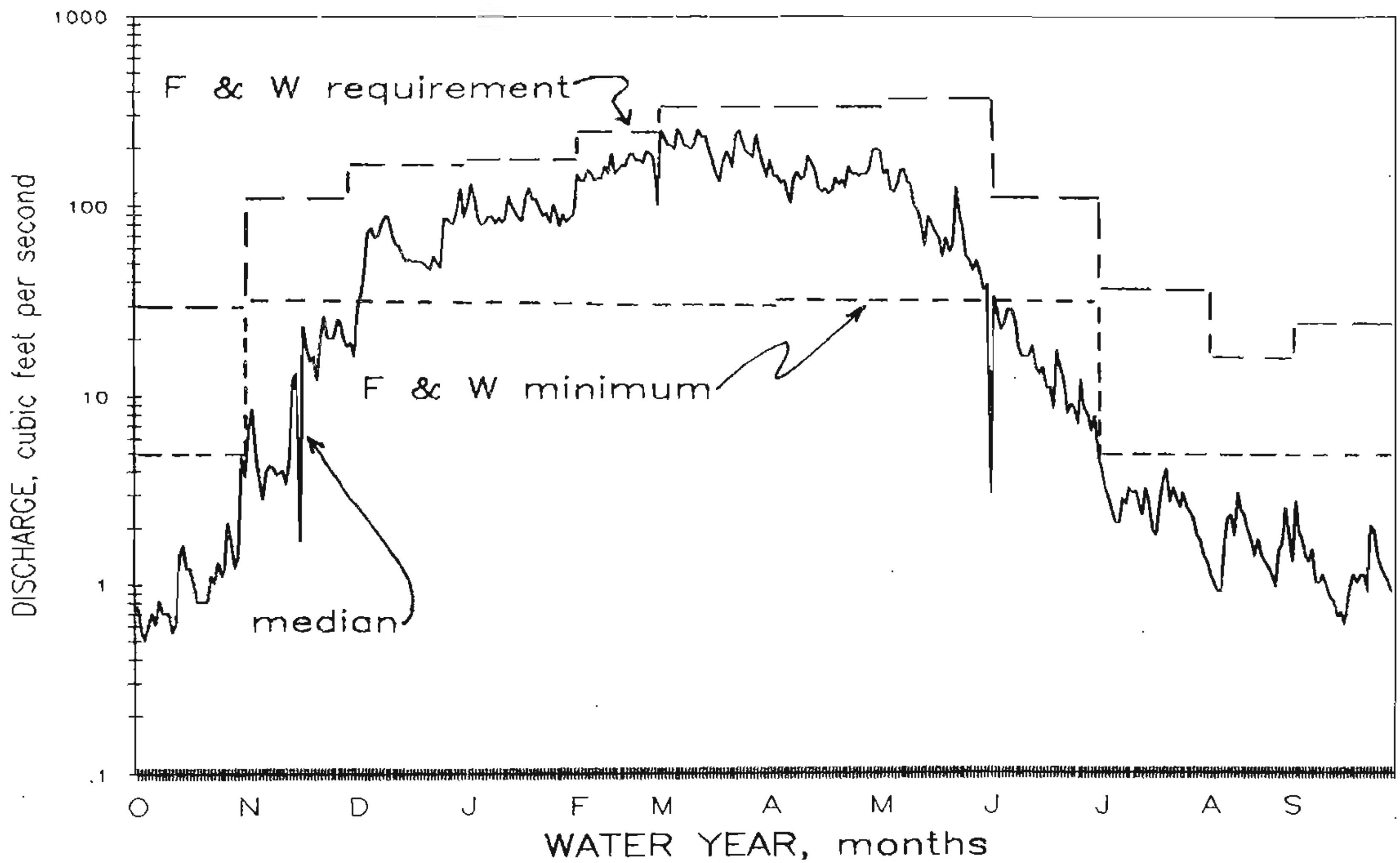
SOURCE: US Geological Survey Streamflow Data

FIGURE 3-4b COMPARISON OF MEDIAN DAILY DISCHARGE AND SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE AT JAMES FORK NEAR HACKETT, ARK.
Period of Record: 1959 to 1984



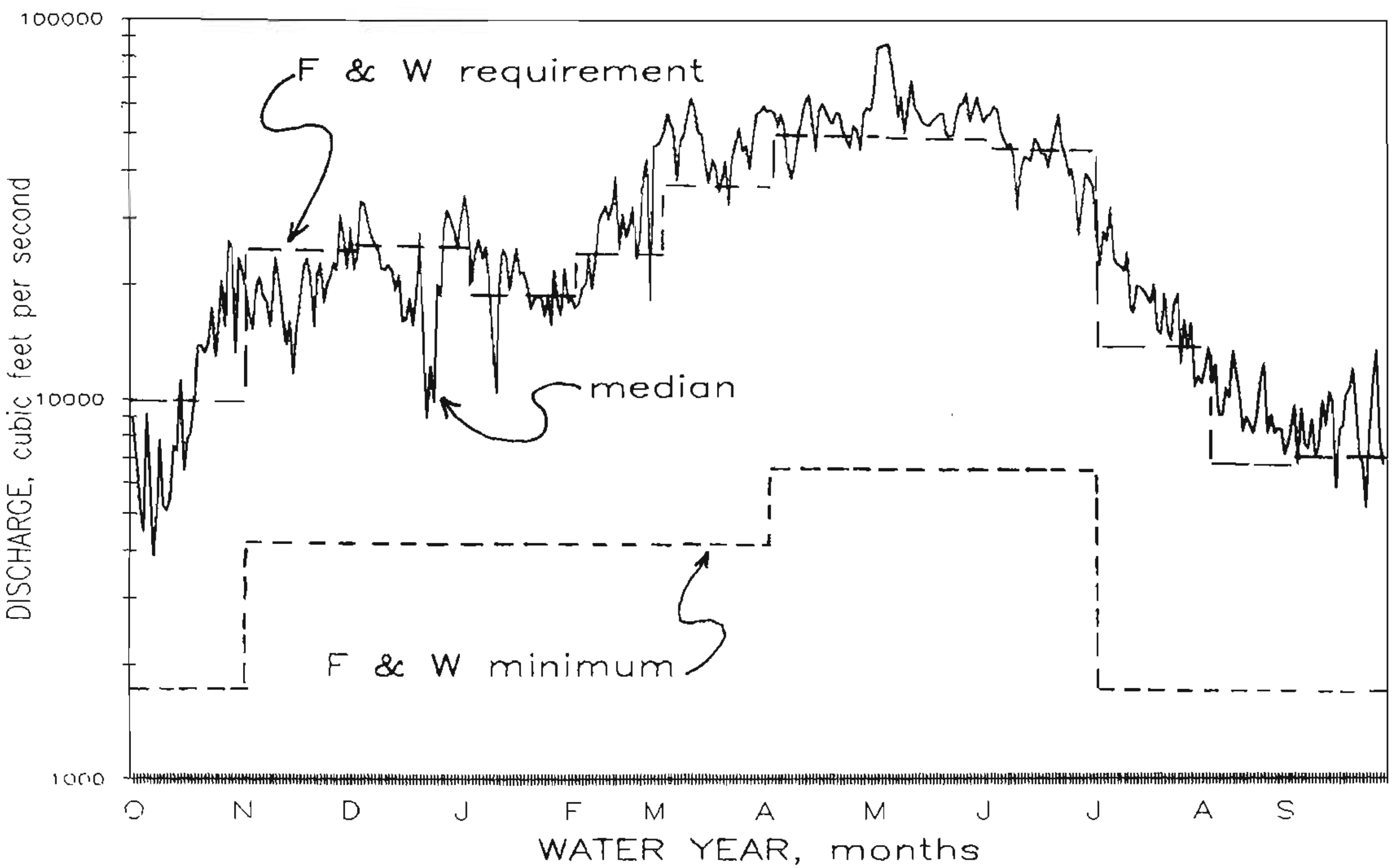
SOURCE: US Geological Survey Streamflow Data

FIGURE 3-4c COMPARISON OF MEDIAN DAILY DISCHARGE AND SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE AT PETIT JEAN RIVER NEAR BOONEVILLE, ARK.
Period of Record: 1940 to 1984



SOURCE: US Geological Survey Streamflow Data

FIGURE 3-4d COMPARISON OF MEDIAN DAILY DISCHARGE AND SELECTED INSTREAM FLOWS REQUIRED FOR FISH AND WILDLIFE AT ARKANSAS RIVER AT MURRAY DAM NEAR LITTLE ROCK, ARK.
Period of Record: 1970 to 1984



SOURCE: U.S. Geological Survey Streamflow Data

In addition to requirements for fish and wildlife, instream flow requirements for water quality, navigation, interstate compacts, and aesthetics were also considered in the determination of minimum streamflows. Since the instream flow requirements are not additive, 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 are shown in Table 3-9.

SAFE YIELD

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

To quantify the safe yield of streams in the Arkansas River Basin, the amount of water available on a dependable basis was designated as the discharge which has been equaled or exceeded 95 percent of the time for the available period of record. Not all of this flow is actually available for use. Minimum streamflow requirements (Table 3-9) which have been established for streams and rivers in the Arkansas River Basin and were previously defined in this report represent discharge that is not available for use. Therefore, the safe yield of a stream or river is defined here as the discharge which can be expected 95 percent of the time minus the discharge necessary to maintain minimum flow in the stream during the July to October low-flow season.

Table 3-10 shows the safe yield at several selected continuous gaging stations in the Arkansas River Basin. The safe yield was computed using mean daily flows for the period of record which is representative of current streamflow conditions. The instream flow requirement from Table 3-9 was for the low flow period of July through September. An analysis of Table 3-10 indicates there is no dependable flow available in the Arkansas River Basin during July through October for other uses.

Table 3-10 indicates that water is not available at times during the year on many of the streams. In order to assure the availability of water, a water storage structure must be constructed. The size of a water storage structure would be based on the estimated demand.

Potential for Development

There is potential for development of surface water resources in the Arkansas River Basin. The most desirable water storage impoundment sites are in forested areas. There would be opposition from environmentalists who are against damming free flowing streams.

Twenty-five potential sites were identified by the University of Arkansas College of Engineering (undated). Potential sites were identified using exiting information such as U.S. Geological Survey maps and other various information. Additional study is needed before any of these sites are

TABLE 3-9 MINIMUM STREAMFLOWS IN THE ARKANSAS RIVER BASIN

USGS GAGED STREAM AND GAGE LOCATION	MINIMUM FLOW AND GOVERNING INSTREAM REQUIREMENT BY SEASON					
	NOV - MAR		APR - JUNE		JULY - OCT	
	Flow, cfs	Requirement	Flow, cfs	Requirement	Flow, cfs	Requirement
Flint Creek at Springtown, AR	7.5	IC	8.5	IC	3.9	IC
Baron Fork at Dutch Mills, AR	18	IC	22	IC	5.6	IC
Poteau River at Cauthron, AR	114	IC	129	IC	19	IC
James Fork near Hackett, AR	67	IC	77	IC	13	IC
Lee Creek near Van Buren, AR	59	FW	79	FW	14	FW
Arkansas River at Dam 13 near Van Buren, AR	3135	FW	5412	FW	3000	N
Mulberry River near Mulberry, AR	69	FW	84	FW	11	FW
Sixmile Creek at Caulksville, AR	12	FW	15	FW	28	FW
Spadra Creek at Clarksville, AR	91	FW	12	FW	1.4	FW
Big Piney Creek near Dover, AR	54	FW	61	FW	6.8	FW
Petit Jean River near Booneville, AR	34	FW	36	FW	53	FW
Dutch Creek at Waltreak, AR	13	FW	13	FW	2	FW
Petit Jean River at Danville, AR	100	FW	118	FW	22	FW
Cadron Creek near Guy, AR	409	FW	37	FW	6	FW
Fourche LaFave River near Gravelly, AR	72	FW	77	FW	105	FW
South Fourche LaFave River near Hollis, AR	44	FW	38	FW	52	FW
Arkansas River at Murray Lock and Dam, Little Rock, AR	4361	FW	6778	FW	3000	N

LEGEND: IC - Interstate Compact FW - Fish and Wildlife N - Navigation

TABLE 3-10 SAFE YIELD OF STREAMS

USGS GAGED STREAM AND LOCATION OF GAGE	FLOW IN CFS WHICH WAS EQUALED OR EXCEEDED 95 % OF THE TIME	JUL - OCT MINIMUM STREAMFLOW (cfs)	SAFE YIELD (cfs)
Flint Creek at Springtown, AR	2.3	3.9	NA
Baron Fork at Dutch Mills, AR	.3	5.6	NA
Poteau River at Cauthron, AR	0	19	NA
James Fork near Hackett, AR	.3	13	NA
Lee Creek near Van Buren, AR	.1	14	NA
Arkansas River at Dam 13 near Van Buren, AR	930	3000	NA
Mulberry River near Mulberry, AR	.6	11	NA
Sixmile Creek at Caulksville, AR	.1	28	NA
Spadra Creek at Clarksville, AR	.6	1.4	NA
Big Piney Creek near Dover, AR	.5	6.8	NA
Petit Jean River near Booneville, AR	0	53	NA
Dutch Creek at Waltreak, AR	0	2	NA
Petit Jean River at Danville, AR	6.3	22	NA
Cadron Creek near Guy, AR	.3	6	NA
Fourche LaFave River near Gravelly, AR	.1	105	NA
South Fourche LaFave River near Hollis, AR	0	52	NA
Arkansas River at Murray Lock and Dam, Little Rock, AR	2300	3000	NA

recommended for development. Table 3-11 lists the estimated yields for the various sites. The twenty-five sites are estimated to have a cumulative yield of 1,255 mgd.

Smaller lake sites are more numerous, but the yield of these sites would be low.

TABLE 3-11 POTENTIAL SITE DATA

Stream	Drainage Area (sq. mi.)	Estimated Yield (mgd)
Spavinaw Creek	100	58
Coon Creek	15	9
Clear Creek	77	22
Cove Creek	40	23
Lee Creek	149	86
Mountain Fork Creek	38	22
Webber Creek	37	22
Cedar Creek	45	26
Mulberry River	373	216
Hurricane Creek	50	29
Fourche La Fave	85	50
Sugar Creek	57	33
Shoal Creek	50	22
Little Mulberry River	45	26
Horsehead Creek	120	70
Spadra Creek	31	18
Little Piney Creek	140	68
North Fork Illinois Bayou	86	50
Illinois Bayou	233	45
Gaffords Creek	39	17
South Fourche La Fave	230	123
West Fork Point Remove	95	55
East Fork Point Remove	122	46
Cadron Creek	165	57
East Fork Cadron Creek	88	34
North Fork Cadron Creek	71	28
Total		1,255

SOURCE: Engineering Planning and Evaluation of Potential Reservoir Sites, undated

WATER USE

Current Water Use

In 1980, the fifteen county study area used 267.61 mgd, in addition to 28,217 mgd for the production of electricity (Holland and Ludwig, 1981). (See Figure 3-4.) The 28,217 mgd used for hydroelectric production is not considered as part of the water used because it essentially is returned to the stream in the same area as it was withdrawn. The water is available for reuse downstream of the power plant and can be used in computations of excess streamflow. The study area water use by category and source is listed in Table 3-12.

A portion of the 267.61 mgd of water used was consumed. The consumed portion was either evaporated, transpired, ingested, or incorporated into a product. Consumptive water use in the study area amounted to 100.57 mgd or 38 percent of the 267.61 mgd of the water withdrawn (Holland and Ludwig, 1981).

TABLE 3-12 1980 USE OF SURFACE WATER IN THE

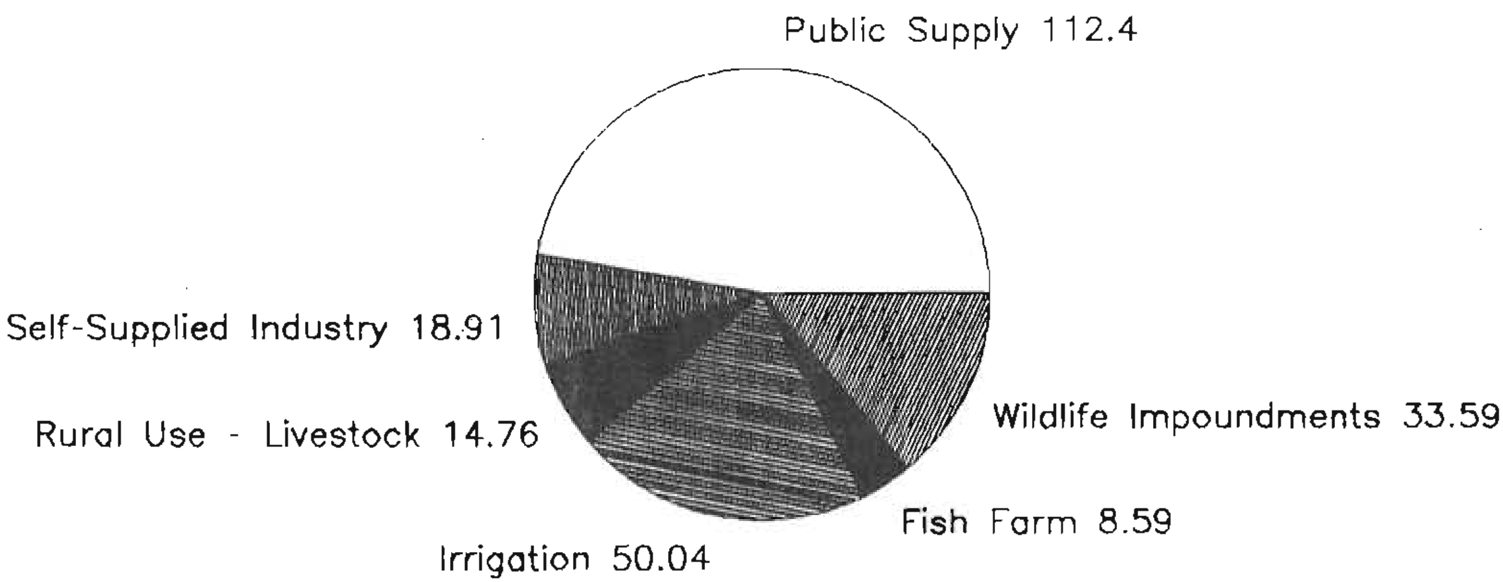
FIFTEEN COUNTY STUDY AREA

(million gallons per day)

USE CATEGORY	SURFACE WATER
Public Supply	112.40
Self Supplied Industry	8.05
Rural Use:	
Domestic	0
Livestock	14.76
Subtotal	14.76
Irrigation	
Rice	41.68
Other	49.54
Subtotal	91.22
Wildlife Impoundments	32.59
Fish and Minnow Farms	8.59
Electric Energy	
Hydropower	19,417.00
Thermoelectric	8,800.00
Subtotal	28,217.00
Total	28,484.61

Source: Holland and Ludwig, 1981.

Figure 3 - 5
SURFACE WATER USE IN THE ARKANSAS RIVER BASIN FOR 1980
(values in million gallons per day)



SOURCE: US Geological Survey Data

Water Use Trends

Water use data from 1960, 1965, 1970, 1975, and 1980 for the various uses are plotted in Figures 3-6a through 3-6g. All categories have shown increases which ranged from 82 percent for irrigation-other to 2,396 percent for irrigation-rice. Irrigation-other is the application of water to crops such as soybeans, cotton, vegetables, fruit trees, pasture, and other crops; but not to rice.

Projected Water Use

Table 3-13 shows the projected surface water use for the year 2030. The projections indicate that the use of water in the Arkansas River Basin could increase greatly by the year 2030. Increases in surface water use are projected to range from 40 percent for livestock water to 260 percent for public supply.

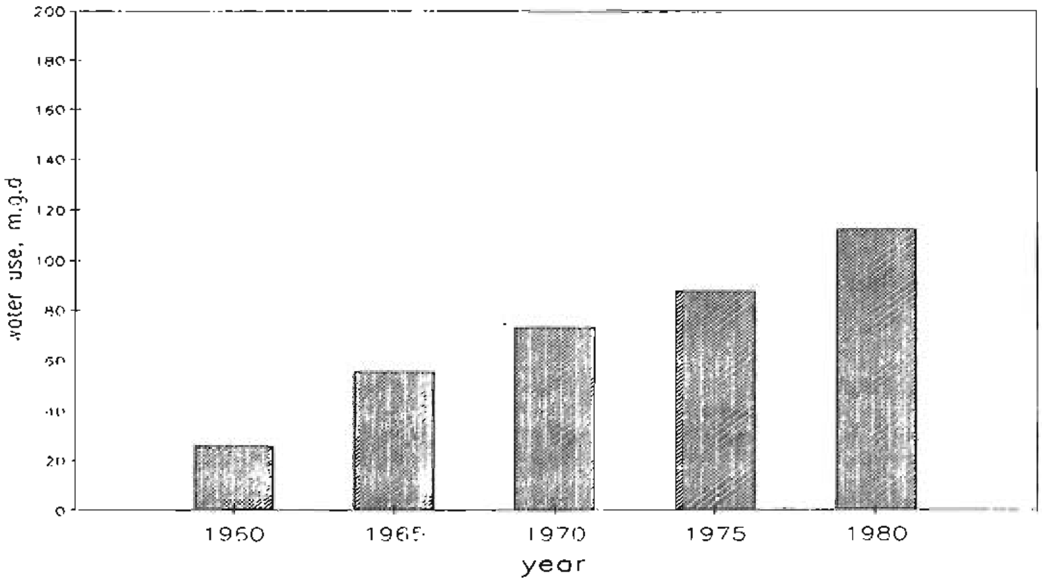
It is projected that hydroelectric energy production will increase dramatically by the year 2000 and continue to increase until all dams on the Arkansas River are developed. With the added hydropower units, surface water use in this category could increase by as much as 550 percent.

TABLE 3-13 SURFACE WATER USE FOR 1980 AND PROJECTIONS FOR 2030 BY CATEGORY (million gallons per day)

USE	1980 1/	2030 2/
Public Supply	102.8	370.0
Self-Supplied Industry	1.4	3.3
Rural Use:		
Domestic	0.0	0.0
Livestock	13.6	19.1
Subtotal (Rural Use)	13.6	19.1
Irrigation 3/	58.1	150.0 4/
Electric Energy	28,400.0	184,136.0 5/
Total	28,575.9	184,678.4

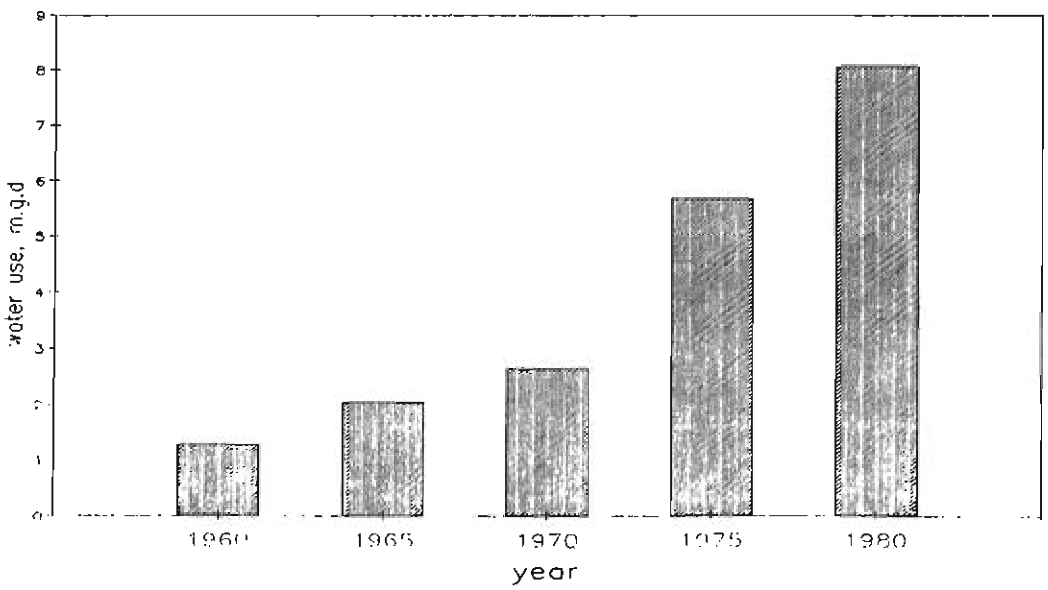
1/USGS, Use of Water in Arkansas, 1980. (Holland and Ludwig, 1981)
2/Arkansas Soil and Water Conservation Commission
3/Includes fish and minnow farms and wildlife impoundments.
4/Adjusted to reflect 140,000 acres of irrigated cropland.
5/Projected from Corps of Engineers file data.

FIGURE 3-6a SURFACE WATER USE FOR PUBLIC SUPPLY IN THE ARKANSAS RIVER BASIN 1960 - 1980



SOURCE: US Geological Survey Water Use Data

FIGURE 3-6b SURFACE WATER USE FOR SELF-SUPPLIED INDUSTRY IN THE ARKANSAS RIVER BASIN 1960 - 1980



SOURCE: US Geological Survey Water Use Data

FIGURE 3-6c SURFACE WATER USE FOR RURAL USE - LIVESTOCK WATER IN THE ARKANSAS RIVER BASIN 1960 - 1980

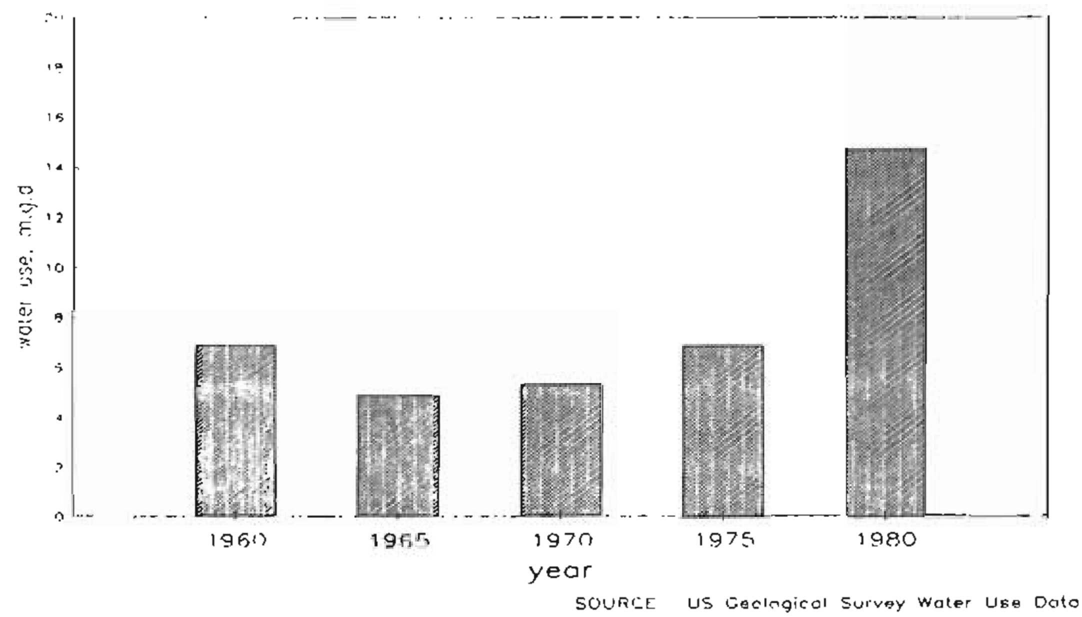


FIGURE 3-6d SURFACE WATER USE FOR IRRIGATION - RICE IN THE ARKANSAS RIVER BASIN 1960 - 1980

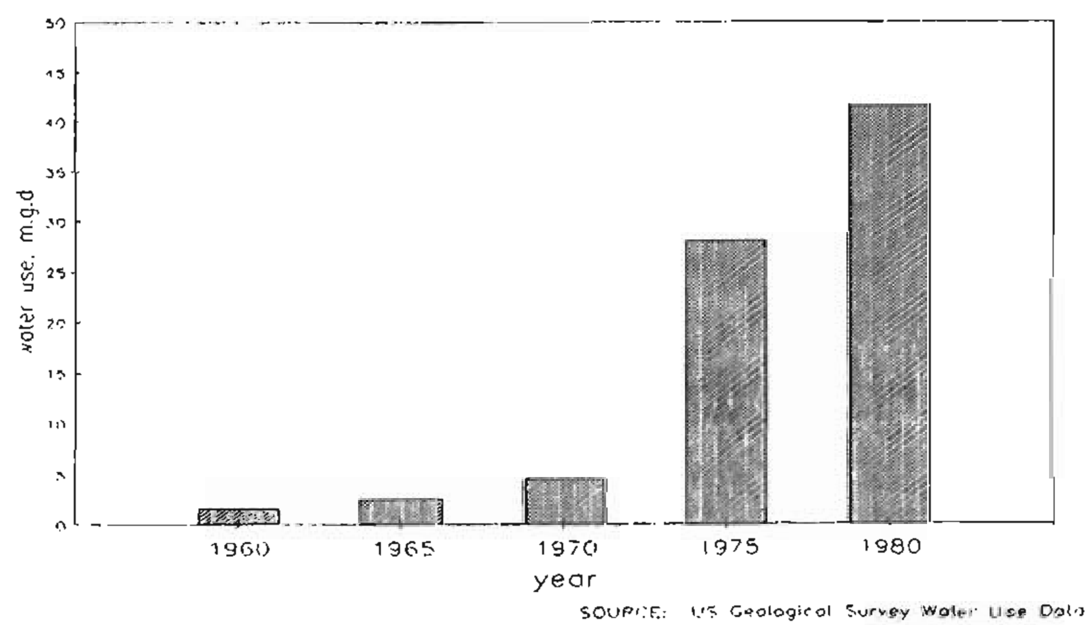


FIGURE 3-6e SURFACE WATER USE FOR IRRIGATION - OTHER IN THE ARKANSAS RIVER BASIN 1960 - 1980

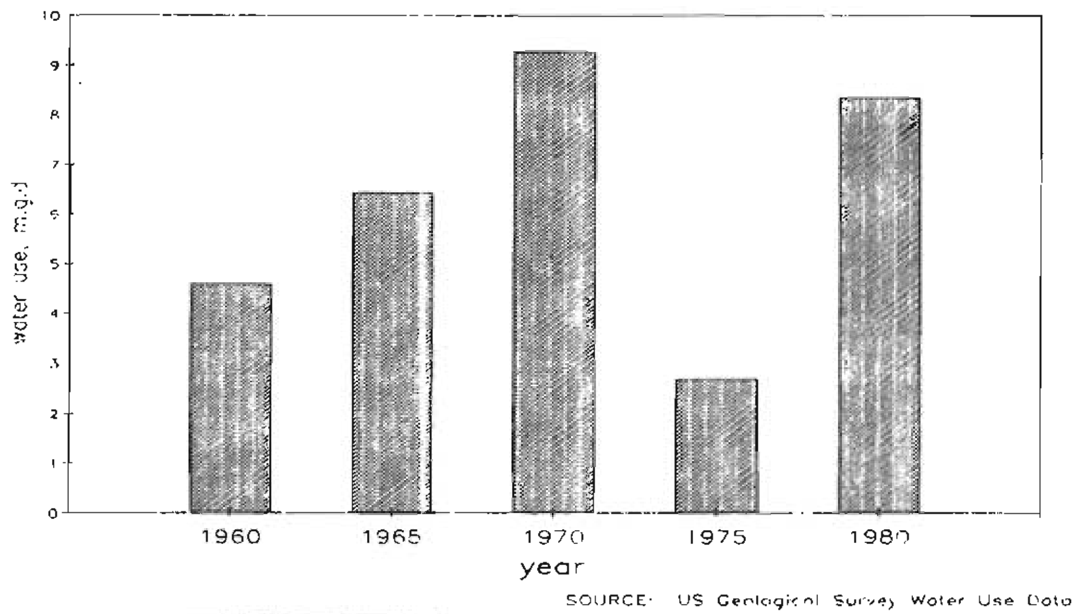


FIGURE 3-6f SURFACE WATER USE FOR FISH FARMING IN THE ARKANSAS RIVER BASIN 1960 - 1980

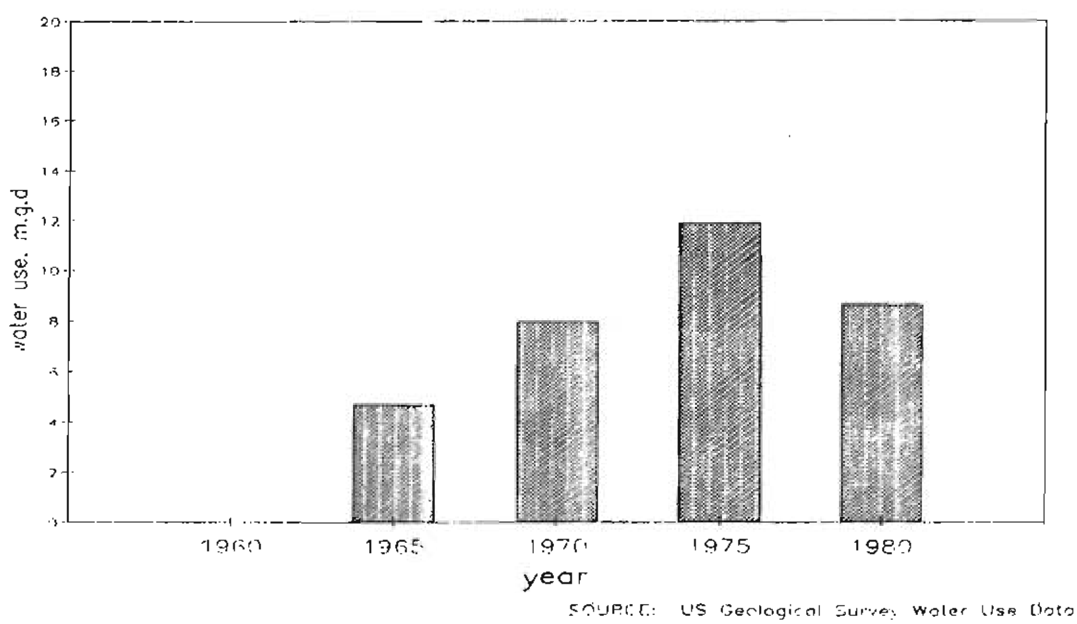
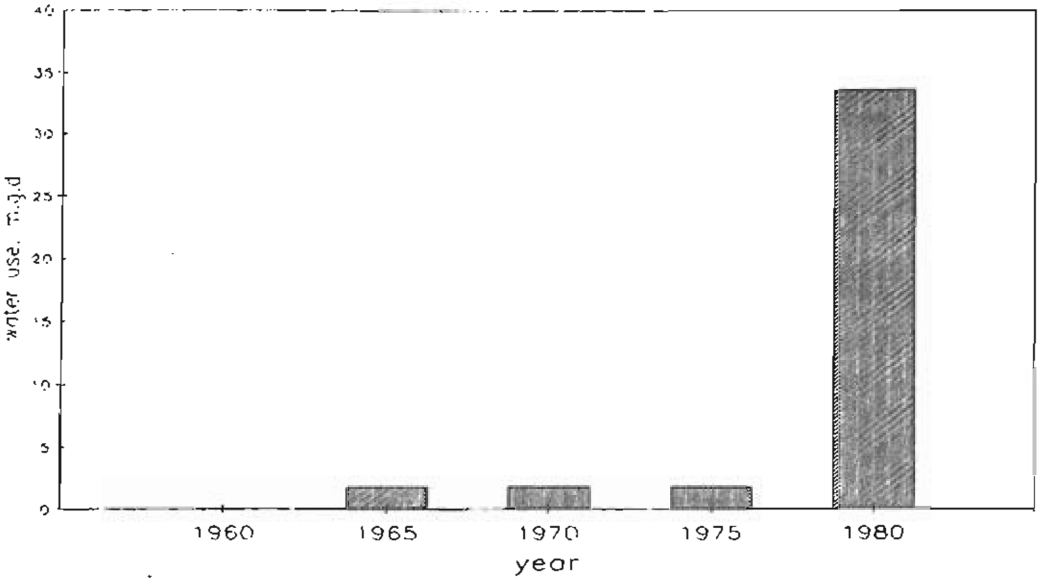


FIGURE 3-6g SURFACE WATER USE FOR WILDLIFE IMPOUNDMENTS IN THE ARKANSAS RIVER BASIN 1960 - 1980



SOURCE US Geological Survey Water Use Data

Excess Streamflow

Excess streamflow is required to be quantified by Act 1051 of 1985. In this Act, excess streamflow is defined as twenty-five percent of that amount of water available on an average annual basis above the amount required to satisfy the existing and projected water needs of the basin. In the Arkansas River Basin, the determination of the amount of available water was based on the mean annual flow of the Arkansas River at Murray Lock and Dam at Little Rock. The mean annual flow at Murray Lock and Dam was adjusted based on drainage area ratio to represent the discharge at the extreme downstream end of the basin. The average annual discharge at the downstream point of the Arkansas River Basin is 29.9 million acre-feet.

The fish and wildlife requirement will satisfy all of instream needs within the basin. The volume of water needed to meet the fish and wildlife requirement is 18.6 million acre-feet or 62.6 percent of the mean annual flow. The 62.6 percent of the mean annual flow was computed by using a weighted average of the monthly flows for fish and wildlife requirement.

Projected water use in the Arkansas River Basin is estimated to be 0.6 million acre-feet excluding hydropower use.

The available water is computed by subtracting the flow necessary to satisfy instream flow requirements and the projected water use from the instream discharge. The computation is shown below.

available water = instream discharge - (instreamflow requirement + projected water use)

available water = 29.9 million ac-ft/yr - (18.6 million ac-ft/yr + 0.6 million ac-ft/yr)

available water = 10.7 million acre-feet per year

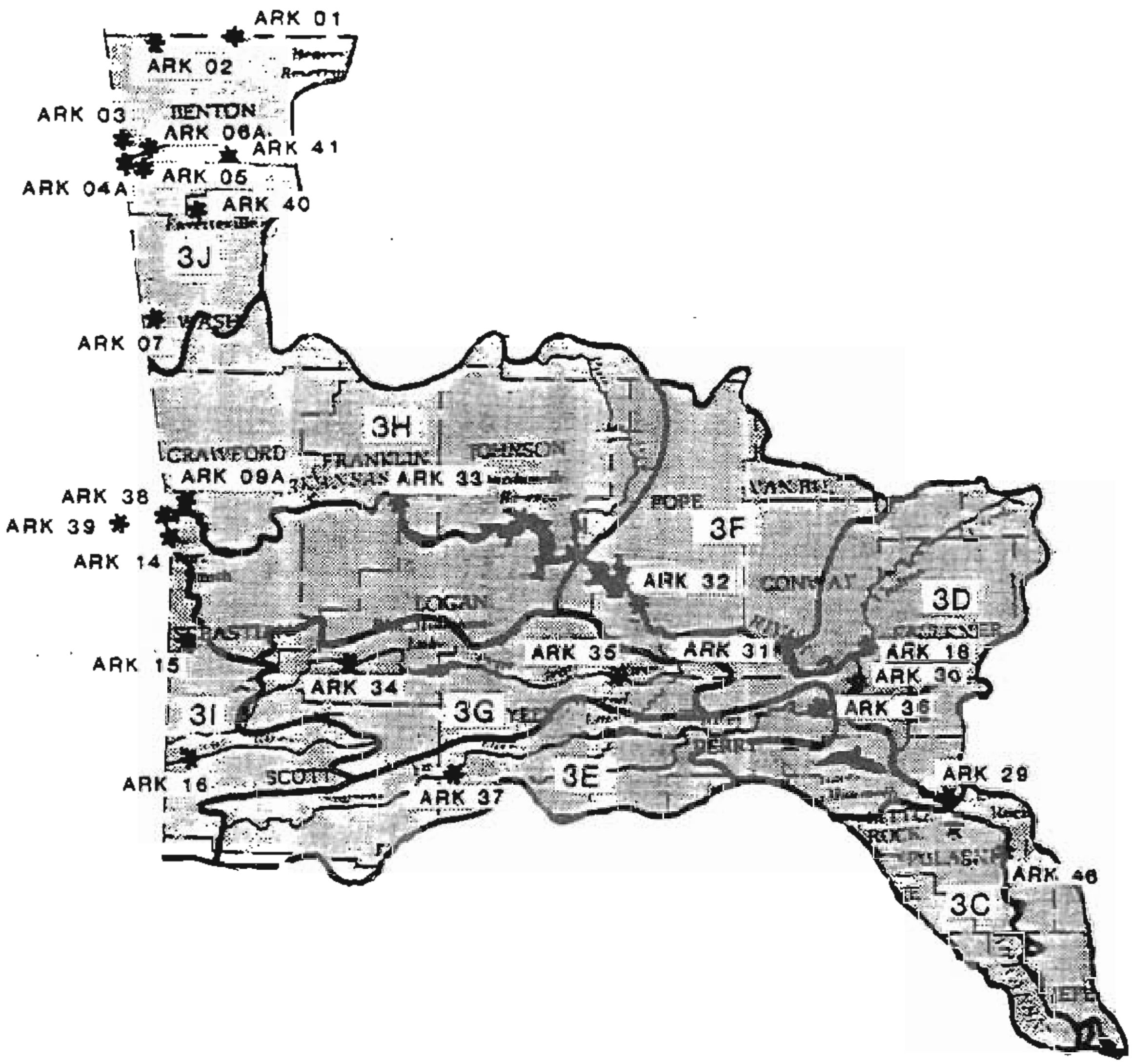
As directed by Act 1051 of 1985, the quantity of excess water is 25 percent of the volume of available water. The quantity of excess water on an average annual basis from the Arkansas River Basin is 2.7 million acre-feet.

QUALITY OF STREAMFLOW

Introduction

Surface water quality has been addressed in the reports "Water Quality Inventory Report, 1986," by the Arkansas Department of Pollution Control and Ecology (ADPC&E) and "Nonpoint Source Pollution Assessment Summaries for the Arkansas River Basin, 1979." ADPC&E divided the Arkansas River Basin into 10 segments, 3A through 3J. Segments 3C throught 3J cover the area of this report. See Figure 3-7 map of water quality segments.

The quality of the Arkansas River water has been improving significantly over the past 25 years. The improvement is attributed to the installation of the McClellan-Kerr Arkansas River Navigation System and stricter pollutions control laws. The tributary streams of the basin are often use impaired due the level of contaminants in the water (Water Quality Inventory Report, 1986).



ARKANSAS RIVER BASIN

WATER QUALITY PLANNING SEGMENTS AND MONITORING STATION LOCATIONS

FEBRUARY 1988

Figure 3-7

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

Segment 3C - Arkansas River and Tributaries; Lock and Dam 4 to Lock and Dam No. 7

Segment 3C includes a section of the Arkansas River from Lock and Dam 4 below Pine Bluff to Lock and Dam 7 at Little Rock. Central Arkansas counties which are in this segment are Pulaski, Jefferson, Grant, Saline, and Lonoke. The area of this segment is 528,869 acres or 826 square miles. The major tributary within this segment is Plum Bayou and the largest impoundment is Lake Pine Bluff.

There is only one water quality monitoring station in this segment. It is located on the Arkansas River at Lock and Dam No. 6 below Little Rock.

Segment 3D - Arkansas River and Tributaries; Lock and Dam 7 to Morrilton

Segment 3D is located in west central Arkansas and covers most of Faulkner County and parts of Conway, Cleburne, White, Perry, Pulaski, Van Buren, and Saline Counties. The drainage area covers 878,953 acres or 1373 square miles. The length of the Arkansas River in this segment is 5.1 miles. Major water bodies within the segment are Lakes Maumelle, Beaverfork, Conway, and Brewer.

There are three water quality monitoring stations in Segment 3D. The stations are located on the Arkansas River (2) and Cadron Creek.

Segment 3E - Fourche LaFave River

Segment 3E encompasses the drainage area of the Fourche LaFave River and its tributaries. The drainage area of Segment 3E covers 723,327 acres or 1,130 square miles in parts of Perry, Yell, Polk, Scott, and Saline Counties. Major tributaries of the Fourche LaFave River are Big Cedar Creek, Mill Creek, Gafford Creek, and South Fourche LaFave River. Major impoundments in this segment are Nimrod Lake and Harris Brake.

There are two water quality monitoring stations within Segment 3E. One station is located on the upper section of the Fourche LaFave River. The second station is located near the mouth of the Fourche LaFave River.

Segment 3F - Arkansas River from River Mile 160 to River Mile 209

Segment 3F is located in west central Arkansas and covers 803,807 acres or 1,256 square miles. Counties includeded in segment 3F are parts of Conway, Perry, Pope, Yell, Van Buren, Logan, and Searcy. Forty-nine miles of the Arkansas River along with its tributaries, the East and West Forks of Point

Remove Creek, Illinois Bayou, Overcup Creek, and Gum Log Creek are the major streams of the segment. The lower reach of Lake Dardanelle is the most significant impoundment.

Water quality monitoring is confined to the Arkansas River. There are two gages within the segment. One gage is located at Lock and Dam No. 9, near Morrilton, and another gage is located near Dardanelle.

Segment 3G - Petit Jean River and Tributaries

Segment 3G, located in west central Arkansas, covers portions of Yell, Conway, Franklin, Perry, Logan, Sebastian, and Scott Counties. The area of Segment 3G is 682,271 acres or 1,066 square miles. The Petit Jean River and its tributaries are the streams which make up this segment. Major tributaries include Dutch Creek, Spring Creek, Chickalah Creek, and Rose Creek. The largest impoundment in this segment is Blue Mountain Lake which is formed by the Petit Jean River.

There are two water quality monitoring stations in Segment 3G. Both stations are located on the Petit Jean River. One station is upstream of Blue Mountain Reservoir near Booneville. The second station is near the mouth.

Segment 3H - Arkansas River and Tributaries from the State Line to River Mile 210

Segment 3H includes a 99-mile reach of the Arkansas River and its tributaries from the Oklahoma State Line to the upper end of Lake Dardanelle. Located in western Arkansas, this segment covers portions of Crawford, Franklin, Johnson, Logan, Madison, Newton, Pope, Sebastian, and Washington Counties. The drainage area of Segment 3H is 1,978,773 acres or 3,092 square miles. Major tributaries in Segment 3H include Big Piney Creek, Lee Creek, Mulberry River, Six Mile Creek and Vache Grasse Creek.

Segment 3H has five ambient monitoring stations. Three stations are located on the Arkansas River. One station is located on Lee Creek. Another station is located on the Poteau River.

Segment 3I - Poteau River

Segment 3I is located on the western border of Arkansas, just south of the Arkansas River. This segment covers 328,976 acres or 514 square miles which includes a large portion of Scott County as well as parts of Sebastian and Polk Counties. Segment 3I consists of the Poteau River from its headwaters to the Oklahoma state line. The principal tributaries within Arkansas are Jones Creek, James Fork, and Cherokee Creek.

There are two water quality monitoring stations located on streams within Segment 3I. One monitoring station is on the upper Poteau River. Another water quality monitoring station is on the James Fork.

Segment 3J - Grand Neosho Basin

The Grand Neosho Basin is located in the extreme northwest corner of Arkansas and covers 744,960 acres or 1,164 square miles. The Arkansas counties included in Segment 3J are Benton and Washington. Illinois River is the major stream in the segment. The main tributaries are Osage Creek, Spavinaw Creek, Little Sugar Creek, Flint Creek, and Spring Creek.

There are nine water quality monitoring stations located in Segment 3J. The reasons for the large number of stations are the large population, the incidence of interstate waters and high quality of waters. Streams with monitoring stations are Little Sugar Creek, Butler Creek, Spavinaw Creek, Flint Creek, Sager Creek, Illinois River (2), Osage Creek, and Baron Fork.

IMPOUNDMENTS

Inventory

In the Arkansas River Basin, there are numerous surface water impoundments. It is estimated there are 469 impoundments over 5 acres in surface area covering 30,033 acres with a combined storage of 486,183 acre-feet owned by private concerns. Impoundments under 5 acres in surface area are estimated to number 35,927 covering 17,217 acres storing 78,748 acre-feet (Lakes of Arkansas, 1981). Also, there are several impoundments owned by state and Federal agencies. These are listed in Table 3-14.

TABLE 3-14 STATE AND FEDERAL IMPOUNDMENTS IN THE ARKANSAS RIVER BASIN

NAME	SURFACE AREA	STORAGE VOLUME
	U. S. Army Corps of Engineers	
Blue Mountain	2,910	24,640
Nimrod	3,550	29,010
Dardanelle	34,300	486,200
Ozark	10,600	148,400
Subtotal	51,360	688,250
	U. S. Forest Service	
Cold Spring	5	50
Shoves Lake	82	820
Cove Lake	160	1,575
No name	37	555
Lake Wedington	102	1,600
Spring Lake	82	1,600

TABLE 3-14 STATE AND FEDERAL IMPOUNDMENTS IN THE

ARKANSAS RIVER BASIN (cont.)

NAME	SURFACE AREA	STORAGE VOLUME
	U.S. Forest Service (cont.)	
Lake Sylvia	14	128
Subtotal	482	6,328
	Arkansas Department of Parks and Tourism	
Lake Bennett	33	422
Lake Bailey	64	512
Lake Roosevelt	11	90
Devils Den Lake	8	40
Subtotal	116	1,064
	Arkansas Game and Fish Commission	
Crystal Lake	60	1,020
Lake Overcup	1,200	4,800
Lake Conway	6,700	40,200
Lake Pine Bluff	500	4,000
Horsehead Lake	10	1,600
Harris Brake	1,300	15,600
Lake Atkins	750	3,760
Lake Hinkle	1,000	15,000
Sugar Loaf Lake	250	3,000
no name	8	24
Lake Elmdale	180	3,000
Bobb Kidd Lake	200	4,018
Kingfisher Lake	37	200
Pullen Pond	130	3,000
Keeland Lake	37	260
Subtotal	12,362	99,482

Source: Lakes of Arkansas, 1981

Impoundment Water Quality

Available water quality data for the two Corps impoundments is displayed in Table 3-15. In this table, mean water quality values are given for 16 parameters at Blue Mountain Lake and Nimrod Lake. Run of the river lakes such as Ozark and Dardenelle lakes are not addressed in this section.

Of the 16 parameters listed in Table 3-15, 12 of the parameters for Blue Mountain Lake and Nimrod Lake are within the standards and guidelines established by the Arkansas Department of Pollution Control and Ecology. The only parameter that exceeded water quality standards is:

1. Turbidity - The turbidity standard is 25 NTU in lakes and 21 NTU in streams. Blue Mountain Lake values are above this by about 15 NTU upstream of the dam. The high upstream turbidity values also result in lake turbidity

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

Lake	Blue Mountain		Nimrod	
	N	Mean	N	Mean
** Specific Conductance (UMHOS)				
Upstream	33	83.606	36	39.389
Midlake	68	77.897	16	34.188
Dam	427	63.875	481	40.708
Downstream of Dam	88	65.500	129	40.372
** PH (units)				
Upstream	33	6.785	37	6.592
Midlake	60	6.662	15	6.356
Dam	419	6.879	483	6.626
Downstream of Dam	84	6.944	124	6.785
** Turbidity (ntu)				
Upstream	26	35.835	31	17.255
Midlake	50	32.486	16	19.125
Dam	64	25.941	69	11.453
Downstream of Dam	27	21.848	28	15.097
** Oxygen, Dissolved (mg/L)				
Upstream	33	7.292	37	8.346
Midlake	60	6.745	16	6.919
Dam	418	7.121	483	6.402
Downstream of Dam	82	9.202	84	9.007
** Coliform, Fecal (colonies/ 100 ml)				
Upstream	12	181.170	17	87.294
Midlake	18	111.110	13	29.769
Dam	22	14.682	22	8.136
Downstream of Dam	19	149.320	18	26.445
** Sulfate, Dissolved (mg/L as SO4)				
Upstream	-	-	30	3.677
Midlake	48	8.204	-	-
Dam	50	8.788	48	3.919
Downstream of Dam	28	8.618	72	2.996
** Chloride, Dissolved (mg/L as CL)				
Upstream	-	-	32	2.544
Midlake	47	4.502	-	-
Dam	52	3.994	52	2.694
Downstream of Dam	29	3.748	74	2.543
** Nitrogen, NO2+NO3 Total (mg/L as N)				
Upstream	5	.280	28	.134
Midlake	49	.215	7	.100
Dam	57	.161	43	.072
Downstream of Dam	29	.167	26	.088

N - Number of Samples

SOURCE: Corps of Engineer file data

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

Lake	Blue Mountain N	Blue Mountain Mean	Nimrod N	Nimrod Mean
** Phosphorous, Total (mg/L as P)				
Upstream	8	.209	37	.038
Midlake	62	.059	6	.042
Dam	85	.086	33	.093
Downstream of Dam	32	.077	31	.049
** Arsenic, Total (ug/L as AS)				
Upstream	-	-	19	.895
Midlake	41	1.171	-	-
Dam	43	1.768	41	1.366
Downstream of Dam	22	1.909	22	1.682
** Chromium, Total Recoverable (ug/L as CR)				
Upstream	-	-	12	10.833
Midlake	18	10.167	-	-
Dam	20	10.300	21	8.476
Downstream of Dam	9	8.889	10	5.800
** Copper, Total Recoverable (ug/L as CU)				
Upstream	-	-	18	21.389
Midlake	27	5.407	-	-
Dam	29	4.759	29	4.104
Downstream of Dam	15	4.400	14	3.286
** Lead, Total Recoverable (ug/L as PB)				
Upstream	-	-	19	7.474
Midlake	28	5.357	-	-
Dam	30	5.367	29	4.310
Downstream of Dam	16	7.938	15	4.267
** Iron, Total Recoverable (ug/L as FE)				
Upstream	-	-	32	977.190
Midlake	48	1697.700	-	-
Dam	51	2448.800	52	1042.300
Downstream of Dam	26	2260	26	1493.100
** Mercury, Total Recoverable (ug/L as HG)				
Upstream	-	-	7	.029
Midlake	12	.033	-	-
Dam	14	.229	12	.033
Downstream of Dam	6	.017	6	.033
** Zinc, Total Recoverable (ug/L as Zn)				
Upstream	-	-	20	50.750
Midlake	26	29.615	-	-
Dam	31	25.968	40	62.250
Downstream of Dam	15	21	16	54.063

N - Number of Samples

SOURCE: Corps of Engineer file data

levels that exceed the standard by 1 to 11 NTU. A practical consideration to solve this problem is to use best management practices in the watershed for soil erosion reduction.

The parameters that exceeded ADPC&E guidelines are:

1. Copper - the ADPC&E guideline of 5.0 ug/l (i.e. 500 mg/l) was exceeded at the midlake sampling station at Blue Mountain Lake (5.407 ug/l) and upstream of Nimrod Lake (21.389 ug/l).

2. Phosphorus - All sampled sites exceeded the ADPC&E guidelines of 50 ug/l at Blue Mountain Lake. Only the dam site at Nimrod Lake exceeded the guideline. These conditions may be the result of ionic bonding of phosphorus and suspended clays in runoff. This form of phosphorus is not thought to be as problematic as a different form that is more biologically available.

3. Mercury - The Blue Mountain Lake Dam site mean value of 0.229 exceeded the ADPC&E guideline of 0.1 ug/l.

4. Zinc - All sample stations for Blue Mountain Lake and Nimrod Lake exceeded the guidelines of 6.5 ug/l for zinc set by the ADPC&E. There seems to be a trend of high zinc concentrations in runoff of the Arkansas River Basin. The causes of this phenomenon have not been accurately determined. One possible cause is background geology. Zinc deposits become leached and enter the waterways. High levels of zinc have also been identified in Lake Dardenelle. Biological damages related to zinc contamination are dependent on the form of zinc (such as zinc oxide). No direct biological damages have been isolated as yet in the Arkansas River Basin.

Impoundment Water Use

The largest impoundments, Ozark and Dardanelle Reservoirs, within the Arkansas River Basin are used for hydropower generation and navigation. Lakes Nimrod and Blue Mountain are mainly for flood control. Lake Nimrod also supplies the City of Plainview with municipal and industrial water.

Several impoundments furnish municipal and industrial water supply. Some of the impoundments which are used for water supply are Lakes Maumelle, Ola-Dale, Bailey, Beaver Fork, Hudson, Charleston, Darby, Ludwig, Booneville, Cove Creek, Eugene, Waldron, Square Rock, Fort Smith, Sheppard Springs, Vache Grasse, Cherokee Creek, and Brewer Lake.

In addition to Lakes Nimrod and Blue Mountain, there are several additional flood water retarding impoundments in the Arkansas River Basin. Most of these sites have been built with the assistance of the U.S. Department of Agriculture, Soil Conservation Service.

A majority of the impoundments, from the small farm ponds to the largest lakes, are used for recreation (fishing). Also, the main use of small impoundments is livestock water and erosion control.

WATER RESOURCE DEVELOPMENT PROJECTS

Corps of Engineers

The most significant water resource development project in the Arkansas River Basin is the modification of the Arkansas River to provide dependable navigation conditions. The navigation project in Arkansas consists of 12 locks and dams, dredging, channel stabilization, operation and maintenance and other related improvements. Since the completion of the project in 1971 until 1984, commercial cargo shipments on the river have averaged 6.9 million tons.

The Corps of Engineers has been active in the area of flood control in the Arkansas River Basin. There are two major flood control impoundments in the basin. The two impoundments are Blue Mountain Lake on the Petit Jean River and Nimrod Lake on the Fourche LaFave River. There are 31 flood control levees in the basin which protect an area in excess of 633,000 acres of agricultural and urban land (Natural Disaster Response Plan, 1986).

In addition, 30 flood control impoundments in Oklahoma, Texas, and Kansas have a significant effect on flows of the Arkansas River in Arkansas (Arkansas River Basin Water Control Master Manual, 1980). These impoundments have prevented many millions of dollars worth of damages. Estimated annual damages have been reduced from $9 million annually to $1 million (Water Resource Development, 1981).

Reservoir Regulation

The Arkansas River Navigation System is managed to achieve a reasonable balance among authorized purposes. Major emphasis of the system operation is for flood operations and navigation requirements following a flood event. The system water control plan provides for a slow decrease or taper in the Arkansas River flow for two reasons. One reason is to decrease the number and magnitude of sand shoals. The other is so that the sand shoals which developed in the navigation channel during high flows can be located and removed before low flow conditions are reached. The tapered flow provides sufficient depth for normal navigation traffic to continue over the shoals while they are being located and removed. Whenever possible, flood releases are kept to a minimum to prevent damages, especially, in the Ft. Smith area.

The flood control dams on the Arkansas River and tributaries, located in Oklahoma, are operated on a system balancing procedure. Releases are made based on inflow, probability of additional rain and percent of flood storage utilized (Arkansas River Basin Water Control Master Manual, 1980).

The two flood control dams in Arkansas, Blue Mountain Dam and Nimrod Dam, are regulated for single purpose flood control. The operating plan for Blue Mountain Dam attempts to limit releases to 2,500 cfs during the growing season and 3,500 cfs during the dormant season. Nimrod Dam is regulated so that the water level on the Fourche LaFave River at Houston stream gage does not exceed 24 feet under non flood conditions. During extreme flood events, releases from the two dams would be increased based on inflow, probability of additional rain and flood storage utilized. (Blue Mountain Water Control Manual and Nimrod Water Control Manual)

United States Department of Agriculture, Soil Conservation Service

The Soil Conservation Service (SCS) is involved in water resource development at the request of local governments and individuals. Projects which have received SCS assistance are Poteau River, Six Mile Creek, Little Mulberry Creek, Little Clear Creek, Galla Creek, West Fork Point Remove Creek, East Fork Point Remove Creek, Ouachita Creek, Tupelo Bayou, Upper Petit Jean River, Cedar-Piney Creeks, and South Fourche LaFave.

Project Management

The size of permanent water pools, in a majority of SCS assisted projects, are based on the volume of sediment expected to accumulate during the project life. Project life is normally either 50 or 100 years. Theoretically, at the end of the project life the pool of water will be filled with sediment or water transported soil.

Floodwater releases from SCS assisted projects are through ungated openings. There are no adjustable gates to vary floodwater discharges. SCS design criteria attempts to evacuate the flood storage within 10 days. Benefits from flood damage reduction are computed based on unregulated retarded releases.

If the reservoir contains municipal and industrial water supply storage, an intake structure is located behind the dam.

Also, some spillway structures have a small low opening to allow water to be discharged in order to supplement the stream discharge during periods of low flow.

Annual inspections are performed by the sponsor, Arkansas Soil and Water Conservation Comission, and SCS to check maintenance and detect items needing repair. Each dam has a low gate which can be opened to drain the reservoir for maintenance purposes.

Non-Federal Water Resource Development

Water resource development by non-Federal interests has occurred in the Arkansas River Basin. The City of Little Rock has built several water impoundments to meet the water supply needs of its residents. The City's largest water supply impoundment is Lake Maumelle on the Maumelle River. Also, the towns and cities of Ola, Fort Smith, Clarksville, Alma, Hector, Lincoln, Ozark, Russellville, Siloam Springs and Subiaco depend on surface water for their drinking water (Appendix 5, 1986).

Also, non-Federal interests are developing hydroelectric facilities at Dam 13 near Van Buren and at Murray Dam at Little Rock. Hydroelectric generation plants are currently under construction at these two locations. Dams 2 through 13 on the Arkansas River, Nimrod Dam, and Blue Mountain Dam have been studied for hydroelectric production and private concerns have obtained Federal Energy Regulatory Commission permits to develop hydropower facilities at these locations.

Private development of flood control and drainage projects in the Arkansas River Basin is also prevalent. Nine private flood control levees have been built along the Arkansas River. These private levees are spaced periodically along the mainstem of the river from near Morrilton to below Little Rock (Natural Disaster Response Plan, 1986).

SURFACE WATER RESOURCE PROBLEMS

Availability

The average annual runoff in the Arkansas River Basin is approximately 17 inches. Even though this amount may seem large, water is not always available when needed. There are several communities which have a water availability problem.

Listed in Table 3-16 is a list of communities with a water availability problems in the Arkansas River Basin. The availability problem is due to the low yield of the water supply sources.

TABLE 3-16 COMMUNITIES WITH WATER AVAILABILITY PROBLEMS

COUNTY	COMMUNITY
Benton	Bella Vista
Conway	Oppelo Hattieville
Faulkner	Greenbrier Vilonia Guy
Franklin	Charleston Denning-Altix-Greenwood Clarksville
Logan	Booneville Magazine Scranton Subiaco
Pope	Russellville
Sebastian	Lavaca Mansfield Fort Smith
Washington	West Fork
Yell	Dardanelle

Source: Appendix E, 1978 and SFY 86 Public Water System Report

From information presented in the Streamflow Characteristics Section, it is concluded that surface water is not available from most free flowing streams. The absence of flow during drought periods prevents withdrawals of surface water. Therefore, free flowing water is not available for muncipal and industrial and irrigation water on a dependable basis except for the mainstem of the Arkansas River or when the stream is used in conjunction with a water storage project.

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

Flooding

Flooding is still a significant problem in the Arkansas River Basin. The flood plain area is estimated to be 692,390 acres. A breakdown of flood plain land use is shown in Table 3-17.

TABLE 3-17 1977 FLOOD PLAIN LAND USE

Land Use	Acres
Cropland	
Cotton	11,964
Corn	862
Soybeans	95,020
Rice	3,680
Wheat	1,796
Grain Sorghum	896
Hayland	6,028
Total Cropland	120,219
Grassland	206,345
Forest Land	365,826
Total Flood Plain	692,390

Source: Arkansas Resource Base Report, 1981

In 1977, total damages from flooding were estimated to be over $22.7 million (Arkansas Resource Base Report, 1981). This amount includes crop, urban values, roads and bridges, and miscellaneous damages.

Many towns and cities have had flood prone areas delineated on FEMA Flood Insurance Rate Maps, FEMA Flood Hazard Boundary Maps, Corps of Engineers Flood Plain Reports, or Soil Conservation Service Flood Plain Management Studies. Also, other areas which are subject to flooding have not been specifically mapped. Some of the towns and cities which have reported flood problems are Fort Smith, Van Buren, Clarksville, Russellville, Ola, Dardanelle, Atkins, Morrilton, Plumerville, Greenbrier, Conway, Little Rock, North Little Rock, Wrightsville, England and Pine Bluff.

SURFACE WATER QUALITY PROBLEMS

Introduction

Water quality problems can be attributed to two sources which are classified as point source and nonpoint source. Point sources are defined as pollution sources which can be traced to one point of origin such as a discharge pipe from a sewage treatment plant. A nonpoint source of pollution is a condition where pollutants enter a waterway through many points. Soil erosion is an example of a nonpoint pollution source. Not only do soil particles cause an increase in turbidity, they also transport nutrients and pesticides. Soil particles in suspension reduce water's ability to transport oxygen which is needed by most aquatic life forms. Precipitation runoff can be a nonpoint source of pollution, if the runoff picks up undesirable chemicals as it flows overland.

At one time, it was estimated that the Arkansas River at Little Rock carried 105 million tons of sediment annually. After the installation of the upstream lakes for flood control and other purposes and dams for navigation, the sediment load has been reduced to 25 million tons annually (Water Resource Development, 198I).

In the following sections, a summary of the water quality conditions of the Arkansas River Basin are discussed. Water Quality Segments 3C through 3H cover most of the basin area.

Segment 3C - Arkansas River and Tributaries from Lock and Dam 4 to Lock and Dam 7

In 1984, the only water quality monitoring station in Segment 3C was located on the Arkansas River at Murray Lock and Dam. Samples from this station continued to have increasing levels of chlorides, sulfates and total dissolved solids.(Water Quality, 1984) Monitoring of organisms at this station indicate a "Fair-Good" condition with a "Stable" trend.

Since 1984, the water quality monitoring network has been altered in Segment 3C. Sampling stations are currently located at Locks and Dams 4 and 5. These stations have not been active for a long enough time to collect sufficient data to determine trends. But from the data collected, ADPC&E has determined that periodic heavy phytoplankton growth has occurred indicating high levels of nutrients. Also, levels of copper, lead, zinc and cadmium have exceeded ADPC&E guidelines for these metals (Water Quality, 1986).

No major health problems have been documented as a result of water quality within this segment. Minor concerns include the incidences of high fecal coliform bacteria that preclude the use of Arkansas River tributary waters as a source of primary contact recreation. Also, organic chemicals, turbidity, pesticide, and fertilizer contamination of these waters are of such concern to the Arkansas Department of Health that the Arkansas River water is not an approved source of public water supplies (Water Quality, 1986).

Erosion is a major nonpoint source pollutant. The soil particles in transport increase the turbidity and decrease the oxygen carrying capacity of water. Cropland comprises 29 percent of the segment's land use, but contributes 87 percent of the sheet and rill erosion or 72 percent of the total erosion from all sources. Arkansas River Mainstem Laterals to Lock and Dam 4, North Little Rock City Drains, Fourche Bayou and Tucker Lake Levee and Drainage Districts watersheds have been identified as having excessive sheet and rill erosion rates on cropland (Nonpoint Source, 1979).

Segment 3D - Arkansas River and Tributaries: Lock and Dam 7 to Morrilton

In Segment 3D, the only station not located on the Arkansas River in 1984 was on Cadron Creek. Data from this station periodically showed high levels of phosphorus, nitrate, turbidity, and fecal coliform. Despite periods of elevated pollutant levels, the water quality exhibited no degrading trends (Water Quality, 1984).

Since 1984, the Cadron Creek station has been discontinued and another station established on Stone Dam Creek below the Conway sewage treatment plant discharge point. Due to the short period of existence, no trends have been established, but data have shown very few parameters analyzed are within an acceptable range, and some values (nutrients, sulfate, chloride, metals) are dangerously high. The high concentrations are of special concern since Stone Dam Creek empties into Lake Conway, a very popular fishing lake (Water Quality, 1986).

The two water quality monitoring stations on the Arkansas River show similar data in relation to each other. Each station periodically reports high total dissolved solids, phosphorus, nitrates, and turbidity. Trend analysis from each station depicts increasing levels of chlorides, sulfates, and total dissolved solids (Water Quality, 1986).

The water quality at the only biological monitoring station in this segment was shown to be undergoing "Moderate Degradation" (Water Quality, 1986).

Arkansas Department of Pollution Control and Ecology reports that no major health problems have been documented as a result of water quality within Segment 3D, but the situation in Stone Dam Creek warrants concern due to the use of the receiving waterbody of this stream. The high fecal coliform bacteria counts associated with watershed runoff in the other tributary streams in the segment are of concern because they prevent the primary contact designation from being achieved (Water Quality, 1986).

Cropland is a major source of sheet and rill erosion in Segment 3D. While comprising only 9 percent of the segment, cropland is the source of 42 percent of the sheet and rill erosion or 36 percent of the total erosion. Areas having excessively high erosion rates are Little Cypress Creek, Palarm Creek, North Fork of Cadron Creek, and East Fork of Cadron Creek watersheds (Nonpoint Source, 1979).

Segment 3E - Fourche LaFave River

There are three water quality monitoring stations in Segment 3E. One station, Ark 37, is located in the upper reaches on Fourche LaFave River. This station indicates waters of high quality even though at times the water is turbid. The second monitoring station, Ark 36, is located near the mouth of the Fourche LaFave River. The water quality at this point is also of high quality but degraded somewhat by turbidity and low dissolved oxygen readings. The third water quality monitoring station, Ark 52, was installed on the lower reaches of the South Fourche LaFave River (Water Quality, 1986).

Levels of metals are consistently higher than the criteria, and are considered to be associated with the high turbidity. The metals do not appear to be affecting aquatic life within the segment. The major problems with water quality are due to watershed runoff following rainfall events (Water Quality, 1986).

Sediment is the number one source of nonpoint pollution. The source of sediment is soil transported by water or soil erosion. Table 3-18 shows a listing of erosion sources, quantity of erosion and percent of all erosion.

Table 3-18 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons per Year	Percent of Total
Road Surface Erosion	38,650	1.5
Road Bank Erosion	51,000	2.0
Gully Erosion	490	0.0
Streambank Erosion	47,550	1.9
Sheet and Rill Erosion	2,368,580	94.6
Total	2,506,270	100.0

Source: Nonpoint Source, 1979

Table 3-19 lists the various land uses and the percent of sheet and rill erosion originating from each land use.

TABLE 3-19 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Percent of Erosion Contributed by Land Use
Cropland	2.8	5.69	6.1
Grassland	12.1	0.63	2.6
Forest Land	83.3	2.59	91.3
Urban & Built-up	0.2	NA	NA
Water, Mines, & Other	1.6	NA	NA
Total	100.0	2.39	100.0

Source: Nonpoint Source, 1979

As shown in Table 3-19, forest land is the major contributor of soil erosion in Segment 3E. Of the 2.5 million tons of soil being eroded annually, only 241,700 tons are being delivered to the segment outlet (Nonpoint Source, 1979).

Areas identified as being major sources of erosion are Upper Fourche La Fave and South Fourche watersheds. Forest land in Upper Fourche La Fave River drainage area is the major source of sediment from that area. Cropland is the major source of sediment from the South Fourche Watershed (Nonpoint Source, 1979).

Segment 3F - Arkansas River, Miles 160 - 209

The quality of water within Segment 3F acquires the characteristics of the region which it drains. The two regions are the Boston Mountain Region and the Arkansas River Valley Region. Waters of the Boston Mountain Region are high quality due to the less intensive land use within the region. Waters of the Arkansas River Valley frequently do not meet water quality standards due to more intensive land uses. Swimmable use is not being met in most of the Arkansas River Valley-type streams.

No major health problems have been documented because of water quality within this segment. Minor concerns involve nonpoint source runoff from pasturelands, which affects the primary contact use of the surface waters within this segment (Nonpoint Source, 1986).

Two of the three water quality monitoring stations have been active only a short time, therefore, no long term trends can be established.

Effects of erosion are present in Segment 3F. Soil erosion is the largest nonpoint source pollutant in the segment. Table 3-20 shows the sources and magnitude of erosion.

TABLE 3-20 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	57,043	3.0
Road Bank Erosion	109,576	5.7
Gully Erosion	41,677	2.2
Streambank Erosion	198,328	10.4
Sheet and Rill Erosion	1,505,662	78.7
Total	1,912,286	100.0

Source: Nonpoint Source, 1979

As shown in Table 3-20, sheet and rill erosion is the largest source of nonpoint pollution. Table 3-21, summarizes the sources of sheet and rill erosion.

TABLE 3-21 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Erosion Contributed by Land Use
Cropland	7.3	7.0	27.2
Grassland	32.4	1.47	25.5
Forest Land	53.9	1.57	47.3
Urban & Built-up	2.7	NA	NA
Water & Other	3.7	NA	NA
Total	100.0	1.87	100.0

Source: Nonpoint Source, 1979

Of the 1.9 million tons of soil erosion per year, 550,000 tons of eroded soil are delivered as sediment to the outlet of Segment 3F. Cropland has the highest per acre average erosion rate. Whig-Holla Bend, Smiley-Pin-Harris

Creeks, Carden Bottom Drainage District No. 2, Galla Creek, West Fork Point Remove Creek, Lower Point Remove Creek, and Cypress Creek watersheds have been identified as having excessive erosion rates on agricultural land (cropland and grassland) (Nonpoint Source, 1979).

Segment 3G - Petit Jean River and Tributaries

There are four water quality monitoring stations in Segment 3G. One station, ARK 34, is located in the upper reaches above Blue Mountain Lake. The data gathered at this station indicates the dissolved oxygen, turbidity and metals do not meet the set standards a majority of the time. The source of the metals is unknown.

ARK 34 is the only water quality monitoring station which has been in operation long enough to compile adequate data to establish trends. The trend shows that total dissolved solids have been increasing at a rate of 2 milligrams per liter per year during high flow situation (Water Quality, 1986).

The second station, ARK 35, is located near the mouth of the Petit Jean River. Samples collected at this site were found to frequently violate the standards for dissolved oxygen and turbidity.

Two new water quality sampling stations have been established in Segment 3G. One of the stations, ARK 58, is located on Chickalah Creek. The second station, ARK 57, is located on Dutch Creek, near Shark. These stations have not been in operation for sufficient time to establish trends (Water Quality, 1986).

No major health problems have been documented as a result of water quality problems within this segment. The fecal coliform bacteria concentration in streams warrants concern because it precludes them from being designated as a swimmable stream. As in other Arkansas River Valley segments, cadmium, copper, lead and zinc exceed ADPC&E guidelines at both monitoring stations (Water Quality, 1986).

Specific pollutants causing impairment include fecal coliform bacteria and sedimentation from watershed activities. Table 3-22 shows the sources of sediment as related to soil erosion.

TABLE 3-22 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	48,258	2.9
Road Bank Erosion	93,529	5.7
Gully Erosion	35,750	2.1
Streambank Erosion	76,982	4.7
Sheet and Rill Erosion	1,398,717	84.6
Total	1,653,236	100.0

Source: Nonpoint Source, 1979

From Table 3-22, it is readily apparent that sheet and rill erosion is the major source of soil erosion. Table 3-23 shows the sources of sheet and rill erosion.

TABLE 3-23 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Erosion Contributed by Land Use
Cropland	2.1	3.90	3.8
Grassland	32.0	0.99	15.6
Forest Land	63.4	2.60	80.6
Urban & Built-up	2.0	NA	NA
Water & Other	0.5	NA	NA
Total	100.0	2.05	100.0

Source: Nonpoint Source, 1979

Forest land which is the major land use, is also the major source of soil erosion of which a percentage eventually is sediment. Agricultural land (cropland and grassland) was found to be eroding at a high rate in Sugar Creek - Blue Mountain Laterals and Petit Jean River - Cedar Creek Watersheds (Nonpoint Source, 1979).

Segment 3H - Arkansas River and Tributaries: State Line to River Mile 210

The water quality monitoring network for Segment 3H consists of three stations on the Arkansas River, one station on Lee Creek, and one station on the Poteau River. The stations on the Arkansas River exhibit characteristics similar to other Arkansas River stations. The data are showing stable trends in chlorides, sulfates, and total dissolved solids. In the majority of samples at these stations, the metal levels exceeded the criteria (Water Quality, 1986).

The samples from Lee Creek and Poteau River indicated a stable condition exists. Occasionally, the Poteau River water samples had low dissolved oxygen and turbidity readings exceeding the standard (Water Quality, 1986).

No major health problems have been documented as a result of water quality problems in Segment 3H. Minor concerns involve the fecal coliform contamination in several tributary streams and the Arkansas River (Water Quality, 1986).

Specific pollutants causing use impairments in Segment 3H include fecal coliform bacteria and possibly sedimentation, which results in high turbidity levels. (Water Quality, 1986) Sources of sediment are areas of eroding soil. Table 3-24 show the estimated sources of erosion in Segment 3H.

TABLE 3-24 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	197,149	3.9
Road Bank Erosion	399,623	8.0
Gully Erosion	478,617	9.5
Streambank Erosion	414,269	8.3
Sheet and Rill Erosion	3,522,577	70.3
Total	5,012,235	100.0

Source: Nonpoint Source, 1979

From Table 3-24, it is readily apparent that sheet and rill erosion is the major source of soil erosion. Table 3-25 shows the sources of sheet and rill erosion.

TABLE 3-25 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Erosion Contributed by Land Use
Mining	0.4	8.89	0
Cropland	4.6	8.82	22.8
Grassland	29.3	1.52	25.1
Orchards & Vineyards	0.2	4.89	0.6
Forest Land	59.7	1.53	51.4
Urban & Built-up	3.4	NA	NA
Water & Other	2.4	NA	NA
Total	100.0	1.78	100.0

Source: Nonpoint Source, 1979

Areas contributing problem quantities of soil erosion from agricultural land are Arkansas River Ridge, Little Clear Creek, Mill Creek, Vine Prairie Lake, and Arkansas River Mainstem to L&D 10 watersheds (Nonpoint Source, 1979).

Segment 3I - Poteau River

The streams monitored in Segment 3I are the Poteau River and the James Fork. The data from Segment 3I indicates a stable trend for the water quality. Parameters which have exceeded standards are low dissolved oxygen and metals. The James Fork has shown a slight increase in sulfate concentrations and the levels of lead exceeded Safe Drinking Water criteria.

The biological evaluation in this segment revealed "Fair-Good" conditions and a "Stable" trend.

No major health problems have been documented as a result of water quality problems in Segment 3I. A source of minor concern is the high fecal coliform bacteria concentrations and high ammonia levels in the stream at Waldron (Water Quality, 1986).

Sources of water quality degradation include the non-compliant point source dischargers within the segment as well as the agricultural activities in the watershed, including cattle and poultry production, which contribute nonpoint source contaminants. Contamination also occurs from the several coal mining operations that exist in this segment (Water Quality, 1986).

Table 3-26 shows the various sources of soil erosion from within the segment.

TABLE 3-26 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	22,337	2.9
Road Bank Erosion	36,752	4.9
Gully Erosion	8,419	1.1
Streambank Erosion	16,261	2.2
Sheet and Rill Erosion	668,491	88.9
Total	752,260	100.0

Source: Nonpoint Source, 1979

From Table 3-26, it is readily apparent that sheet and rill erosion is the major source of soil erosion. Table 3-27 shows the sources of sheet and rill erosion.

TABLE 3-27 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Erosion Contributed by Land Use
Cropland	0.8	20.2	2.1
Grassland	36.7	0.5	19.1
Forest Land	57.5	2.2	77.2
Urban & Built-up	3.5	NA	NA
Water	1.0	NA	NA
Extractive	0.5	NA	NA
Total	100.0	1.91	100.0

Source: Nonpoint Source, 1979

Forest land is the major contributor of soil erosion. Poteau River and Black Fork Creek watersheds are areas with high erosion rates on forest land (Nonpoint Source, 1979).

Segment 3J - Grand Neosho

The waters of Segment 3J are closely monitored by nine water quality sampling stations. Common violations of water quality standards, shown in collected samples, are high levels of nitrates and low levels of dissolved oxygen.

Parameters which are showing a trend are increasing concentrations of phosphorus, nitrates, copper, lead, zinc, cadmium, chromium and fecal coliforms. The suspected source of these parameters is the waste from large numbers of confined animals and chickens within the segment (Water Quality, 1986).

No major health problems have been documented as a result of water quality within this segment. Minor concerns involve potentially high nitrate levels both in surface and groundwater. Consumption of water containing nitrate levels greater than 10 parts per million can cause health problems, only in infants. Also the high bacterial counts associated with runoff events pose a health concern (Water Quality, 1986).

The Illinois River and tributaries is area where the streamflows do not meet water quality standards. Parameters which often exceed standards are dissolved oxygen, water temperature, total phosphorus-P, and fecal coliform bacteria. The sources of the pollutants are pasture grazing livestock, land application of confined animal wastes, and discharge effluent from municipal waste water discharge in the Illinois River Basin. Simulations by U.S. Geological indicate that the Illinois River and Muddy Fork of the Illinois River can not meet Arkansas disolved oxygen standards with the discharge of any additional wastewater effluent into their waters (Terry et al, 1984).

Erosion is a major pollutant is Segment 3J. Table 3-28 lists the sources of the erosion.

TABLE 3-28 SUMMARY OF EROSION BY SOURCE

Erosion Source	Tons Per Year	Percent of Total
Road Surface Erosion	105,254	5.9
Road Bank Erosion	148,793	8.3
Gully Erosion	2,277	0.1
Streambank Erosion	71,116	4.0
Sheet and Rill Erosion	1,460,518	81.7
Total	1,787,958	100.0

Source: Nonpoint Source, 1979

From Table 3-28, it is readily apparent that sheet and rill erosion is the major source of soil erosion. Table 3-29 shows the sources of sheet and rill erosion.

TABLE 3-29 SHEET AND RILL EROSION BY LAND USE

Land Use	Percent of Total Land Use	Avg. Erosion Rate (tons/acre/year)	Erosion Contributed by Land Use
Cropland	3.8	7.4	14.6
Grassland	53.7	1.0	26.4
Forest Land	29.5	3.3	54.5
Orchards & Vineyards	0.8	0	0
Feedlots	0.8	13.0	4.5
Urban & Built-up	8.4	NA	NA
Water	0.3	NA	NA
Mining	0.1	NA	NA
Other Agriculture	2.6	NA	NA
Total	100.0	2.0	100.0

Source: Nonpoint Source, 1979

Cropland areas having high erosion rates were found in Upper Illinois River, Osage Creek, Sugar Creek, and Upper Spavinaw Creek watersheds. Watersheds found to have high erosion rates on forest land were Osage Creek, Middle Illinois River, Flint Creek, Sugar Creek, and Upper Spavinaw Creek (Nonpoint Source, 1979).

DATA BASE PROBLEMS

Irrigated Cropland

Information on irrigated cropland should be available for planning purposes. Since about 40 percent of total surface water use, excluding water used in electrical energy production, in the Arkansas River Basin is for irrigation, the total irrigated acreage of each crop, is needed to determine the total amount of water needed for irrigation.

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

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

Streamflow Data

In the Arkansas River Basin, there are many streams without flow measuring devices. In some cases, the gaged streams do not have an adequate number of gages to define the streamflow characteristics. There are no gages on the Arkansas River between Murray Lock and Dam and the Mississippi River.

Some of the streams which are not adequately gaged are Cadron Creek, Piney Creek and Mulberry River. The Cadron Creek has one gage located in the upper reaches of the stream. Piney Creek and Mulberry River have a single gage located in the middle reaches of these streams.

Diversion Reporting

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

All surface water diversions are to be registered except those diversions from lakes or ponds owned exclusively by the diverter. Along with being beneficial should periods of shortage make allocation necessary, diversion registration is a necessary tool in the planning process for maximum development of the state's water resources. There is no penalty for non-registration other than being non-preferential should allocation become necessary.

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.

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

Determining Instream Flow Requirements

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

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

Instream flow requirements determined by the "Arkansas Method" were not applicable for use in determining minimum streamflows in the basin. Minimum streamflow is defined as the lowest discharge that will satisfy minimum instream flow needs by fish biological season. The "Arkansas Method" is not supported by field data collection or documentation from other studies. Comparison of the percentages used in the "Arkansas Method" with the percentages used in the Tennant Method indicates that the instream needs for fish and wildlife determined by the "Arkansas Method" would provide excellent to outstanding fisheries habitat. Therefore, the instream flow requirements determined by the "Arkansas Method" were not applicable for use in determining minimum streamflows in the basin.

Rigid methodologies is another problem in determining instream flow requirements. Methodologies such as the Arkansas Method do not take into consideration the diversity of the aquatic systems or the historic instream and off-stream uses of water from the stream. For example, according to the Arkansas Method, instream flow requirements for fish and wildlife are computed as a percent of the mean monthly discharge at each of the gaging station locations in the basin. At the present time, there is no flexibility in the method so that the unique streamflow needs of the different fisheries in the basin are taken into account.

Critical Surface Water Areas

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

From the data presented earlier in this report, there are no critical surface water areas in the Arkansas River Basin.

SOLUTIONS AND RECOMMENDATIONS

Availability

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

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

The solution for a small group of water users with a water availability problem is to connect to a nearby municipal or water district distribution system. In the case of a municipal system or large water user, the solution is to contract with an existing private, state, or Federally owned water storage facility. It is possible for the Corps of Engineers to reallocate water storage from existing reservoirs and sell the necessary water storage or the right of water withdrawal under contract for municipal and industrial purposes. In effect, this solution would mean the formation of an area water distribution system.

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

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

Flooding

For the areas which are subject to periodic flooding, there are two basic types of solutions: nonstructural methods or structural methods.

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

Structural solutions are modifications within the drainage area that reduce flood heights. Flood control dams, channel modifications, and leveed floodways are examples of structural solutions to flooding problems.

Even though there are many solutions to flood problems, a careful study should be made to determine the least cost alternative at a specific location. There is governmental assistance available for water resource problems which meet certain requirements. For an additional discussion of governmental assistance, see the section entitled Governmental Assistance later in this chapter.

Quality of Surface Water - Best Management Practices

As mentioned earlier in this report, soil erosion is a major source of nonpoint pollution in the Arkansas River Basin. The methods used to control soil erosion are frequently referred to as Best Management Practices (BMP's). There are BMP's which are effective in controlling erosion caused by different operations. Table 3-30 lists some of the BMP's (Nonpoint Source, 1979).

TABLE 3-30 BEST MANAGEMENT PRACTICES

Agricultural BMP's

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

Forestry BMP's

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

Construction BMP's

1. Mulching
2. Traffic barriers
3. Limited soil disturbance
4. Site planning and proper timing of operation
5. Temporary vegetative cover
6. Conservation of natural vegetation

TABLE 3-30 BEST MANAGEMENT PRACTICES (cont.)

Construction BMP's(cont.)

7. Diversions
8. Water control structures
9. Hard surface heavy use areas
10. Roadside stabilization

Subsurface Disposal BMP's

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

Urban Runoff BMP's

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

Mining BMP's

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

Hydrological Modifications BMP's

1. Grade stabilization structures
2. Dikes
3. Streambank protection
4. Surface drainage
5. Revegetation after construction
6. Spoil spreading
7. Water control structures
8. Dams
9. Rock lined waterways

TABLE 3-30 BEST MANAGEMENT PRACTICES (cont.)

Hydrological Modifications BMP's (cont.)

10. Designing of side slopes to facilitate revegetation and maintenance
11. Floodways
12. Construction of irrigation reservoirs
13. Irrigation return systems
14. Levees to prevent flooding
15. Low water weirs
16. Clearing and snagging

Disposal Sites BMP's

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

Road BMP's

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

Streambank BMP's

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

Gully BMP's

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

There are also point sources of pollution in the Arkansas River Basin. The solution to these problems is continued intensive enforcement of pollution control laws. Initially, the enforcement could consist of notifying point source violators of their non-compliance. Many violators will take action when notified. If violators do not voluntary comply, legal action would be the second course of action.

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

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

Conservation - Agricultural Water Use

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

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

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

Application methods have a wide range of efficiencies for each method and between the different methods. Table 3-31 shows the various application methods and their range of efficiencies.

TABLE 3-31 ESTIMATED EFFICIENCIES OF APPLICATION METHODS

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

Source: Agricultural Water Use Study

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

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

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

Conservation - Public Supply

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

Conservation - Self-Supplied Industries

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

Conservation - Wastewater Reuse, Recyling and Land Application

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

Governmental Assistance

There are several government programs which are intended to aid communities and organizations in solving water resource problems. Table 3-32 is a list of selected government programs and their administering agency. Additional program information may be obtained by contacting the administering agency.

Purposes of the programs vary. Program purposes include flood prevention, water supply, waste water treatment, technical assistance or land use planning.

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

Data Bases - Irrigated Cropland

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

TABLE 3-32 SELECTED GOVERNMENT PROGRAMS TO AID IN SOLVING WATER RESOURCE PROBLEMS

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

TABLE 3-32 SELECTED GOVERNMENT PROGRAMS TO AID IN SOLVING WATER RESOURCE PROBLEMS (cont.)

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

Source: Catalog of Resources for Community Development, 1983, Arkansas Industrial Development Commission.

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

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

Data Bases - Streamflow Data

One solution to the lack of streamflow gaging station data in the Arkansas River Basin would obviously be to install more gaging stations on streams in the basin. Additional gages on streams with limited gages would be particularly helpful to define streamflow characteristics at intermediate locations on the stream.

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 (Hines, 1975) provides an alternative to a regionalization method, however, this technique is limiting since it requires several low-flow 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 the Arkansas River Basin 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 in determining water use in the state. The importance of the report was magnified by Act 1051 of 1985 which required the Arkansas Soil and Water Conservation Commission to determine the water requirements of riparian land owners. Without diversion registrations this determination would prove costly and time consuming. Determination of riparian water use is necessary to insure that an over-utilization of a stream or lake does not occur or if currently over utilized; to what degree.

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

Determining Instream Flow Requirements

Determination of instream flow requirements for water quality and fish and wildlife in the Arkansas River Basin is a problem at the present time. Quantification of the amount of water in this basin that is available for other uses is not possible until these instream flow needs are identified.

The criteria for water quality flow requirements have been established by ADPC&E, but the low-flow characteristics have been determined for only a relatively small number of sites in the Arkansas River Basin. 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 using the "Arkansas Method" (Filipek, et. al., 1985). 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.

An alternative or modification to the method of determining fish and wildlife requirements could be the development of an instream flow needs priority matrix for determining the level of protection which should be afforded a stream. Barnes (1986) recommended that establishing stream priorities in a given basin is a rational approach to afford streamflows which are necessary to protect and to maintain existing aquatic life, recreational use, aesthetics, and ecological stability as well as considering other uses.

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

In Table 3-33, Example Priority Matrix for Determining Stream Flow Protection Levels, is a suggested format of a priority matrix. The different factors would be assigned a point value to get a composite score and the assigned values for the different factors would be summed. An interdisciplinarian committee could assign the point values for the rating factors and for the different protection levels for the streams. These protection levels or minimum flows could be based on a percentage of the historic flow for the stream for that season (Barnes, 1986).

TABLE 3-33 EXAMPLE PRIORITY MATRIX FOR DETERMINING STREAM FLOW PROTECTION LEVELS

STREAM OR SEGMENT OF STREAM	ENDANGERED SPECIES	WATER QUALITY	RECREATION USE	FISHERY QUALITY
	YES - pts	HIGH - pts	HIGH - pts	HIGH - pts
	NO - pts	MEDIUM - pts	MEDIUM - pts	MEDIUM - pts
		LOW - pts	LOW - pts	LOW - pts

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

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

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

CHAPTER 4

GROUND-WATER RESOURCES OF THE ARKANSAS RIVER BASIN

By John M. Kilpatrick and A.H. Ludwig

Administrative Report

Prepared for the

U.S. ARMY CORPS OF ENGINEERS

Little Rock, Arkansas

1988

CONVERSION FACTORS

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

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

INTRODUCTION

The study area consists of the entire Arkansas River basin (fig. 4-1), most of which lies in the Interior Highlands physiographic division. The Interior Highlands is an area of hilly to mountainous terrane which is underlain by consolidated rocks consisting of sandstone, shale, limestone, and dolomite. The southeastern tip of the study area extends into the Gulf Coastal Plain physiographic province. The Coastal Plain is characterized by flat to hilly topography and is underlain by unconsolidated sediments consisting chiefly of sand, gravel, silt and clay. The boundary between the Coastal Plain and the Interior Highlands trends northeast-southwest through Little Rock and is known as the Fall Line.

The Interior Highlands is divided on the basis of physiographic expression into two provinces; the Ozark Plateaus province and the Ouachita province. The Ozark Plateaus province encompasses the northwestern corner of the study area north of the Arkansas Valley section of the Ouachita province. The Ozark Plateaus is dominated by deeply dissected plateaus rising over 2,000 feet (ft) above sea level[1], underlain by limestone, dolomite, shale, and sandstone of Pennsylvanian to Cambrian age (fig. 4-2). A more detailed description of the geologic units of the Ozark Plateaus is contained in the stratigraphic column in table 4-1. Small amounts of water, less than 10 gallons per minute (gal/min), are available in the area from surficial rock units, but as much as 500 gal/min may be obtained from deeply buried sandstone and chert units which constitute regionally important aquifers.

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

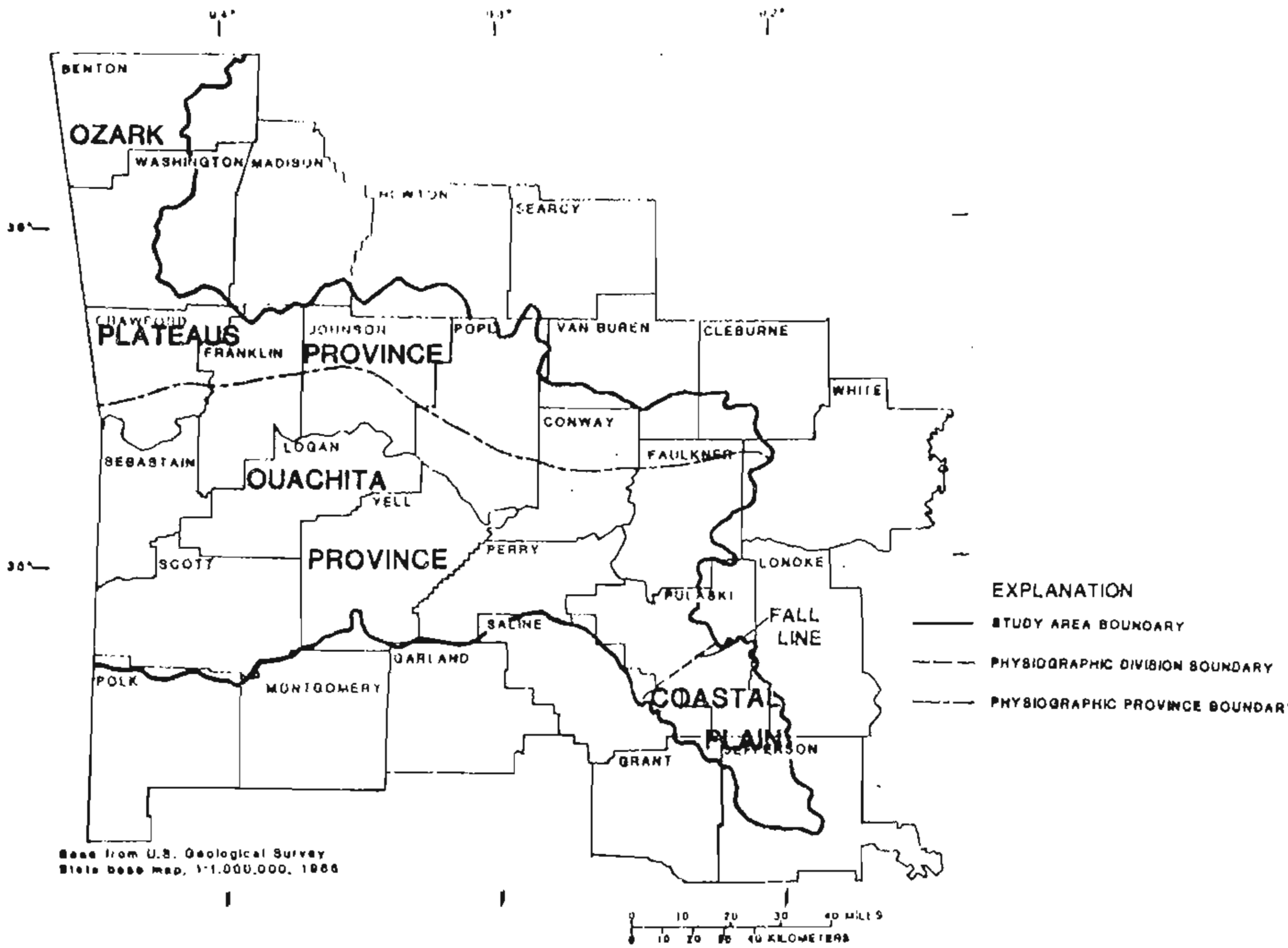

Figure 4-1.--Location and physiography of the study area.

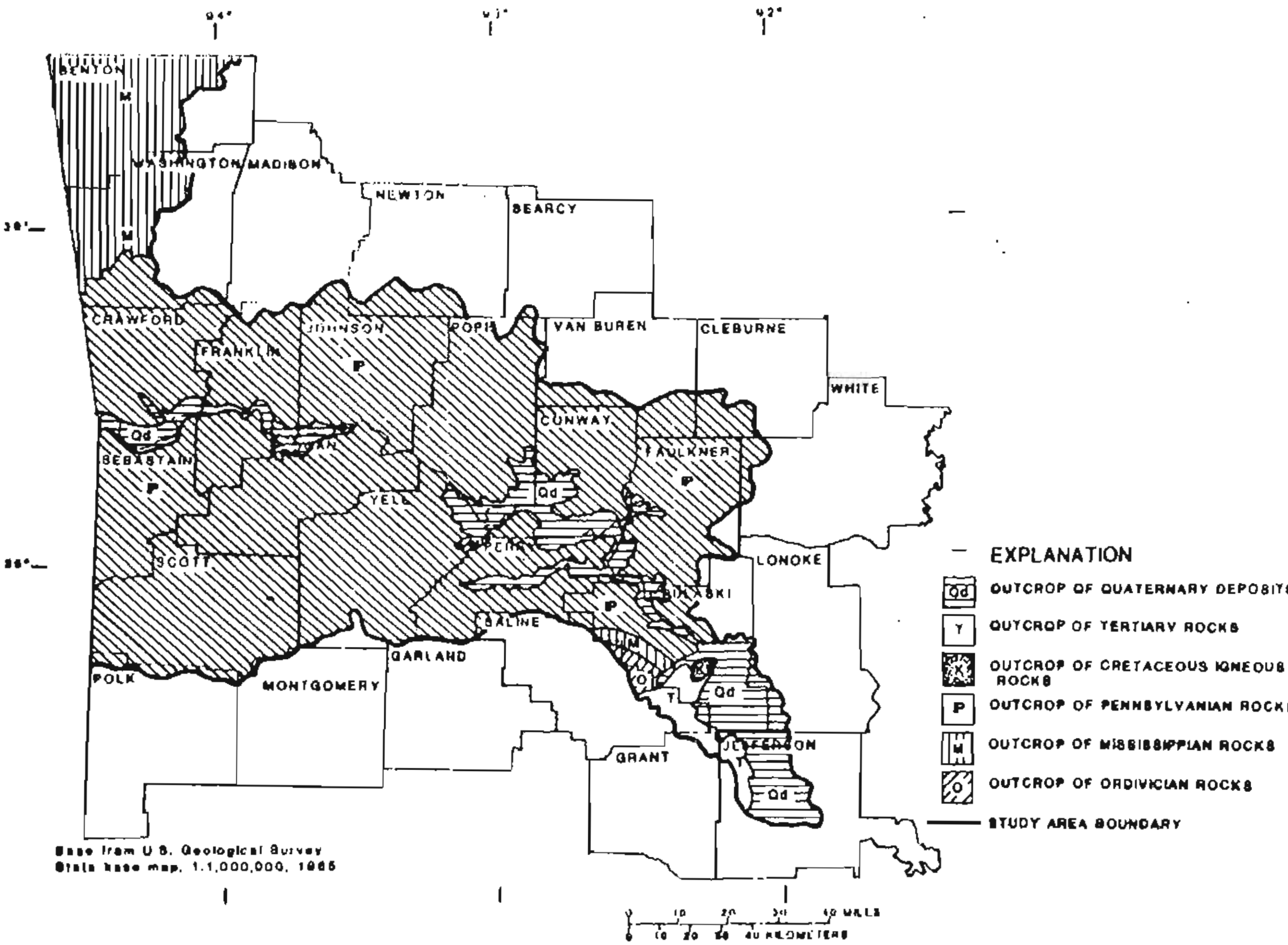

Figure 4-2.--Geology of the study area (modified from Haley, 1976 and Hosman, 1982).

Table 4-1.—Generalized stratigraphic column of the study area in the Ozark Plateaus physiographic province

(modified from Caplan, 1957; 1960)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
	Pennsylvanian	Atoka Formation	0-4,600	Sandstone, medium grained, interbedded with dark shale.	
		Bloyd Shale	0-628	Shale, dark, fissile; contains beds of sandy, gray limestone	
		Hale Formation	0-980	Upper part - massive limestone, shaly layers. Lower part - shale, fissile, dark.	Yields small quantities of water to wells in the weathered zones in the outcrop area. Most wells yield 2 to 5 gallons per minute. In some areas, fracture zones and bedding planes may yield up to 25 gallons per minute.
	Mississippian	Pitkin Limestone	0-219	Limestone, crystalline, gray-black	
		Fayetteville Shale	0-297	Shale, dark, black sandstone beds near top	
		Batesville Sandstone	0-457	Sandstone, medium grained with basal limestone	
		Ruddell Shale		Shale, fissile, dark gray-green	
		Moorefield Formation		Shale, platy, gray-black	
		Boone Formation (including St. Joe Limestone member)	0-388	Chert, dense or cherty limestone contains a basal pink to maroon finely crystalline limestone	
		Chattanooga Shale	0-70	Shale, black, bituminous, with basal sandstone	Weathered rubble of limestones yield 2 to 5 gallons per minute to wells. Wells tapping solution channels can yield up to 25 gallons per minute.
	Devonian	Pentera Chert	0-260	Chert, gray to black, with interbedded limestone	
	Silurian	Lafferty Limestone	0-254	Limestone, earthy, thinly bedded, red to gray	
		St. Clair Limestone		Limestone, pinkish-gray	
		Brassfield Limestone		Limestone, light gray, containing vugs	
	Ordovician	Cason Shale	0-57	Shale, platy to fissile, black and gray	
		Fernvale Limestone	0-108	Limestone, coarsely crystalline, white, gray, pink	Commonly yield 5 to 10 gallons per minute from solution channels, bedding planes, and fractures. Yields from some wells may exceed 50 gallons per minute.
		Kimmswick Limestone	0-400	Limestone, saccharoidal, white to gray, fossiliferous	
		Plattin Limestone		Limestone, dense, light gray to blue gray	
		Joachim Dolomite	0-117	Dolomite, silty, gray to brown, some sandstone	
		St. Peter Sandstone	0-158	Sandstone, medium grained, white, frosted	
		Everton Formation	0-1,180	Dolomite, dense, gray to brown and sandstone	
		Powell Dolomite	0-404	Dolomite, silty, shaly, sandstone and sandy dolomite	
		Cotter Dolomite	0-527	Dolomite, light gray to brown, cherty	Solution channels and fractures yield 5 to 10 gallons per minute. Yields in some wells may exceed 50 gallons per minute.
		Jefferson City Dolomite	100-496	Dolomite, cherty, silty, gray to brown. Minor beds of sandstone.	
		Roubidoux Formation	132-455	Dolomite, dolomitic sandstone, and chert	Average yield is less than 150 gal/min but up to 450 gal/min is possible
		Gasconade-Van Buren Formations (including Gunter Sandstone member)	319-600	Dolomite, cherty, light brown-gray. Basal sandstone-Gunter member, white to gray quartz sandstone.	Wells commonly yield 150 to 300 gallons per minute. Can yield up to 500 gallons per minute.

Table 4-1.—Generalized stratigraphic column of the study area in the Ozark Plateaus physiographic province (con.)

(modified from Caplan, 1957; 1960)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
	Cambrian	Eminence-Potosi Formations	307-389	Dolomite, cherty, light colored	Little is known about water yields of these formations in Arkansas. With the exception of the Eminence-Potosi, these formations yield less than 50 gallons per minute in southern Missouri. The Eminence-Potosi has reportedly yielded up to 230 gallons per minute in a well in Benton County.
		Derby-Doerun Formations		Dolomite, granular, cherty, sandy, silty	
		Davis Formation		Dolomite, sandy, shaly	
		Bonneterre Dolomite	0-71	Dolomite, light gray, glauconitic	
		Lamotte Sandstone	0-59	Quartzose sandstone, locally arkosic	
	Precambrian	Igneous Rocks			

The Ouachita province, which encompasses most of the study area, consists of two sections; the Arkansas Valley to the north and the Ouachita Mountains to the south. The Arkansas Valley is an east-west trending synclinorium 30 to 50 miles wide with a surface generally lower than the Boston Mountains on the north and the Ouachita Mountains on the south (Fenneman, 1938). The rocks cropping out in the Arkansas Valley are nearly horizontal beds of Pennsylvanian-aged sandstones and shales (fig. 4-2). In contrast, the Ouachita Mountains section is a faulted anticlinorium, with mountains and intermountain valleys being the dominant topographic features. The outcropping rocks in this part of the study area range in age from Pennsylvanian to Ordovician. The dominant lithologies are shale, sandstone, chert and novaculite. A more detailed description of the geologic units of the Ouachita province is contained in the stratigraphic column in table 4-2.

The Arkansas River flows within a narrow valley 1 to 5 miles in width through the Arkansas Valley section. Alluvial deposits associated with the river occur in several disconnected areas along the river between Fort Smith and Little Rock. The coarse-grained basal section of the alluvium is a highly productive aquifer.

Except for the alluvial aquifer, there are no regionally significant water-bearing formations either at the surface or at depth in the Ouachita province.

Table 4-2.--Generalized stratigraphic column of the study area in the Ouachita physiographic province

(modified from Cordova, 1963; Albin, 1965)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
Cenozoic	Quaternary	Alluvial and terrace deposits	0-80	Gravel at the base, grading upward to sand, silt, and clay	Yields 300 to 700 gallons per minute.
	Pennsylvanian	Boggy Shale	0-900	Shale, dark, contains three buff sandstone beds	Yield small quantities of water to wells in the weathered zones in the outcrop areas. Most wells yield less than 10 gallons per minute, but yields as high as 72 gallons per minute have been reported.
		Savanna Sandstone	0-1,610	Shale and sandstone with six coal beds and one lenticular limestone bed	
		McAlester Shale	0-1,820	Shale, dark, gritty; sandstone; siltstone; coal	
		Hartshorne Sandstone	0-300	Sandstone, medium grain, whitish to light gray, shaley in some areas	
		Atoka Formation	0-19,000	Shale, silty, dark and sandstone, light gray	
		Johns Valley Shale	0-1,000	Shale and claystone, gray and tan	
	Mississippian	Jackfork Sandstone	0-7,000	Sandstone, fine to coarse grained, light gray to brown	
		Stanley Shale	0-12,200	Shale, black, fissile and sandstone, fine grained, green; basal Hot Spring sand- basal Hot Springs sandstone member - sandstone, medium grained, gray, quartzitic	
	Mississippian / Devonian	Arkansas Novaculite	0-950	Upper Member: novaculite, gray to black, calcareous, massive Middle Member: novaculite, dark, thinly bedded, interbedded shale Lower Member: novaculite, white, dense massive	
	Silurian	Missouri Mountain Shale	0-300	Shale, red and green; contains thin beds of chert and sandstone	
		Blaylock Sandstone	0-500	Shale, black and green, interbedded sandstone, medium grained	
		Polk Creek Shale	0-175	Shale, black, graphitic, contains abundant graptolites	
	Ordovician	Polk Creek Shale	0-175	Shale, black, graphitic, contains abundant graptolites	
		Bigfork Chert	0-800	Chert, gray to black, interbedded black limestone and shale	
		Womble Shale	0-1,000	Shale, black, some sandstone and blue-black limestone	
		Blakely Sandstone		Shale, black and green, and interbedded sandstone, medium grained	

The geologic units that underlie the Coastal Plain province of the study area range in age from Tertiary to Quaternary (fig. 4-2). They consist of a series of sand, clay, and marl formations which outcrop in bands parallel to the Fall Line and dip to the southeast and, of alluvial deposits that blanket the area in the Coastal Plain from the Arkansas River east to the boundary of the study area. The alluvial deposits are part of the Mississippi River Valley alluvium and contain the most productive aquifer in the study area. The Sparta Sand of Tertiary age, which is part of the older sequence of beds underlying the Coastal Plain province, is also a highly productive unit in the study area as well as in much of the southeastern part of the State. Other Tertiary-age units, including the Cockfield Formation and the Midway Group, are of local significance. More detailed information describing the geologic units of the Coastal Plain is summarized in the stratigraphic column in table 4-3.

Table 4-3.--Generalized stratigraphic column of the study area in the Coastal Plain physiographic province

(modified from Klein and others, 1950; Terry and others, 1979; and Petersen and others, 1985)

Erathem	System	Geologic unit	Thickness in feet	Description	Water-bearing characteristics
	Quaternary	Alluvium and terrace deposits	0-150	Gravel at the base grading upward to sand, silt and clay	Yields up to 2,500 gallons per minute
	Tertiary	Jackson Group	0-380	Clay with some fine sand and silt	Does not yield water
		Cockfield Formation	0-175	Sand, fine, lignitic, carbonaceous	Commonly yields less than 100 gallons per minute but can yield up to 750 gallons per minute
		Cook Mountain Formation	0-150	Clay, carbonaceous with lenses of fine sand	Does not yield water
		Sparta Sand	0-500	Sand, clay, and silt, fine grained near top to coarse grained at the bottom	Commonly yields 1,000 gallons per minute to wells. Yield from some wells may exceed 1,900 gallons per minute
		Cane River Formation	0-500	Clay, sand, and silt	Source of water only in or near its outcrop area. Yields up to 35 gallons per minute.
		Carrizo Sand	0-200	Sand, fine to medium	Generally yields less than 50 gallons per minute
		Wilcox Group	0-800	Sand and clay interbedded	Commonly yields over 50 gallons per minute
		Midway Group	0-500	Clay with some silt and lime	Yields water in outcrop area
	Cretaceous			Sand, calcareous, and glauconitic, with thin beds of clay and lime	Does not yield potable water

PURPOSE AND SCOPE

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

The purpose of this report is to (1) describe the general geologic and hydrologic characteristics of the basin, (2) describe the significant water-bearing units in more detail, and (3) examine specific ground-water problems and potential problems.

The study area includes all of the Arkansas River basin. For convenience, water-use figures were assembled by county for the 15-county area shown in figure 4-3. This 15-county area does not correspond exactly to the study area.

The general physiographic and geologic characteristics of the study area including topography, geologic structure, and lithologies present are described in this report. In addition the general hydrologic characteristics of the study area including ground-water availability, ground-water use, and ground-water quality are described. Several regionally important water-bearing units are described in more detail. These units included subsurface and surficial rock units in the Interior Highlands, Quaternary deposits throughout the study area, and the Sparta Sand in the Coastal Plain. The availability and quality of water from each of these units are discussed in detail. Ground-water availability and quality problems in the study area are also described in detail.

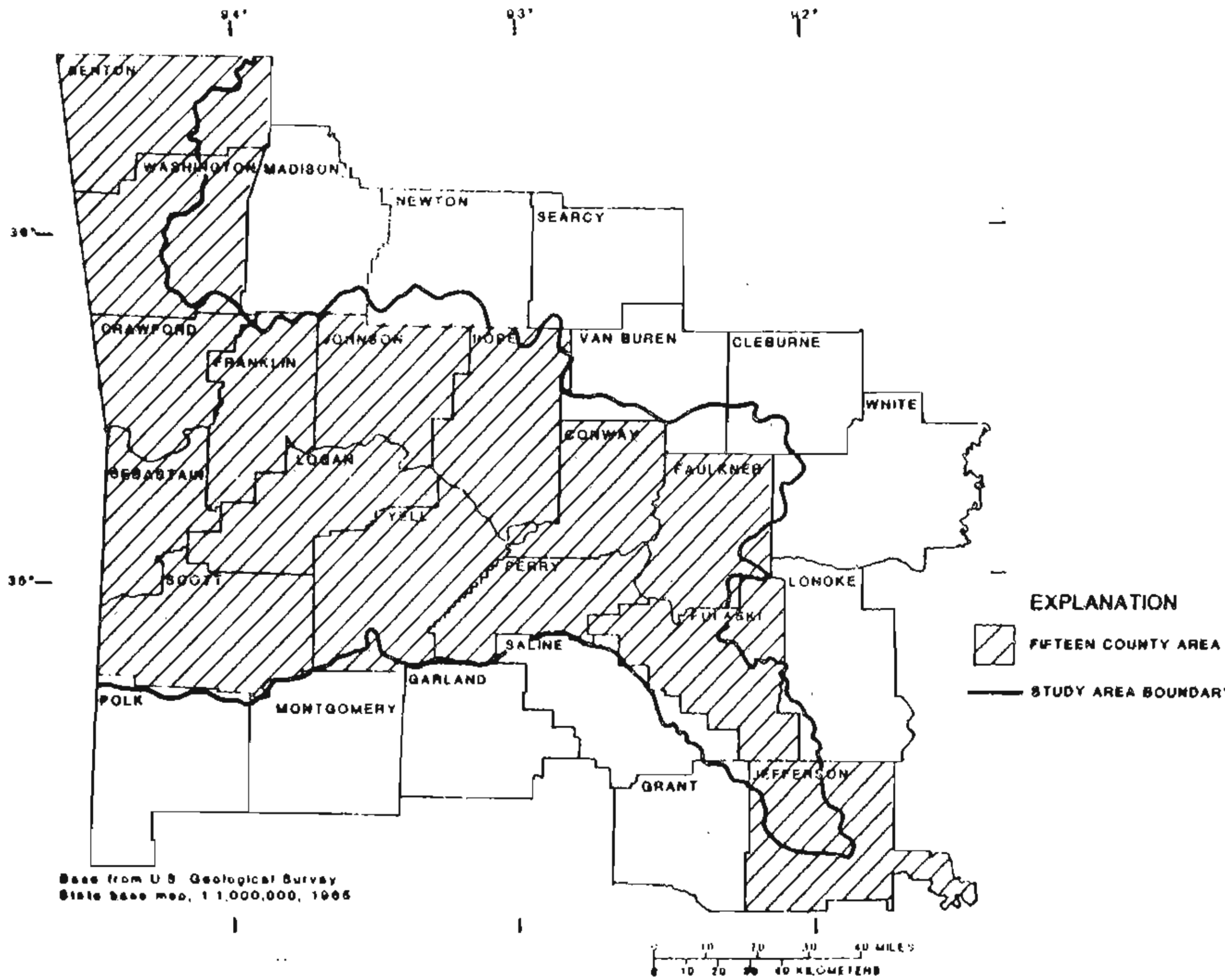

Figure 4-3.--Location of fifteen county area used for water-use data compilation.

GENERAL HYDROLOGY OF THE STUDY AREA

Ground water is available from nearly all of the geologic units in the study area. However, many of the units do not yield enough water even for domestic use. Others, such as surficial rock units generally are marginally acceptable as sources of water, but are important because they are readily accessible and usually are the only available source of ground water.

Ground-water withdrawals (Holland, 1987) in the 15-county area approximating the study area totaled 257 million gallons per day (Mgal/d) in 1985 (table 4-4), which represented 7 percent of the ground water withdrawn from all aquifers statewide. Over 70 percent of the water withdrawn in the 15-county area was from wells tapping Quaternary deposits and the Sparta Sand in southern Pulaski and Jefferson Counties. Less than 10 percent was withdrawn from the Paleozoic units that underlie the Interior Highlands.

More than 15 percent of the total usage was from the Quaternary deposits in the Arkansas River Valley between Fort Smith and Little Rock. Ground-water withdrawals from all aquifers in the 15-county area peaked in 1980 and declined between 1980 and 1985 (fig. 4-4).

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

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

County	Deposits of Quaternary age	Sparta Sand	Rocks of Paleozoic age, undifferentiated	County total
Benton	--	--	6.76	6.76
Conway	4.19	--	.13	4.32
Crawford	4.15	--	1.46	5.61
Faulkner	.67	--	3.03	3.70
Franklin	.96	--	.78	1.74
Jefferson	120.59	51.68	--	172.27
Johnson	2.87	--	1.09	3.96
Logan	.33	--	2.93	3.26
Perry	--	--	.98	.98
Pope	6.53	--	.20	6.73
Pulaski	29.58	.85	.01	30.44
Scott	--	--	1.23	1.23
Sebastian	1.07	--	1.53	2.60
Washington	--	--	5.67	5.67
Yell	5.96	--	1.52	7.48
Study area total	176.90	52.53	27.32	256.75

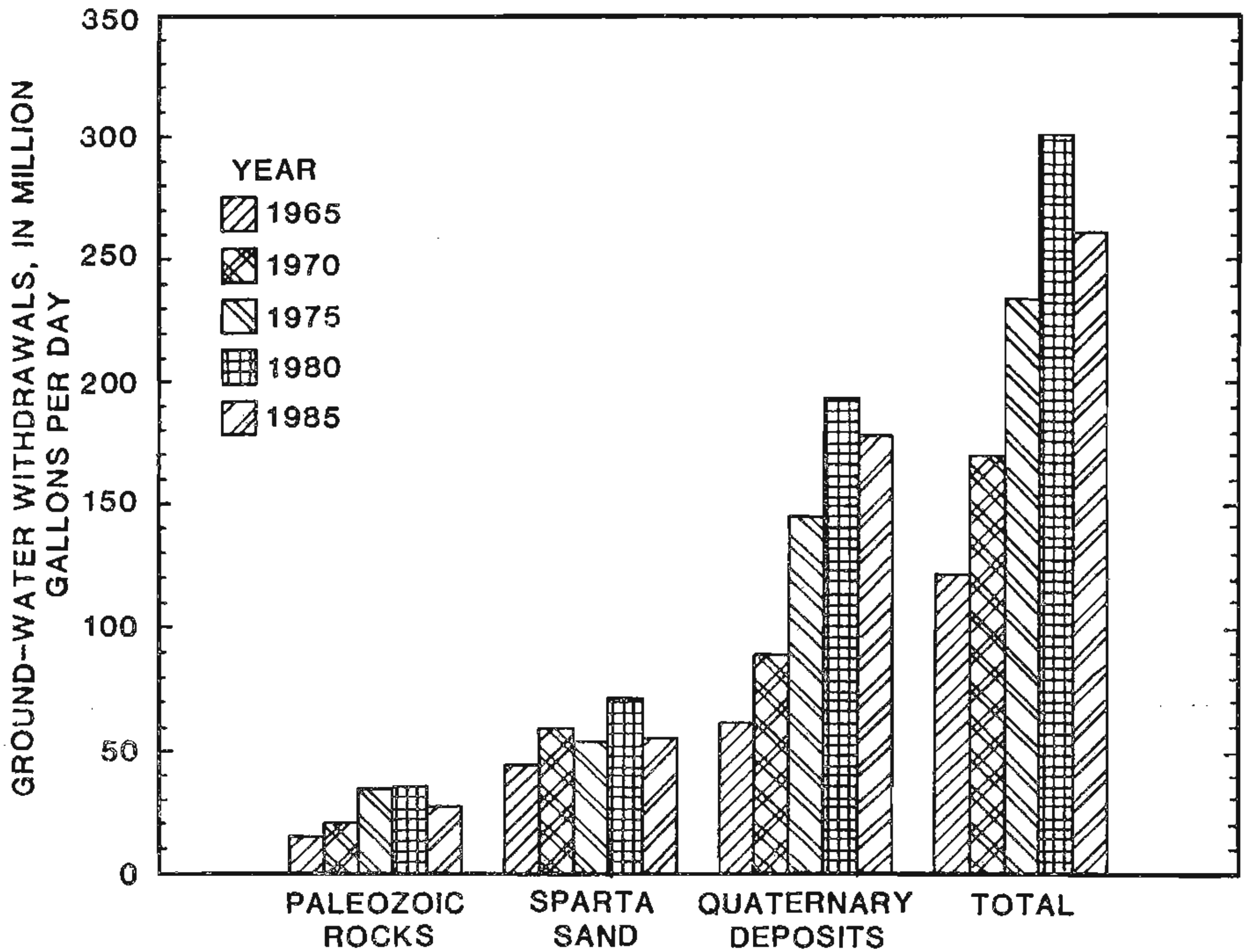

Figure 4-4.--Ground-water withdrawals between 1965 and 1985.

Over 60 percent (164 Mgal/d) of the water withdrawn in the 15-county area in 1985 was used for irrigation. Most of this use was in Jefferson County but a substantial amount was withdrawn from alluvial deposits adjacent to the Arkansas River upstream from Little Rock. The next largest use category was rural use with more than 15 percent (41 Mgal/d) of the 15-county area total. Self-supplied industry and public supply accounted for the remainder of the pumpage, most of which was in Jefferson County. Fluctuations in pumpage in each of these categories over the past 25 years are shown in figure 4-5. A more detailed breakdown of water use in the 15-county area by county and use category is contained in table 4-5.

In the Ozark Plateaus, ground-water quality in both the surficial and subsurface rock units is similar and closely related to the mineral content of the units. The ground water in the limestones and dolomites that exist in this area is primarily of the calcium magnesium bicarbonate type and very hard (Lamonds and others, 1969). Ground water from these units is used wihtout treatment for rural, domestic, and some industrial purposes; but requires softening to be used for municipal supplies and most industrial purposes. High nitrate concentrations, indicating contamination from septic tanks and barnyard wastes, are common local problems in the Ozark Plateaus.

In the Ouachita province, both the surficial rock units and the Quaternary deposits yield ground water of the calcium bicarbonate type. The water from these units is generally hard and high in iron. In some areas water from the surficial units is slightly saline, while in other areas, high nitrate concentrations can be a problem in shallow wells.

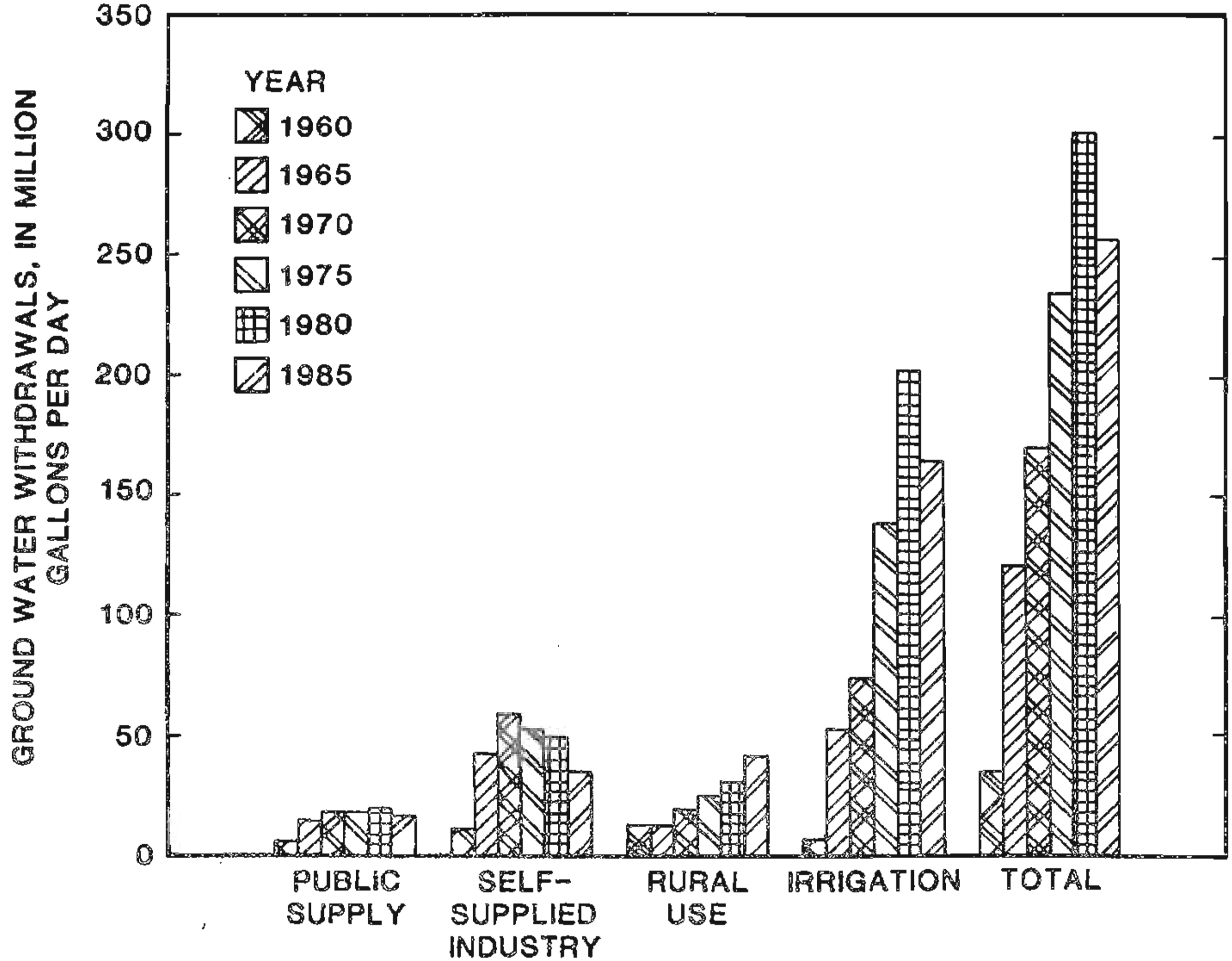

Figure 4-5.--Ground-water withdrawals for each use category between 1960 and 1985.

Table 4-5.--Ground-water withdrawals from the study area between 1960 and 1985

[Withdrawals in million gallons per day]

	Public supply						Self-supplied industry[a]					
County	[b]1960	[c]1965	[d]1970	[e]1975	[f]1980	[g]1985	[b]1960	[c]1965	[d]1970	[e]1975	[f]1980	[g]1985
Benton	0.89	2.36	2.00	1.78	0.43	0.43	2.10	0.11	0.30	0.70	0.15	0.54
Conway	.53	1.02	1.07	1.29	1.39	1.12	.22	.02	5.40	5.02	.06	.06
Crawford	0	0	0	—	—	—	.78	0	.01	—	.03	.03
Faulkner	0	.02	.09	.32	.84	.82	.10	0	.01	0	.03	—
Franklin	.15	.52	1.26	—	—	—	.04	.02	.07	.23	.19	.22
Jefferson	—	5.40	7.83	8.86	11.63	10.97	—	38.96	51.23	44.83	45.45	30.98
Johnson	0	.04	0	—	—	—	.22	.01	.02	.03	.10	.10
Logan	0	.04	.11	.15	.10	.09	0	.01	.16	.01	.04	.06
Perry	0	.03	.05	.07	.10	.10	.02	0	.03	.02	.02	.15
Pope	.12	.21	.45	.43	—	—	.52	.05	.02	.04	.47	.21
Pulaski	2.20	3.17	3.76	4.19	3.38	1.81	6.73	2.98	1.63	1.50	1.74	.66
Scott	0	0	.01	—	—	—	0	0	.01	.01	.01	.01
Sebastian	.03	.08	.10	.08	.09	.13	0	0	.05	.04	.05	.07
Washington	.92	.25	.13	.31	.02	.02	0	0	.01	.02	.03	.15
Yell	.20	.74	.98	.56	.93	.93	.04	.03	.03	.46	1.26	1.34
Total	5.04	13.86	17.84	18.04	18.91	16.42	10.77	42.19	58.98	52.91	49.63	34.58

	Rural						Irrigation[h]					
County	[b]1960	[c]1965	[d]1970	[e]1975	[f]1980	[g]1985	[b]1960	[c]1965	[d]1970	[e]1975	[f]1980	[g]1985
Benton	2.11	1.87	2.78	3.67	4.42	5.79	0	0.77	0.91	5.54	0.61	—
Conway	.54	.60	.86	1.02	1.23	1.30	0.14	1.01	1.56	1.19	3.50	1.84
Crawford	.60	.70	1.02	1.04	1.53	1.90	0	1.08	1.64	.77	3.90	3.68
Faulkner	.72	.88	1.33	1.74	2.00	2.59	.91	0	1.84	.23	.43	.29
Franklin	.46	.49	.75	1.05	.83	1.20	0	.22	.07	—	1.13	.32
Jefferson	—	1.28	1.33	.84	.60	6.76	—	41.25	50.87	106.27	154.86	123.56
Johnson	.55	.46	.68	.94	1.18	1.43	0	.49	.93	1.19	2.59	2.43
Logan	.73	.75	.93	1.29	1.52	1.60	.04	.16	.47	.18	.93	1.51
Perry	.25	.26	.42	.52	.59	.73	0	0	1.71	.25	.01	—
Pope	1.27	.70	1.32	1.63	2.18	2.64	0	.60	1.00	2.81	2.57	3.88
Pulaski	.34	.35	2.45	2.14	5.91	5.78	5.37	6.49	10.92	15.59	24.55	22.19
Scott	.35	.42	.62	.82	1.05	1.22	0	0	.02	—	—	—
Sebastian	.36	.62	.63	2.41	1.23	1.37	0	.21	.04	.01	.61	1.03
Washington	2.95	1.93	3.11	3.96	4.72	5.50	0	.26	.17	3.46	3.97	—
Yell	.91	.69	1.06	1.52	1.61	1.59	.24	.40	1.44	.96	2.34	3.62
Total	12.14	12.00	19.29	24.59	30.60	41.40	6.70	52.94	73.59	138.45	202.0	164.35

	Total					
County	[b]1960	[c]1965	[d]1970	[e]1975	[f]1980	[g]1985
Benton	5.10	5.11	5.99	11.69	5.61	6.76
Conway	1.43	2.65	8.89	8.52	6.18	4.32
Crawford	1.38	1.78	2.67	1.81	5.46	5.61
Faulkner	1.73	.90	3.27	2.29	3.30	3.70
Franklin	.65	1.25	2.15	1.28	2.15	1.74
Jefferson	—	86.89	111.26	160.80	212.54	172.27
Johnson	.77	1.00	1.63	2.16	3.87	3.96
Logan	.77	.96	1.67	1.63	2.59	3.26
Perry	.27	.29	2.21	.86	.72	.98
Pope	1.91	1.56	2.79	4.91	5.22	6.73
Pulaski	14.64	12.99	18.76	23.42	35.58	30.44
Scott	.35	.42	.66	.83	1.06	1.23
Sebastian	.39	.91	.82	2.54	1.98	2.60
Washington	3.87	2.44	3.42	7.75	8.74	5.67
Yell	1.39	1.86	3.51	3.50	6.14	7.48
Total	34.65	121.01	169.70	233.99	301.14	256.75

[a] Includes fuel-electric power
[b] Stephens and Halberg, 1961
[c] Halberg and Stephens, 1966
[d] Halberg, 1972
[e] Halberg, 1977
[f] Holland and Ludwig, 1981
[g] Holland, 1987
[h] Includes fish and minnow farms, wildlife improvements, and national fish hatcheries

South of the Fall Line, in the Coastal Plain, the Quaternary deposits yield a very hard calcium bicarbonate water, which generally has a high iron content, while the Sparta Sand yields a very soft sodium bicarbonate water. In most cases, ground water from the Quaternary deposits is more highly mineralized than that from the Sparta Sand, which is widely used for public supply with little or no treatment.

Ground-water-quality data by geologic unit are listed in table 4-6. The recommended limits for several of these constituents, as established by the U.S. Environmental Protection Agency under the Safe Drinking Water Act, can be found in tables 4-7 and 4-8. The Arkansas Department of Health uses the National Primary Standards to set State standards for public water supply systems.

Table 4-6.—Ground-water quality of geologic units

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

Geologic unit	Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)	Dissolved iron (µg/L as Fe) (01046)
Quaternary deposits	17.3	5.0	599	7.8	254	4	201	247	70.6	17.3	[a]204
Sparta Sand	24.6	9.0	142	7.2	56	0	44	27	7.5	2.1	[b]846
Surficial Rocks	18.8	9.0	526	7.2	178	5	138	127	23.4	14.1	[c]814
Subsurface Rocks	18.9	6.0	508	7.9	195	0	175	148	36.3	13.9	451

Geologic unit	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Quaternary deposits	31.5	1.0	2.3	51.2	25.3	0.21	21.6	385.5	3.91
Sparta Sand	12.3	1.1	3.8	3.8	7.3	.10	14.2	80.8	.01
Surficial Rocks	51.0	4.4	3.1	44.5	45.5	.23	11.4	284.3	1.06
Subsurface Rocks	28.3	1.2	2.5	15.3	12.1	.43	7.1	196.9	4.06

[a] Median value was 60
[b] Median value was 100
[c] Median value was 8
[d] Median value was 180

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

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

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

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

Table 4-8.--National secondary drinking-water regulations[1]

[Data in milligrams per liter unless otherwise specified]

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

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

SIGNIFICANT WATER-BEARING UNITS

Subsurface Rock Units

Geology

Cambrian and Ordovician units, consisting primarily of dolomite and sandstone, outcrop in southern Missouri and dip to the south into Arkansas where they are present only in the subsurface. They underlie the Ozark Plateaus province where they are sources of ground water. The Gunter Sandstone, which is the basal member of the Gasconade Formation, and the Roubidoux Formation are the most regionally significant water-bearing units present in the section. The Gunter Sandstone ranges from 20 to 100 ft in thickness (fig. 4-6) and is composed of dolomitic sandstone. The Roubidoux Formation is about 900 ft below land surface at the Arkansas-Missouri State line and ranges from 130 to 450 ft in thickness (fig. 4-7). It consists primarily of dolomite, sandstone, and chert. The two water-bearing units are separated by as much as 500 ft of dolomite. The Eminence-Potosi Formations which are composed of crystalline dolomite with some associated chert lie several hundred feet below the Gunter Sandstone and are essentially untapped in the study area.

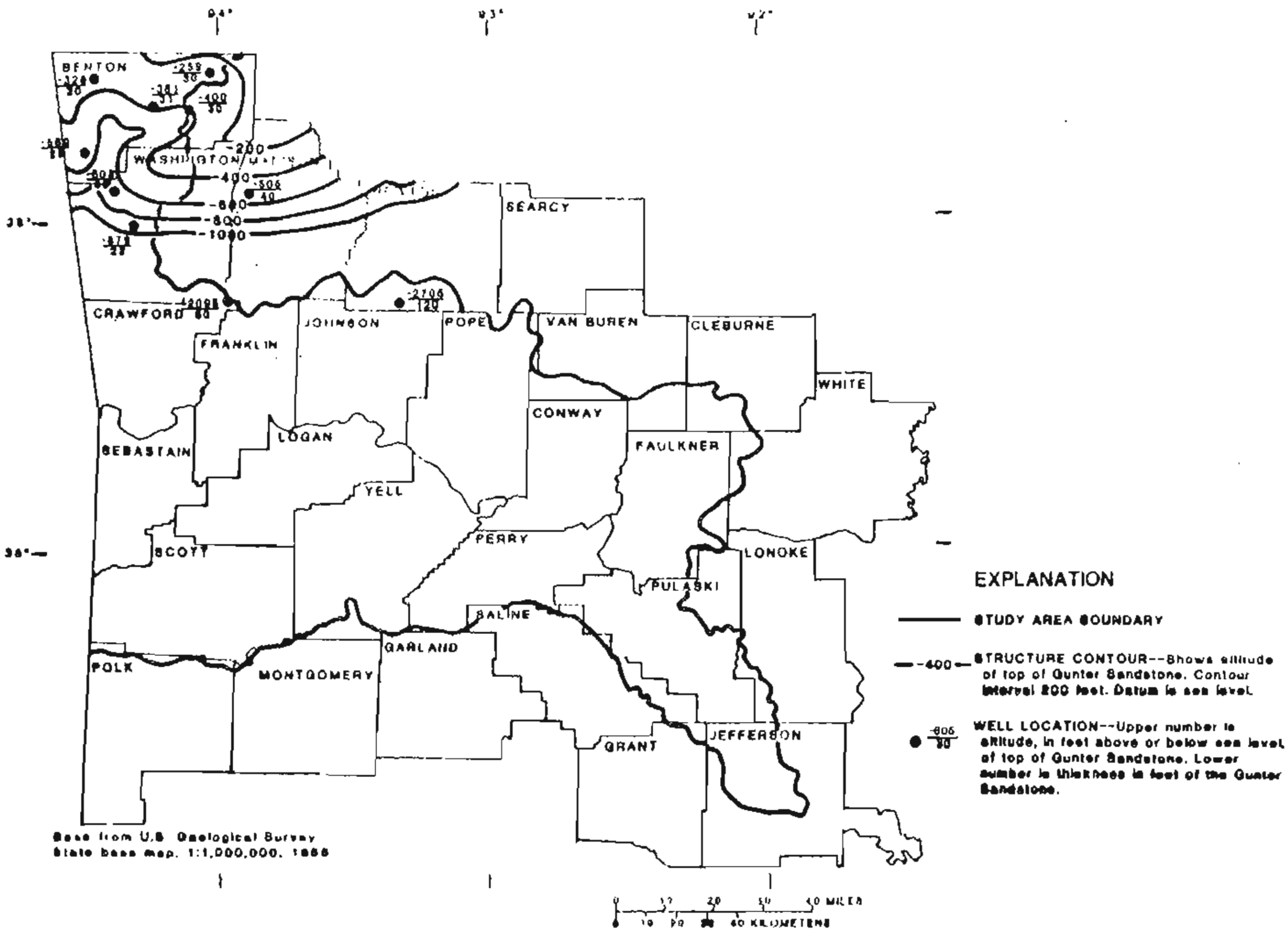

Figure 4-6.--Structure of the top of the Gunter Sandstone (modified from Lamonds, 1972).

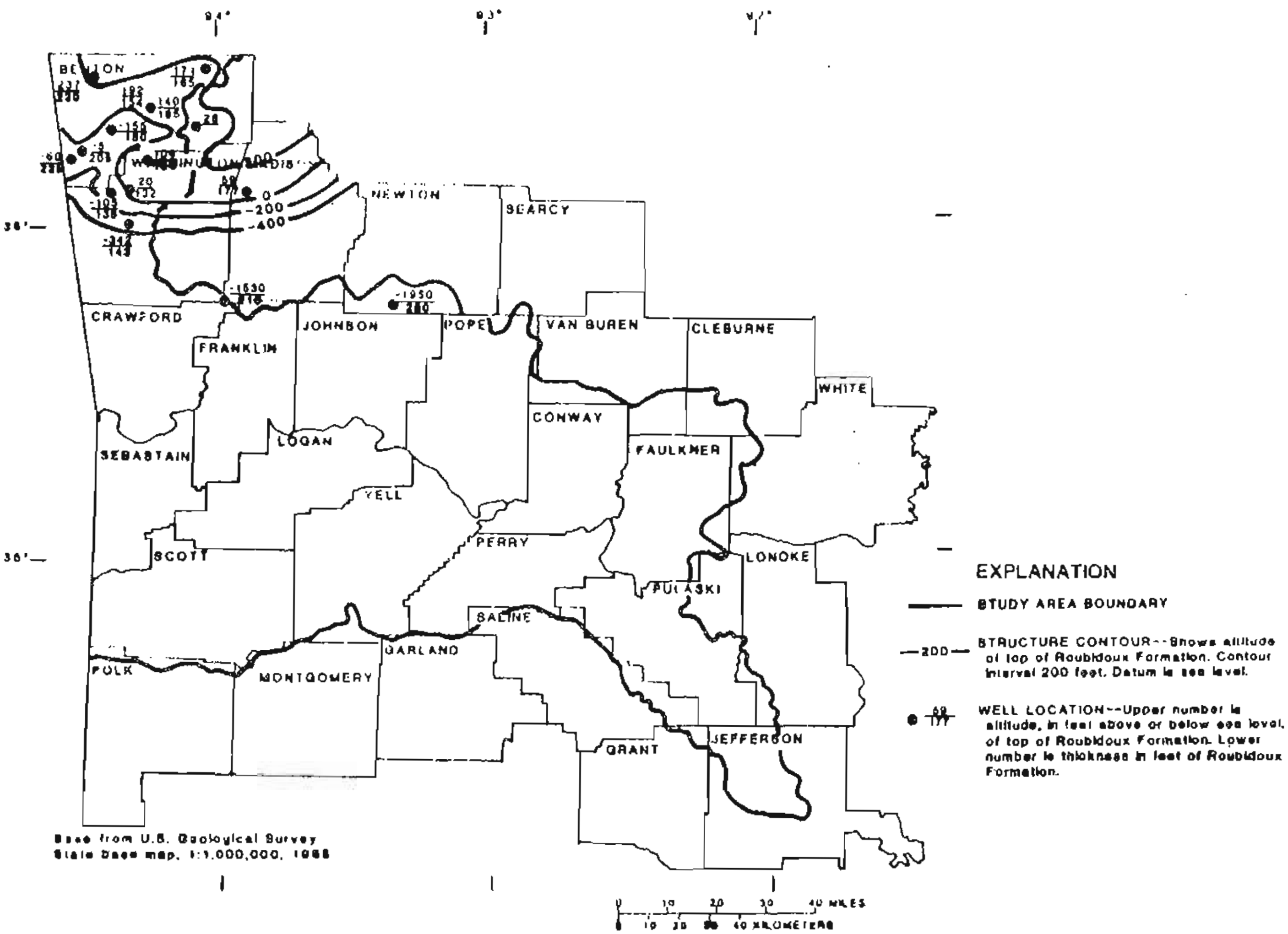

Figure 4-7.--Structure of the top of the Roubidoux Formation (modified from Lamonds, 1972).

Hydrology

Most of the water withdrawn from the subsurface rock units is from the Gunter Sandstone. Well yields from the Gunter average more than 200 gal/min, with local yields up to 500 gal/min. Wells in the Roubidoux Formation yield up to 450 gal/min. Water levels in the Gunter Sandstone range from 27 to 465 ft below land surface in the study area and those in the Roubidoux Formation range from 90 to 200 ft below land surface. Year-to-year water-level fluctuations are significant, as much as 70 ft in some wells. However, the fluctuations are due primarily to temporal variations in pumpage and do not represent long-term trends.

Analyses of samples from wells tapping subsurface rock units show that water in these units is a moderately hard to very hard, calcium magnesium bicarbonate water. The quality of water from these units is well within the established drinking water standards (tables 4-7 and 4-8) with the exception of high iron and nitrate concentrations in a few isolated Benton County wells. A summary of the available water-quality data can be found in table 4-9. The subsurface rock units will yield freshwater in Benton and Washington Counties, but the water becomes mineralized and is unusable to the south.

Table 4-9.--Subsurface rock units ground-water quality

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

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Benton	No. samples	4	11	8	9	7	7	9	11	9	9
	Minimum	17.0	0	332	7.4	200	0	166	110	25.0	6.6
	Maximum	20.5	20	413	8.2	220	0	182	260	64.0	26.0
	Mean	18.9	6	368	7.8	211	0	173	162	41.6	15.0
Washington	No. samples	0	1	3	3	3	3	2	3	3	3
	Minimum	—	1	459	7.7	23	0	155	84	17.0	10.0
	Maximum	—	1	1,640	8.2	260	0	211	110	25.0	11.0
	Mean	—	1	883	8.0	158	0	183	96	20.3	10.7

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Benton	No. samples	8	8	7	7	10	11	11	8	7	7
	Minimum	0	5.0	0.2	0.4	3.4	7.0	0.10	1.7	184	0.00
	Maximum	3,000	38.0	2.0	3.7	24.0	39.0	.95	9.3	225	28.00
	Mean	507	18.3	.7	2.3	10.0	13.1	.36	6.9	203	4.63
Washington	No. samples	1	2	2	2	3	3	1	1	2	1
	Minimum	0	55.0	2.0	2.8	5.8	6.0	1.20	8.8	93	0.05
	Maximum	0	82.0	4.0	3.2	49.0	11.0	1.20	8.8	257	0.05
	Mean	0	68.5	3.0	3.0	32.9	8.3	1.20	8.8	175	0.05

Surficial Rock Units

Geology

Paleozoic units ranging in age from Ordovician to Pennsylvanian crop out throughout the Interior Highlands. Almost all sedimentary lithologies are represented, but sandstone and shale are the most common. These units crop out along an east-west trending synclinorium, whose axis runs approximately along the Arkansas River in western Arkansas, and north of the Arkansas River in central Arkansas. Consequently, the oldest Paleozoic units crop out to the north in the Ozark Plateaus and along the southern boundary of the study area in the Ouachita Mountains, while younger Paleozoic rocks crop out in the Arkansas Valley.

Hydrology

Ground water in these surficial units occurs mostly in secondary openings such as fractures, joints, bedding planes, and solution channels. These secondary openings are generally larger and more numerous near the surface, consequently, the quantity of available ground water generally decreases with depth (Lamonds, 1972). Wells in these units are generally less than 300 ft deep and yield less than 10 gal/min. The yield of a well depends on the number and size of openings penetrated by the well bore. The water levels in these units form a subdued reflection of the land surface, and are closest to the land surface in the valleys (Lamonds, 1972). Shallow wells are generally adequate for domestic supplies during the wet months but the well yields are marginal during droughts.

Surficial rock units yield a hard to very hard, calcium bicarbonate water. The quality of this water is as variable as the lithologies, but the water is generally suitable for most uses. Local concentrations of dissolved solids, nitrate, sulfate, iron and chloride can exceed allowable limits in some parts of the study area. Low pH values and colored water are problems in other areas. These problems are all of a local nature. In most areas, the quality of water from these units is well within the limits established for drinking water (tables 4-7 and 4-8). Additional quality data are summarized in table 4-10.

Table 4-10.—Surficial rock units ground-water quality

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

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Benton	No. samples	2	3	3	3	3	3	3	3	3	3
	Minimum	16.0	5	299	7.1	190	0	154	160	61.0	1.3
	Maximum	18.5	5	332	7.7	210	0	171	180	65.0	4.7
	Mean	17.3	5	312	7.5	197	0	161	170	63.0	3.1
Conway	No. samples	1	2	5	5	3	3	3	3	2	2
	Minimum	18.5	5	236	6.0	28	0	23	33	8.4	2.8
	Maximum	18.5	8	602	8.1	110	0	90	120	19.0	8.3
	Mean	18.5	7	364	7.1	59	0	49	78	13.7	5.6
Crawford	No. samples	3	2	6	6	6	6	4	6	6	6
	Minimum	18.5	5	60	5.8	12	0	19	15	1.7	2.5
	Maximum	19.5	45	1,080	7.4	700	0	59	320	60.0	41.0
	Mean	18.8	25	290	6.6	151	0	39	86	16.8	10.6
Faulkner	No. samples	6	5	7	8	9	8	7	9	7	7
	Minimum	15.5	0	263	6.3	33	0	27	30	21.0	11.0
	Maximum	22.0	8	1,210	8.1	370	15	272	330	65.0	34.0
	Mean	19.0	4	616	7.1	246	2	189	186	39.1	21.6
Franklin	No. samples	6	8	12	12	12	12	3	12	11	11
	Minimum	15.0	5	64	6.7	19	0	23	3	0.9	0.1
	Maximum	22.0	12	983	8.8	520	460	171	280	74.0	24.0
	Mean	18.0	7	495	7.8	239	39	94	70	18.6	6.8
Johnson	No. samples	3	2	4	4	4	4	0	4	2	2
	Minimum	18.0	1	54	6.1	12	0	—	17	4.7	1.2
	Maximum	21.0	6	1,540	8.4	340	4	—	420	62.0	45.0
	Mean	19.0	4	854	7.5	213	1	—	282	33.4	23.1
Logan	No. samples	5	8	10	10	9	9	3	9	8	8
	Minimum	15.5	3	21	5.9	7	0	89	4	1.2	0.2
	Maximum	23.0	23	899	8.0	400	0	330	200	39.0	26.0
	Mean	18.9	9	381	7.1	153	0	180	74	14.5	6.2
Perry	No. samples	6	5	6	6	6	6	6	6	6	6
	Minimum	16.5	3	59	6.2	8	0	7	13	2.1	2.0
	Maximum	21.0	20	804	8.2	510	0	417	270	45.0	39.0
	Mean	18.9	9	256	7.2	126	0	103	84	14.9	11.5
Pope	No. samples	4	8	8	7	8	8	1	8	8	8
	Minimum	17.5	1	43	6.7	20	0	118	15	3.2	1.7
	Maximum	24.0	10	612	7.4	220	0	118	190	37.0	24.0
	Mean	20.4	5	244	7.0	93	0	118	80	17.9	8.8
Pulaski	No. samples	4	5	6	6	5	5	6	6	6	6
	Minimum	14.0	2	134	6.9	39	0	32	46	2.3	9.7
	Maximum	18.5	6	1,230	8.2	590	0	485	360	50.0	57.0
	Mean	16.1	4	419	7.6	215	0	167	156	22.9	24.1
Saline	No. samples	0	1	0	1	1	0	1	1	1	1
	Minimum	—	5	—	6.6	260	—	216	270	89.0	12.0
	Maximum	—	5	—	6.6	260	—	216	270	89.0	12.0
	Mean	—	5	—	6.6	260	—	216	270	89.0	12.0
Scott	No. samples	23	8	25	12	10	10	9	12	11	11
	Minimum	16.5	3	126	6.7	18	0	15	11	3.3	0.6
	Maximum	24.0	35	3,050	8.1	380	0	315	290	50.0	40.0
	Mean	19.6	14	811	7.6	135	0	134	110	20.6	15.6
Sebastian	No. samples	7	10	15	15	13	13	4	14	13	13
	Minimum	16.0	6	175	3.2	0	0	0	6	1.5	0.5
	Maximum	19.5	45	1,400	8.5	760	20	624	410	46.0	28.0
	Mean	17.9	11	606	6.9	199	2	175	134	25.4	13.4
Van Buren	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
	Maximum	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
	Mean	16.5	5	1,840	8.0	980	0	804	1,100	95.0	210.0
Washington	No. samples	0	0	4	4	4	4	2	3	3	3
	Minimum	—	—	80	4.8	2	0	23	25	4.8	1.9
	Maximum	—	—	364	7.1	32	0	25	31	6.8	4.6
	Mean	—	—	160	6.2	23	0	24	27	5.5	3.2
White	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	20.0	3	154	6.3	44	0	36	37	7.9	4.3
	Maximum	20.0	3	154	6.3	44	0	36	37	7.9	4.3
	Mean	20.0	3	154	6.3	44	0	36	37	7.9	4.3
Yell	No. samples	3	5	10	10	10	10	7	10	8	8
	Minimum	18.0	5	101	5.7	17	0	14	4	1.6	0.0
	Maximum	20.0	45	1,150	8.2	360	0	236	410	[illegible]	[illegible]
	Mean	19.0	14	478	7.4	187	0	104	131	19.2	12.5

Table 4-10.--Surficial rock units ground-water quality--Continued

County		Dis-solved iron (µg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180° C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Benton	No. samples	3	3	3	3	3	3	3	3	3	3
	Minimum	0	2.5	0.1	0.8	2.5	2.8	0.30	5.3	183	0.18
	Maximum	10	3.0	.1	1.0	3.5	15.0	1.20	6.5	208	1.00
	Mean	7	2.7	.1	.9	2.8	8.7	.73	5.8	194	.47
Conway	No. samples	2	3	3	3	4	3	2	2	2	3
	Minimum	0	21.0	2.0	2.2	24.0	6.2	0.20	5.7	24	1.80
	Maximum	0	63.0	3.0	11.0	150.0	22.0	.30	6.3	126	3.40
	Mean	0	40.7	2.3	7.2	67.0	16.7	.25	6.0	75	2.57
Crawford	No. samples	5	6	6	6	6	6	6	6	5	4
	Minimum	0	3.2	0.3	0.9	2.5	2.4	0.00	7.5	35	0.02
	Maximum	150	150.0	4.0	4.8	20.0	42.0	.20	18.0	681	1.10
	Mean	34	30.6	1.1	1.8	11.0	12.3	.07	13.2	206	.62
Faulkner	No. samples	6	7	7	7	9	9	7	7	5	5
	Minimum	0	15.0	0.7	1.0	2.5	6.4	0.10	5.8	192	0.00
	Maximum	1,400	150.0	4.0	3.2	180.0	120.0	.40	22.0	790	.16
	Mean	280	59.6	2.0	1.8	49.4	36.1	.21	15.3	418	.09
Franklin	No. samples	11	8	8	8	12	12	3	3	8	3
	Minimum	0	5.7	0.5	1.2	3.8	0.2	0.10	8.5	55	0.00
	Maximum	6,000	220.0	55.0	4.9	60.0	170.0	.20	20.0	638	.34
	Mean	869	122.0	15.7	3.1	19.5	36.7	.17	13.5	379	.12
Johnson	No. samples	3	2	2	2	4	4	2	2	2	0
	Minimum	0	1.4	0.2	0.9	2.0	9.0	0.10	3.4	32	—
	Maximum	200	33.0	.8	2.0	340.0	170.0	.30	6.9	478	—
	Mean	67	17.2	.5	1.5	123.3	83.5	.20	5.2	255	—
Logan	No. samples	5	8	8	8	10	9	6	6	4	3
	Minimum	0	0.8	0.1	0.6	1.5	1.0	0.10	0.3	19	0.00
	Maximum	70	210.0	49.0	24.0	100.0	120.0	1.00	11.0	572	1.20
	Mean	16	52.8	7.4	5.2	20.9	34.1	.32	5.6	221	.45
Perry	No. samples	1	6	6	6	6	6	2	4	4	6
	Minimum	0	3.1	0.4	0.7	3.0	2.8	0.10	5.2	49	0.00
	Maximum	0	94.0	3.0	7.0	35.0	540.0	.60	23.0	545	6.80
	Mean	0	23.6	1.0	2.5	11.7	95.2	.35	11.4	204	1.57
Pope	No. samples	8	6	6	6	8	8	8	8	8	1
	Minimum	0	1.1	0.1	0.2	1.2	0.4	0.00	6.8	37	1.90
	Maximum	80	49.0	2.0	7.6	56.0	150.0	.50	19.0	385	1.90
	Mean	15	24.4	1.1	1.8	13.0	23.6	.19	11.8	160	1.90
Pulaski	No. samples	4	6	6	6	6	6	8	5	5	5
	Minimum	0	5.4	0.2	0.3	3.3	2.4	0.10	1.1	90	0.00
	Maximum	47	150.0	3.0	3.4	78.0	71.0	.30	14.0	819	.99
	Mean	12	32.2	.8	1.4	24.7	20.7	.18	6.6	281	.28
Saline	No. samples	1	1	1	0	1	1	1	0	1	0
	Minimum	620	4.2	0.1	—	6.5	74.0	0.08	—	341	—
	Maximum	620	4.2	.1	—	6.5	74.0	.08	—	341	—
	Mean	620	4.2	.1	—	6.5	74.0	.08	—	341	—
Scott	No. samples	4	11	12	11	25	12	12	3	11	9
	Minimum	0	12.0	0.4	0.5	6.0	2.8	0.00	9.7	70	0.00
	Maximum	9,600	170.0	23.0	14.0	500.0	130.0	.70	22.0	582	7.70
	Mean	3,184	50.8	3.2	4.2	98.4	33.1	.22	17.9	240	1.62
Sebastian	No. samples	11	13	13	13	15	13	6	6	13	2
	Minimum	0	6.2	0.3	0.9	2.1	3.4	0.10	7.3	163	0.00
	Maximum	32,000	280.0	53.0	9.0	160.0	300.0	.70	24.0	746	2.10
	Mean	2,953	66.9	6.7	3.1	37.5	91.4	.35	12.8	372	1.05
Van Buren	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	0	53.0	0.7	6.0	100.0	260	0.40	5.6	1,450	0.00
	Maximum	0	53.0	.7	6.0	100.0	260	.40	5.6	1,450	.00
	Mean	0	53.0	.7	6.0	100.0	260	.40	5.6	1,450	.00
Washington	No. samples	0	3	3	3	4	4	3	3	3	2
	Minimum	—	3.2	0.3	0.7	3.5	1.7	0.00	12.0	46	0.34
	Maximum	—	4.2	.3	1.6	51.0	8.0	.00	21.0	56	.34
	Mean	—	3.7	.3	1.1	16.0	3.9	.00	17.0	53	.34
White	No. samples	1	1	1	1	1	1	1	1	1	1
	Minimum	0	9.4	0.7	0.8	9.5	5.6	0.10	13.0	7.0	0.68
	Maximum	0	9.4	.7	.8	9.5	5.6	.10	13.0	7.0	.68
	Mean	0	9.4	.7	.8	9.5	5.6	.10	13.0	7.0	.68
Yell	No. samples	5	8	8	8	10	10	7	5	6	7
	Minimum	0	3.0	0.2	0.5	2.0	0.6	0.00	8.2	176	0.09
	Maximum	80	140.0	27.0	9.7	100.0	240.0	.60	23.0	870	7.20
	Mean	20	57.5	7.2	4.2	31.1	53.1	.26	14.2	350	1.99

Sparta Sand

Geology

The Sparta Sand, of Tertiary age, is the middle sand in the Claiborne Group. It is underlain by the Cane River Formation and overlain by the Cook Mountain Formation, both of which are confining units. The Sparta Sand subcrops beneath Quaternary deposits in eastern Pulaski and western Lonoke Counties and is exposed at the surface in a thin band in southwestern Pulaski and in Saline Counties (fig. 4-8). It dips gently to the southeast and is more than 700 ft below land surface near Pine Bluff. The thickness of the formation ranges from less than 300 at the updip limit to 500-600 ft in the vicinity of Pine Bluff. The Sparta Sand consists mostly of beds of fine to medium sand in the lower half of the formation, and of beds of sand, clay, and lignite in the upper half.

Hydrology

The Sparta aquifer becomes confined by overlying and underlying clay beds downslope from the outcrop areas producing artesian conditions in the aquifer. The sources of recharge to the Sparta aquifer are precipitation on the outcrop, leakage through Quaternary deposits where it subcrops and leakage through confining layers, where the vertical hydraulic gradient is towards the Sparta. The lower half of the formation contains the most productive water-bearing zone. Production-well yields from the Sparta aquifer range from a few hundred to over 1,900 gal/min.

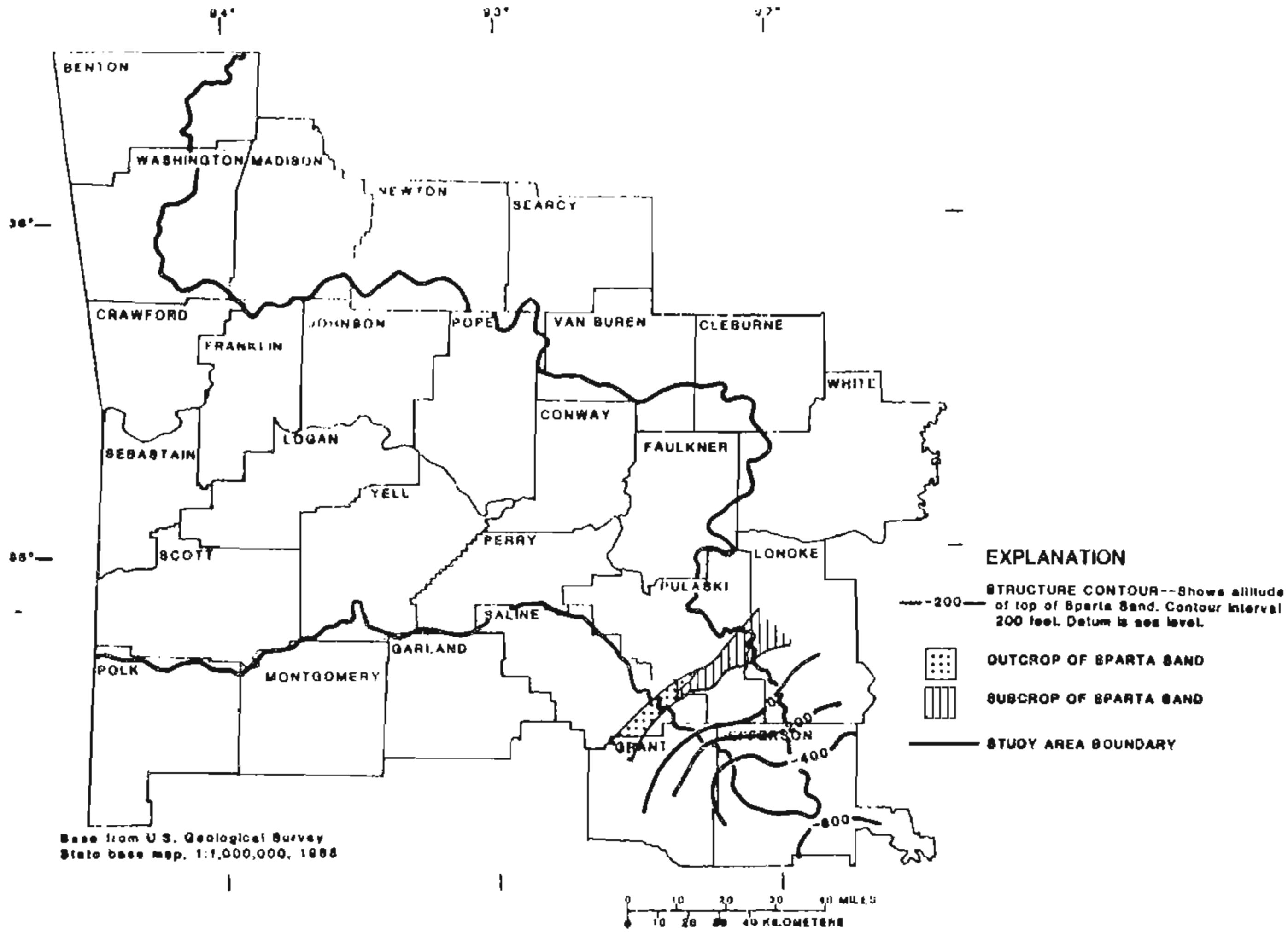

Figure 4-8.--Outcrop and subcrop of the Sparta Sand (modified from Hosman and others, 1968, and Petersen and others, 1985).

The potentiometric surface in the Sparta Sand in 1985 (fig. 4-9) illustrates the steepness of the gradient toward the cone of depression at Pine Bluff. Water levels in the Pine Bluff area have declined almost 200 ft in the last 31 years (fig. 4-10), but water levels have shown a net increase in the last 5 years. Water levels near Pine Bluff are currently (1987) approximately 250 ft below land surface (40 ft below sea level).

Withdrawals from the Sparta Sand in 1985 totaled over 55 Mgal/d, with the majority of the water withdrawn being used for public supply and self-supplied industry in the Pine Bluff area. Use declined between 1980 and 1985 after increasing for the previous 15 years. Over 35 percent of the withdrawals made statewide from the Sparta Sand were in Jefferson and Pulaski Counties.

Withdrawals from the Sparta aquifer

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

County	1965	1970	1975	1980	1985
Jefferson	44.36	59.30	53.82	71.13	54.44
Pulaski	--	.16	.20	.30	.85
Total	44.36	59.46	54.02	71.43	55.29

The Sparta Sand yields a soft, sodium bicarbonate water of good quality. Water from the Sparta Sand is less mineralized than water from any other unit in the study area, and is suitable for most uses without treatment. Water-quality data for wells in the Sparta Sand are summarized in table 4-11.

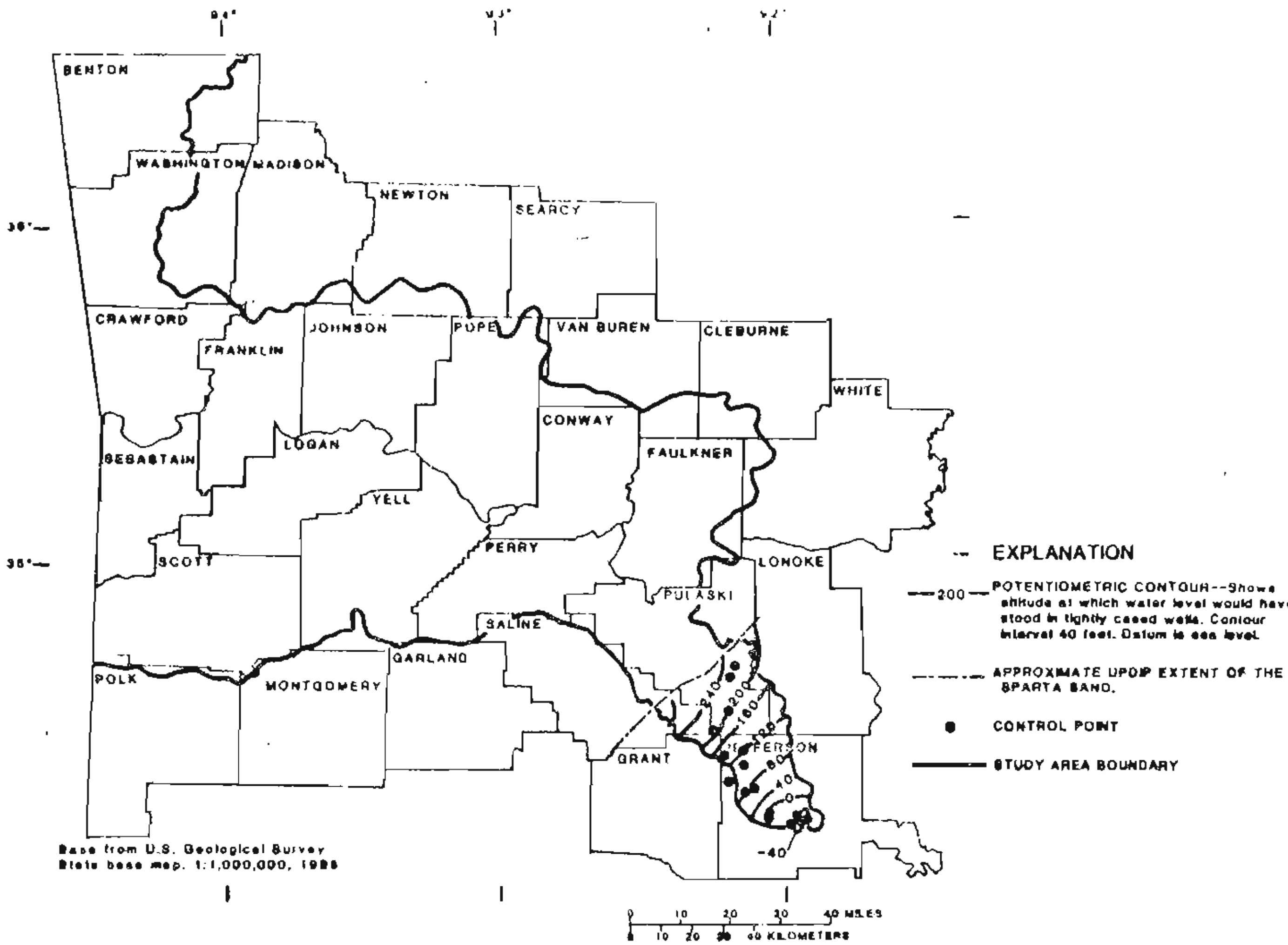

Figure 4-9.--Potentiometric surface in the Sparta Sand in 1985 (modified from Edds and Fitzpatrick, 1986).

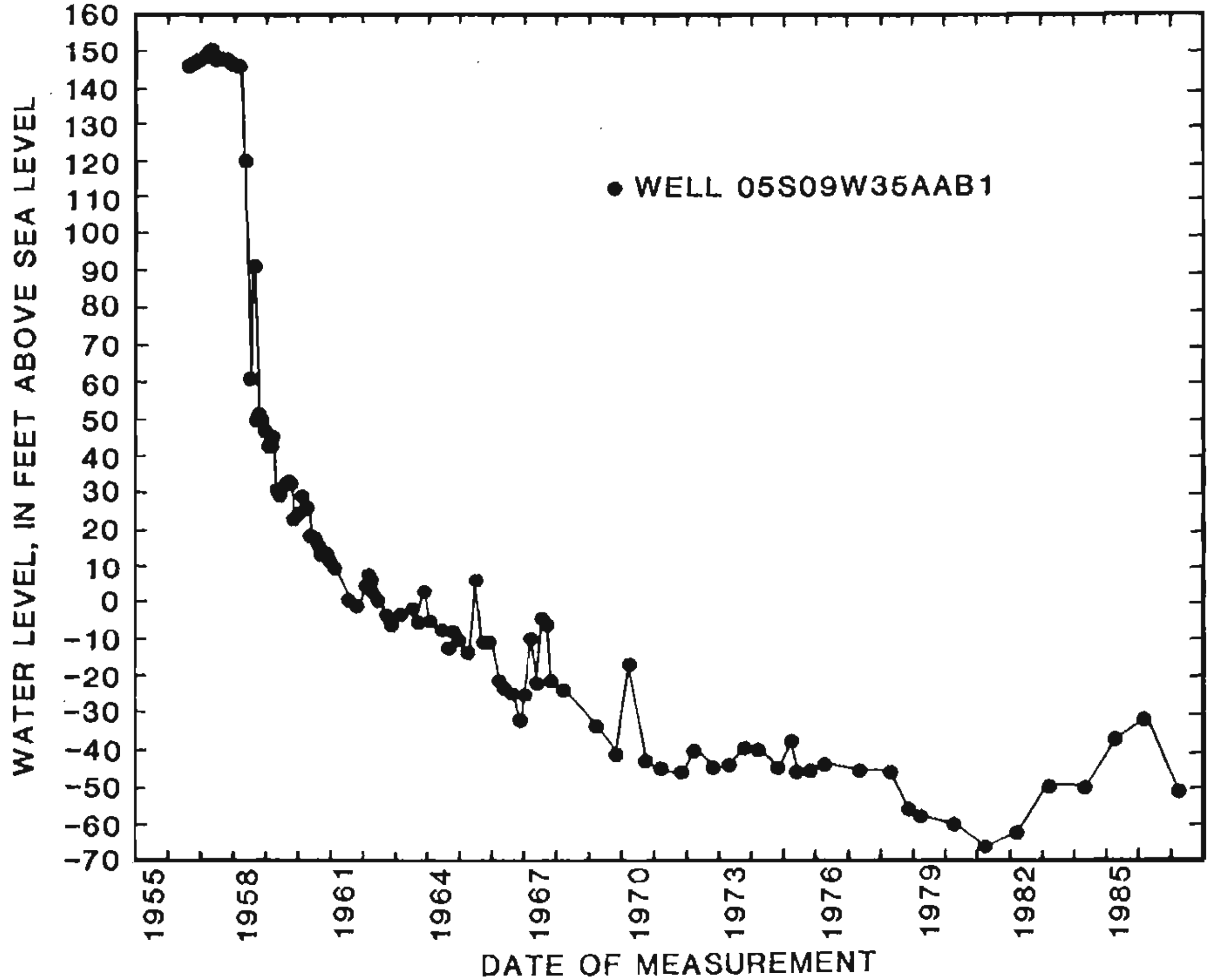

Figure 4-10.--Hydrograph of a well tapping the Sparta Sand in the Pine Bluff area.

Table 4-11.—Sparta Sand ground-water quality

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

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Jefferson	No. samples	18	17	19	19	17	18	16	19	17	17
	Minimum	23.0	0	87	6.5	38	0	31	21	5.1	1.5
	Maximum	27.0	80	439	7.7	110	0	77	54	18.0	2.5
	Mean	24.6	9	142	7.2	57	0	44	27	7.5	2.1
Pulaski	No. samples	0	0	0	0	0	0	0	0	0	0
	Minimum	—	—	—	—	—	—	—	—	—	—
	Maximum	—	—	—	—	—	—	—	—	—	—
	Mean	—	—	—	—	—	—	—	—	—	—

County		Dissolved iron (µg/L as Fe) (01046)	Dissolved sodium (mg/L as Na) (00930)	Sodium absorption ratio (00931)	Dissolved potassium (mg/L as K) (00935)	Dissolved chloride (mg/L as Cl) (00940)	Dissolved sulfate (mg/L as SO_4) (00945)	Dissolved fluoride (mg/L as F) (00950)	Dissolved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dissolved nitrate (mg/L as N) (00618)
Jefferson	No. samples	19	17	17	17	19	17	14	17	17	16
	Minimum	30	6.6	0.6	1.9	1.8	2.9	0.0	11.0	60	0.00
	Maximum	10,000	31.0	3.0	7.1	8.0	21.0	.2	17.0	150	.07
	Mean	[a]846	12.3	1.1	3.8	3.9	7.3	.1	14.2	81	.01
Pulaski	No. samples	0	0	0	0	1	0	0	0	0	0
	Minimum	—	—	—	—	2.5	—	—	—	—	—
	Maximum	—	—	—	—	2.5	—	—	—	—	—
	Mean	—	—	—	—	2.5	—	—	—	—	—

[a] Median value is 100

Quaternary Deposits

Geology

Quaternary deposits underlie the flood plain of the Arkansas River between Fort Smith and Little Rock and from the Arkansas River east to the study area boundary downstream from Little Rock (fig. 4-2). These deposits are composed of a coarse sand and gravel aquifer at the base grading upward to fine-grained sand, silt, and clay at the surface. They range in thickness from 40 ft at Fort Smith to 80 ft at Little Rock, and are about 150 ft thick where they occur in the Coastal Plain part of the study area (Klein and others, 1950; Cordova, 1963).

Hydrology

Recharge to Quaternary deposits is primarily by downward percolation of precipitation and by seepage of water from the Arkansas River. Average well yields upstream from Little Rock are 300 to 700 gal/min, while in the Coastal Plain, well yields average more than 1,000 gal/min with a maximum of about 2,500 gal/min. Ground-water levels in the flood plain of the Arkansas River are strongly influenced by the stage of the navigation pools on the river. Since completion of the navigation system water levels have risen several feet in wells close to the river and lesser amounts at greater distances from the river. Because of the high degree of connection between the river and the Quaternary deposits, the river serves as a large reservoir to sustain water levels and well yields. Water levels in the flood plain range from 5 to 30 ft below land surface. Water levels in the Quaternary deposits east of the river in the Coastal Plain have been influenced by the large withdrawals from the Quaternary deposits in the Grand Prairie and are at progressively greater depth below land surface from the river eastward. Along the eastern boundary of the study area, water levels are more than 40 ft below land surface. The potentiometric surface in the Quaternary deposits in the Coastal Plain in 1985 is shown in figure 4-11.

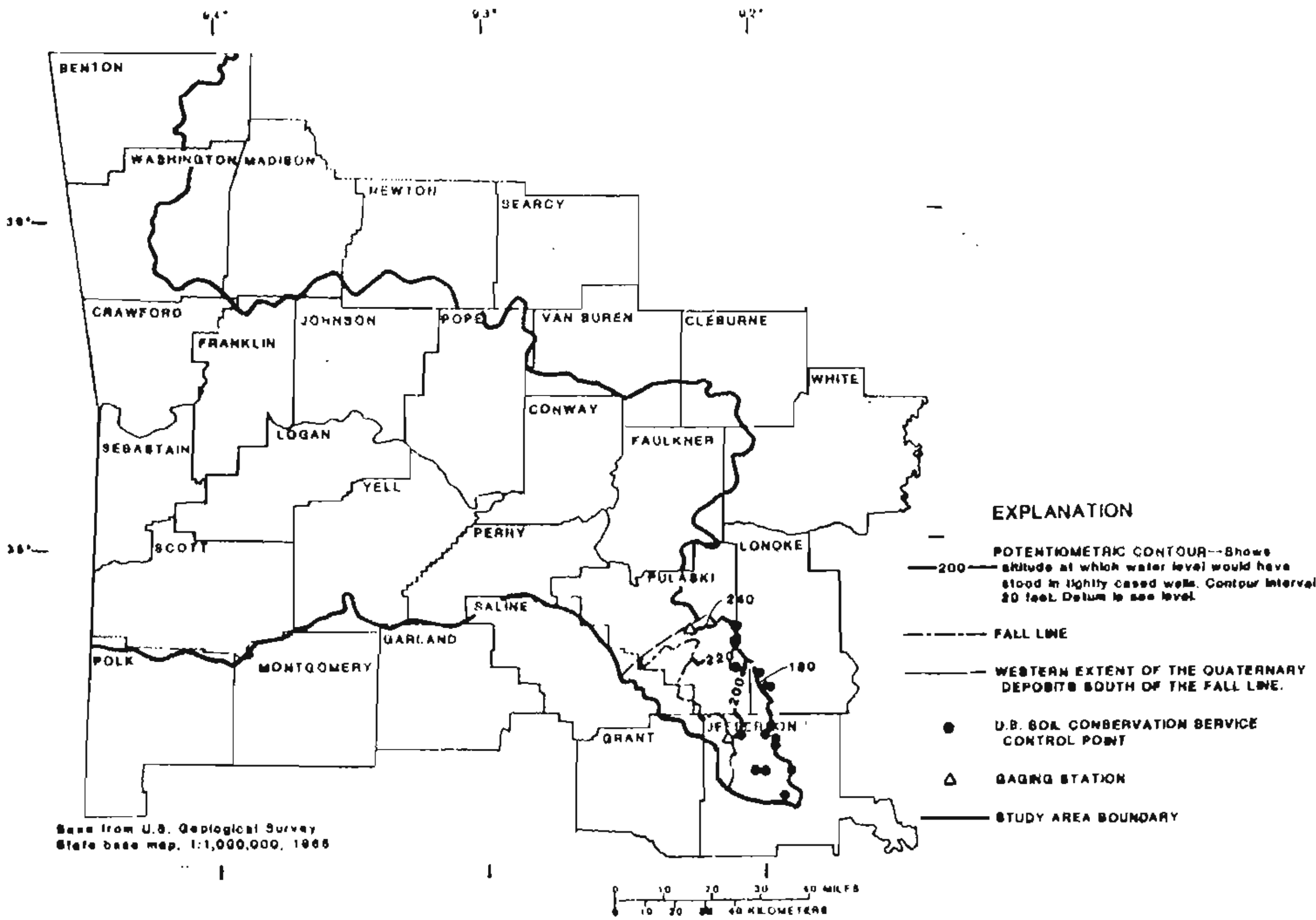

Figure 4-11.--Potentiometric surface in the Quaternary deposits south of the Fall Line in 1985 (modified from Plafcan and Fugitt, 1987).

Water use from Quaternary deposits in the study area in 1985 totaled 178.18 Mgal/d, accounting for only 5 percent of the statewide total from these deposits. Pumpage from these deposits in Pulaski and Jefferson Counties made up 85 percent of the total for the study area in 1985 (table 4-12). Use from these deposits in 1985 decreased almost 8 percent from 1980, after increasing between 1965 and 1980. Currently, these deposits are little used as a source of public supply in the study area. The primary use of water from Quaternary deposits is for irrigation.

Water from Quaternary deposits is of suitable quality for irrigation and some industrial uses. It is used for domestic supply when no public supply is available. Hardness and iron are the most pervasive problems, while locally concentrations of nitrate, iron, chloride, sulfate, and dissolved solids can exceed allowable limits. Water-quality data for wells in Quaternary deposits are summarized in table 4-13.

Table 4-12.--Withdrawals from Quaternary deposits

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

County	1965	1970	1975	1980	1985
Conway	2.10	8.06	7.53	5.44	4.19
Crawford	1.18	1.71	.84	2.51	4.15
Faulkner	--	1.93	.36	.53	.67
Franklin	.76	1.32	.27	.24	.96
Jefferson	42.01	51.60	106.79	141.14	121.91
Johnson	.60	.97	1.25	2.24	2.87
Logan	.31	.54	.29	.25	.33
Perry	--	1.74	.28	.24	--
Pope	1.02	1.49	3.25	3.45	6.53
Pulaski	12.78	16.80	21.69	33.50	29.54
Sebastian	.21	.12	.17	.15	1.07
Yell	.47	2.52	2.15	3.75	5.96
Total	61.44	88.80	144.87	193.44	178.18

Table 4-13.--Quaternary deposits ground-water quality

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

County		Temperature (°C) (00010)	Color (pcu) (00080)	Specific conductance (µS) (00095)	pH (00400)	Bicarbonate (mg/L as HCO_3) (00440)	Carbonate (mg/L as CO_3) (00445)	Carbonate hardness (mg/L as $CaCO_3$) (00410)	Total hardness (mg/L as $CaCO_3$) (00900)	Dissolved calcium (mg/L as Ca) (00915)	Dissolved magnesium (mg/L as Mg) (00925)
Conway	No. samples	133	13	177	128	86	86	53	84	13	13
	Minimum	13.5	0	157	0.0	11	0	9	30	22	7.1
	Maximum	21.0	27	2,150	8.8	700	19	572	690	180	48.0
	Mean	17.2	7	576	7.8	328	1	243	311	90	22.5
Crawford	No. samples	80	15	187	147	92	93	11	145	28	25
	Minimum	15.0	2	245	6.8	0	0	126	49	13	4.0
	Maximum	28.5	10	1,230	9.5	590	430	378	540	430	70.0
	Mean	17.2	5	541	8.0	317	10	285	296	113	20.9
Faulkner	No. samples	22	5	32	22	15	15	5	15	5	5
	Minimum	14.5	4	227	7.0	44	0	36	74	54	9.0
	Maximum	21.5	5	937	8.5	560	8	264	450	130	32.0
	Mean	16.9	4	551	7.8	317	1	172	291	80	18.0
Franklin	No. samples	294	51	333	72	68	67	0	71	63	63
	Minimum	0.0	0	102	6.0	19	0	—	26	4	3.0
	Maximum	26.5	11	44,100	8.2	390	26	—	1,300	170	23.0
	Mean	17.1	3	800	7.2	168	0	—	192	49	12.2
Jefferson	No. samples	33	6	35	35	35	34	31	35	8	8
	Minimum	16.0	5	280	5.7	4	0	3	14	8	2.3
	Maximum	19.0	10	1,150	8.5	560	26	462	570	160	39.0
	Mean	18.0	7	570	7.7	267	2	211	236	74	20.3
Johnson	No. samples	11	0	31	21	10	6	4	21	3	3
	Minimum	15.0	—	311	6.7	0	0	112	140	82	19.0
	Maximum	21.0	—	1,420	8.6	430	480	349	840	130	30.0
	Mean	17.1	—	679	8.0	249	135	231	326	104	25.0
Logan	No. samples	69	9	111	88	51	50	3	54	15	15
	Minimum	11.5	2	133	6.2	20	0	117	42	19	4.3
	Maximum	20.0	8	1,750	8.5	770	18	362	730	180	92.0
	Mean	16.9	5	556	7.8	354	0	209	315	89	24.3
Lonoke	No. samples	31	2	32	32	32	32	31	32	2	2
	Minimum	17.0	5	124	6.6	80	0	75	13	31	9.0
	Maximum	19.0	5	767	8.5	450	16	371	400	48	17.0
	Mean	18.0	5	429	7.4	232	2	197	191	40	13.0
Perry	No. samples	2	1	8	8	2	2	1	2	2	1
	Minimum	16.0	4	267	7.4	0	0	363	220	22	26.0
	Maximum	16.5	4	939	8.3	440	190	363	370	100	26.0
	Mean	16.3	4	560	8.0	220	95	363	295	61	26.0
Pope	No. samples	43	6	95	75	63	63	47	63	7	7
	Minimum	14.0	4	108	6.6	31	0	25	42	47	8.8
	Maximum	20.0	22	1,450	8.9	510	25	417	510	99	31.0
	Mean	17.1	8	395	7.7	195	1	174	187	66	17.8
Pulaski	No. samples	65	9	106	102	84	83	80	84	11	11
	Minimum	14.0	3	142	6.7	14	0	15	6	36	8.6
	Maximum	30.5	12	1,200	8.9	600	38	495	510	140	29.0
	Mean	18.9	6	552	7.8	267	3	227	241	89	18.8
Sebastian	No. samples	0	0	21	21	8	8	8	17	7	7
	Minimum	—	—	362	7.0	340	0	278	180	80	23.0
	Maximum	—	—	2,360	8.8	1,050	84	1,000	630	150	40.0
	Mean	—	—	796	8.0	491	13	424	346	101	28.4
Yell	No. samples	20	8	195	185	185	184	170	186	32	32
	Minimum	16.0	2	101	6.3	8	0	6	20	1	3.0
	Maximum	20.5	7	1,580	8.8	560	100	463	550	99	40.0
	Mean	17.8	6	490	7.9	193	3	165	193	45	14.7

Table 4-13.--Quaternary deposits ground-water quality--Continued

County		Dis-solved iron (μg/L as Fe) (01046)	Dis-solved sodium (mg/L as Na) (00930)	Sodium absorp-tion ratio (00931)	Dis-solved potassium (mg/L as K) (00935)	Dis-solved chloride (mg/L as Cl) (00940)	Dis-solved sulfate (mg/L as SO_4) (00945)	Dis-solved fluoride (mg/L as F) (00950)	Dis-solved silica (mg/L as SiO_2) (00955)	Dissolved solids (mg/L residue at 180 °C) (70300)	Dis-solved nitrate (mg/L as N) (00618)
Conway	No. samples	60	29	24	29	176	97	4	4	13	30
	Minimum	0	3.7	0.1	0.8	1.5	0.0	0.0	0.0	138	0.02
	Maximum	1,000	200.0	3.0	6 0	430.0	120.0	.40	22.0	971	64.00
	Mean	105	27.8	.5	2.4	26.5	21.9	.13	15.5	420	4.29
Crawford	No. samples	76	20	20	7	185	102	5	5	20	5
	Minimum	0	5.5	0.2	0.6	2.0	0.2	0.00	17.0	199	0.11
	Maximum	200	150.0	10.0	14.0	980.0	95.0	.10	22.0	634	6.80
	Mean	10	19.7	.8	5.0	21.0	26.5	.06	19.4	376	2.73
Faulkner	No. samples	10	7	7	7	31	16	0	0	5	3
	Minimum	0	5.4	0.2	0.6	1.5	0.4	—	—	214	0.07
	Maximum	80	13.0	.6	10.0	53.0	64.0	—	—	491	2.30
	Mean	33	9.4	.3	2.4	8.7	16.9	—	—	319	.90
Franklin	No. samples	5	51	51	55	332	67	57	55	50	0
	Minimum	0	8.0	0.5	0.0	2.2	7.8	0.00	0.0	98	—
	Maximum	60	110.0	3.0	3.4	18,000.0	58.0	.60	34.0	743	—
	Mean	16	49.4	1.6	1.7	135.3	22.4	.25	23.7	372	—
Jefferson	No. samples	1	33	31	34	34	30	4	8	8	7
	Minimum	230	9.5	0.2	0.2	3.8	0.0	0.00	8.3	214	0.00
	Maximum	230	97.0	3.0	4.7	130.0	240.0	.40	43.0	748	.63
	Mean	230	35.0	1.1	2.1	38.6	39.0	.13	21.4	387	.22
Johnson	No. samples	1	1	1	2	31	12	1	1	1	4
	Minimum	20	20.0	0.5	4.1	4.0	1.0	0.10	20.0	441	0.43
	Maximum	20	20.0	.5	8.2	32.0	240.0	.10	20.0	441	1.40
	Mean	20	20.0	.5	6.2	15.0	76.5	.10	20.0	441	.78
Logan	No. samples	39	15	15	15	111	58	14	14	13	0
	Minimum	0	8.5	0.2	0.8	1.5	0.2	0.00	5.8	179	—
	Maximum	8,600	160.0	5.0	2.9	56.0	790.0	.60	30.0	1,290	—
	Mean	299	32.4	.9	1.5	11.7	30.1	.16	16.8	480	—
Lonoke	No. samples	2	25	27	27	32	10	0	0	2	6
	Minimum	80	5.3	0.2	0.8	4.0	0.0	—	—	220	0.11
	Maximum	100	34.0	2.0	2.8	74.0	26.0	—	—	260	5.20
	Mean	90	18.2	.6	1.7	22.7	11.3	—	—	240	1.80
Perry	No. samples	4	2	1	1	8	2	0	0	1	1
	Minimum	0	0.9	0.4	0.8	10.0	18.0	—	—	445	0.23
	Maximum	8,100	19.0	.4	.8	130.0	25.0	—	—	445	.23
	Mean	2,205	10.0	.4	.8	32.9	21.5	—	—	445	.23
Pope	No. samples	54	7	7	7	95	67	0	1	6	46
	Minimum	0	7.1	0.3	1.0	2.2	0.2	—	34.0	199	0.00
	Maximum	6,200	34.0	1.0	3.3	190.0	150.0	—	34.0	420	33.00
	Mean	228	17.7	.5	1.5	14.1	16.4	—	34.0	335	4.55
Pulaski	No. samples	56	34	32	33	105	85	6	6	10	50
	Minimum	0	6.8	0.2	0.0	1.7	0.0	0.00	14.0	242	0.02
	Maximum	5,500	170.0	5.0	6.2	150.0	140.0	.30	26.0	584	9.00
	Mean	382	25.4	.7	1.6	30.0	24.7	.15	18.2	419	.78
Sebastian	No. samples	1	2	2	2	21	8	2	2	2	8
	Minimum	10	7.1	0.2	2.9	5.5	10.0	0.10	16.0	414	0.00
	Maximum	10	17.0	.4	4.1	210.0	240.0	.10	18.0	597	.45
	Mean	10	12.1	.3	3.5	41.8	73.3	.10	17.0	506	.18
Yell	No. samples	152	12	11	12	195	185	6	7	10	167
	Minimum	0	5.5	0.4	0.9	1.0	1.0	0.10	4.1	88	0.00
	Maximum	3,800	240.0	12.0	48.0	270.0	250.0	1.20	35.0	733	67.00
	Mean	213	50.5	2.4	7.4	32.3	23.2	.30	22.7	330	5.34

Future Ground Water Use (Corps of Engineers)

Ground water use is predicted to increase during the period 1985 to 2030. Overall ground water use is projected to increase 160 percent from 256.8 million gallons per day to 668.0 million gallons per day. The ground water use category predicted to increase the greatest is irrigation which will increase 164.4 million gallons per day to 593.1 million gallons per day or an increase of 261 percent. The ground water use category with the greatest decrease is Self-supplied Industry category which is projected to have a 74 percent decrease during the period 1985 to 2030. See Table 4-13 for the ground water use projections in the Arkansas River Basin.

TABLE 4-13 GROUND WATER USE PROJECTIONS

Use	1985 1/	2000 2/	2030 2/
Public Supply	16.4	10.6	7.8
Self-Supplied Industry	34.6	6.1	8.9
Rural Use	41.4	46.4	58.2
Irrigation 3/	164.4	410.0	593.1
Total	256.8	463.1	668.0

1/ Holland, 1987

2/ Adapted from Arkansas Soil and Conservation Commission data

3/ Includes Fish and Minnow Farms and Other Crops irrigation

Public Supply use of ground water is projected to decrease to 10.6 million gallons per day by 2000 and 7.8 million gallons per day by 2030. This is an overall decrease of 52 percent. The decrease in ground water will be off set by an increase use of surface water.

Self-Supplied Industry use of ground water is predicted to show a 74 percent decrease. Industry will look for dependable source of water such as offered by a municipal distribution system. Also, by using a municipal water supply the expense will be distributed to all users.

Ground water use for Rural Use is predicted to increase to 46.4 million gallons per day by 2000 and to 58.2 million gallons per day or an overall increase of 40 percent. The low yields of the Rocks of Paleozoic Age will be the reason for the small increases in the rural use of ground water.

Irrigation ground water use is projected to increase from 164.4 million gallons per day in 1985 to 410.0 million gallons per day in 2000 and eventually, to 593.1 million gallons per day in 2030. This is an overall increase of 260 percent. The reason for this increase is the irrigated cropland is projected to increase from 70,964 acres in 1980 to 140,000 acres in 2030. Supplemental irrigation for cotton and soybeans is projected to increase significantly. The source of the additional irrigation water will be the Quaternary alluvial aquifer.

GROUND-WATER PROBLEMS

Quantity

The most widespread ground-water problems in the study area are low yields and poor water quality. In a large part of the study area, the only source of ground water is the outcropping Paleozoic units, which yield less than 10 gal/min. Such low yields are due to the nature of the occurrence of ground water in secondary openings with low storage capacities. Quaternary deposits yield substantially more water, particularly south of the Fall Line but their area of use is somewhat smaller. Subsurface rock units and the Sparta Sand also yield large amounts of water, but only in relatively small areas within the study area.

Quality

The quality of ground water in the study area is highly variable from aquifer to aquifer and from one area to another. Hardness and iron concentrations are the most common problems, although in local areas nitrate, chloride, dissolved solids and sulfate concentrations can exceed allowable limits.

The occurrence of bacterial contamination in shallow wells and springs in the Interior Highlands has increased as human and animal populations have increased in the study area. Fractures and solution channels in surficial rocks, particularly limestones and dolomites, are highly susceptible to contamination because the fractures allow rapid infiltration of fecal matter from a variety of sources including septic tanks, landfills, poultry and cattle operations, and runoff from pastures. Wells can also be contaminated because of a poor seal between the well bore and the casing which allows contaminants to enter the well.

Studies by Steele and others (1975), MacDonald and others (1976), and Wagner and others (1976) documented bacterial contamination of both wells and springs in the northern part of the study area. Chesney (1979) reported the contamination of spring water at two trout hatcheries near Springdale by wastewater from a city lagoon and an industrial waste lagoon.

Several other water-quality problems are also related to man's activities. In the coal region of the Arkansas Valley acid water flows from at least two abandoned underground coal mines (Potts, 1987). One mine is near Huntington, while the other is near Hartford. Water from both these mines is flowing into tributaries of the James Fork River.

Critical Use Areas

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

Water table aquifers

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

Artesian aquifers

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

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

Subsurface rock units are considered to be artesian aquifers throughout the study area. Water levels in wells tapping these units show no long-term declines and most water-quality problems appear to be of a local nature. The quality and quantity problems of available ground water are primarily due to natural constraints. Based on available data, no areas in these subsurface rock units are critical use areas.

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

Water in the Sparta Sand exists under artesian conditions downdip from its outcrop area. Water levels rose in most areas between 1982 and 1987 (Freiwald and Plafcan, 1987), but many wells showed over 5 ft of decline in the last year of that 5-year period. While no critical use areas exist in the Sparta Sand because of the net rise in water levels in the past 5 years, the 5 to 10 ft decline in water levels in the past year is reason for concern.

Water in Quaternary deposits exists under water-table conditions in the study area. Available data indicate that water levels in most areas have shown a net increase between 1982 and 1987 (Freiwald and Plafcan, 1987). Water-quality problems in the Quaternary deposits are of local concern only.

In summary, the problem of declining water levels is not severe enough to meet the criteria for a critical use area. Water-quality problems are either isolated to individual wells or are naturally occurring. Water use from the Sparta Sand and the Quaternary deposits, while significant, does not at this time appear to be causing water levels to decline at a rate high enough to meet critical use criteria. Therefore, no areas in the study area are critical use areas.

POTENTIAL GROUND-WATER PROBLEMS

The potential for ground-water contamination exists throughout the study area. Potential sources of contamination include landfills, surface impoundments, hazardous waste operations, storage tanks, septic tanks, and saline water intrusion. The probability of contamination of ground water varies from area to area depending largely on the permeability of the surface materials. Permeable materials that allow water to recharge aquifers will also allow contaminants to enter the ground-water system. Figure 4-12 shows the recharge potential of the basin in different areas. Zones shown on figure 4-12 as having high recharge potential include the outcrop areas of Paleozoic limestones, Arkansas Novaculite, Big Fork Chert, and the Cockfield Formation. Zones with medium recharge potential are outcrops of Paleozoic sandstones and shales and low interstream terraces of Quaternary deposits. Zones with low recharge potential are the outcrops of the Jackson Group and the Cook Mountain Formation. The greatest potential for contamination is in zones with high recharge potentials.

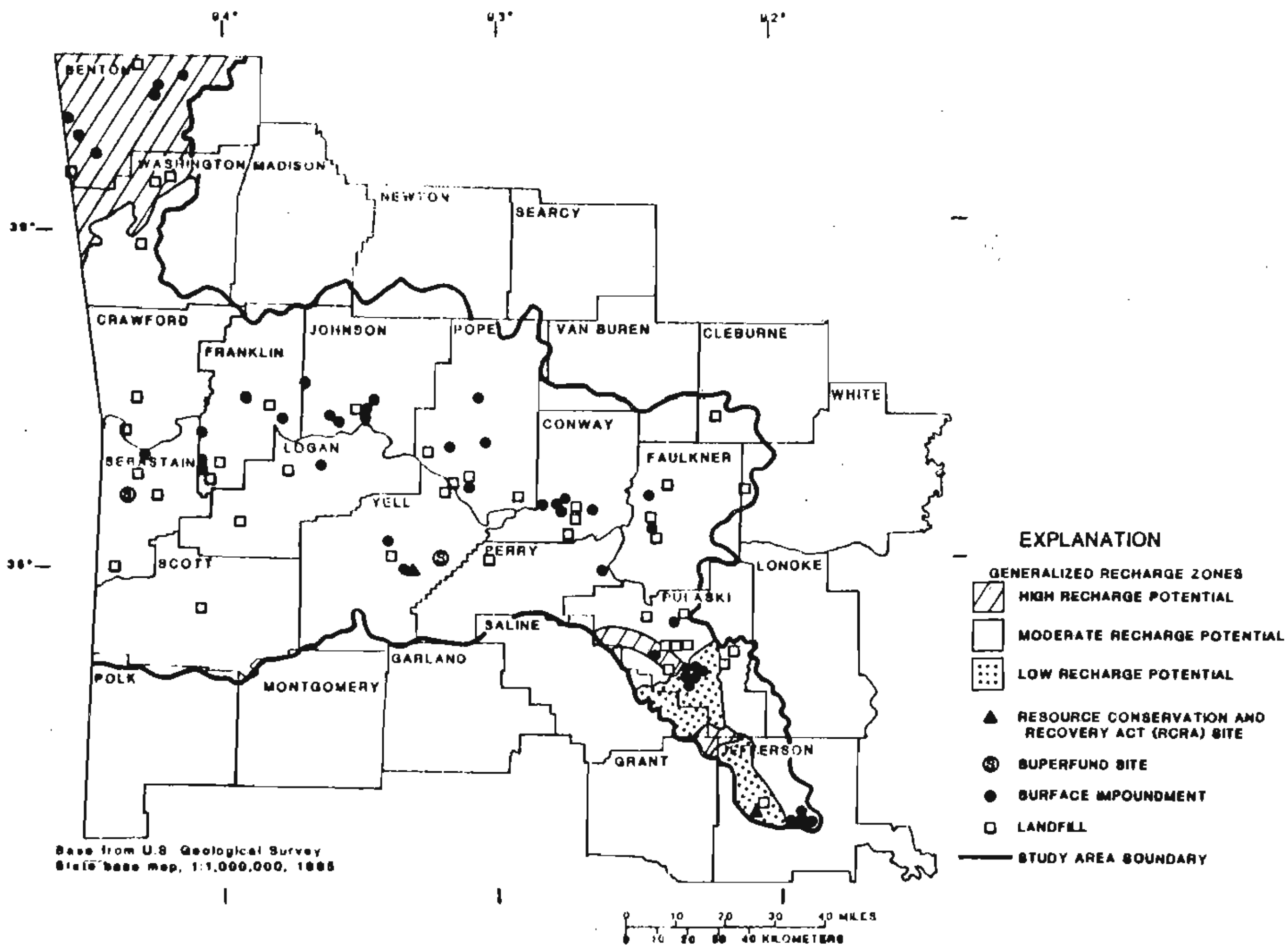

Figure 4-12.--Generalized recharge zones and potential ground-water contamination sources (modified from Bryant and others, 1985).

At least 41 open landfills and dumps exist in the study area (fig. 4-12). The contents of the majority of these landfills and dumps are essentially unknown. Hazardous materials may be stored in these areas and could be leaking into the shallowest aquifer. One Resource Conservation and Recovery Act (RCRA) site and two Superfund sites exist in the study area. Over 2.3 million tons of hazardous waste were generated or stored in the study area in 1982 (C.T. Bryant, U.S. Geological survey, written commun., 1984).

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

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

Solutions to Ground Water Problems (Corps of Engineers)

Quantity

The low yields of the surface Rocks of Paleozoic age are a natural occurrence which can not be corrected. The solution to the low ground water yields is change to a surface water source. The surface water source would most likely include the construction of a reservoir.

Quality

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

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

LITERATURE CITED

Agricultural Water Use Study prepared as part of the Arkansas Statewide Cooperative River Basin Study, Soil Conservation Service in cooperation with the Arkansas Soil and Water Conservation Commission, 1983, Little Rock, Arkansas.

Albin, D.R., 1965, Water-resources reconnaissance of the Ouachita Mountains, Arkansas: U.S. Geological Survey Water-Supply Paper 1809-J, 14 p.

Appendix E, Public Water Supply Inventory, Arkansas State Water Plan, Arkansas Soil And Water Conservation Commission.

Appendix 5, SFY 86, Public Water System Supervision Program Report, Arkansas State Health Department, written communication from Mr. H. R. Seifort, 1987.

Arkansas Resource Base Report, Arkansas Statewide Study, U. S. D. A., Soil Conservation Service, Economic Research Service, and Forest Service in cooperation with the Arkansas Soil and Water Conservation Commission.

Arkansas River Basin Compact, Arkansas-Oklahoma, 1970.

Arkansas River Basin Water Control Master Manual, Department of the Army, Tulsa and Little Rock Districts, Corps of Engineers, July 1980.

Arkansas Soil and Water Conservation Commission Water Diversion records.

Arkansas Soil and Water Conservation Commission Staff.

Arkansas Soil and Water Conservation Commission file data.

Arkansas Water Quality Inventory Report, 1984, State of Arkansas, Department of Pollution Control and Ecology.

Arkansas Water Quality Inventory Report, 1986, State of Arkansas, Department of Pollution Control and Ecology.

Barnes, James M., Instream Flow Needs for Fish and Wildlife for the Arkansas River Basin, Little Rock District, Corps of Engineers, Unpublished Report.

Bedinger, M. S., Emmett, L. F., and Jeffery, H. G., Ground-Water Potential of the Alluvium of the Arkansas River Between Little Rock and Fort Smith, Arkansas: Geological Survey Water-Supply Paper 1669-L, United States Printing Office, 1963, Washington, D. C.

Blue Mountain Reservoir Regulation Manual, 1953, U.S. Army Corps of Engineers, Little Rock District.

Boswell, E.H., and others, 1968, Quaternary aquifers in the Mississippi embayment: U. S. Geological Survey Professional Paper 448-E, 15 p.

Bryant, C. T., Ludwig, A. H. and Morris, E. E., Ground-Water Problems in Arkansas, Water Resources Investigations Report 85-4010: U. S. Geological Survey in Cooperation with the Arkansas Department of Pollution Control and Ecology and the Arkansas Soil and Water Conservation Commission, 1985.

Caplan, W.M., 1957, Subsurface geology of northwestern Arkansas: Arkansas Geological and Conservation Commission Information Circular 19, 14 p.

----- 1960, Subsurface geology of Pre-Everton rocks in northern Arkansas: Arkansas Geological and Conservation Commission Information Circular 21, 17 p.

Catalog of Resources for Community Development, Prepared by the Arkansas Industrial Development Commission, 1983.

Chesney, Clay, 1979, Surface Impoundment Assessment, State of Arkansas, Arkansas Soil and Water Conservation Commission, 48 p.

Cordova, R. M., Reconnaissance of the Ground Water Resources of the Arkansas Valley Region, Arkansas: Geological Survey Water Supply Paper, 1669-BB, U. S. Geological Survey, United States Government Printing Office, Washington, D. C., 1963.

Edds, Joe, and Fitzpatrick, D.J., 1986, Maps showing altitude of the potentiometric surface and changes in water levels in the aquifer in the Sparta and Memphis Sands in eastern Arkansas, spring 1985: U.S. Geological Survey Water-Resources Investigations Report 86-4084, 1 sheet.

Engineering Planning and Evaluation of Potential Reservoir Sites, College of Engineering, University of Arkansas, Fayetteville, Arkansas, 116 pp.

Fenneman, N. M., Physiography of the Eastern United States, McGraw Hill, 1938, New York, N.Y.

Filipek, S., Keith, W. E., and Giese, J., 1985, Instream Flow Requirements for Fisheries, Lower Ouachita River Basin, Arkansas and Arkansas River Basin, Arkansas, Arkansas Game and Fish Commission, unpublished report.

Freiwald, D.A., and Plafcan, Maria, 1987, Ground-water levels in Arkansas, spring 1987: U.S. Geological Survey Open-File Report 87-459, 66 p.

Freiwald, David A., Average Annual Precipitation and Runoff for Arkansas, 1951-80, U.S. Geological Survey, Water-Resources Investigations Report 84-4363, Little Rock, Arkansas, 1985.

Freiwald, David, Stream Losses and Gains in the Upper White River Basin, U.S. Geological Survey, unpublished report.

Halberg, H. N. and Stephens, J. W., Use of Water in Arkansas, 1965, U. S. Geological Survey in cooperation with the Arkansas Geological Commission, 1966.

Halberg, H. N., Use of Water in Arkansas, 1970, U. S. Geological Survey in cooperation with the Arkansas Geological Commission, 1972.

Halberg, H. N., Use of Water in Arkansas, 1975, U. S. Geological Survey in cooperation with the Arkansas Geological Commission, 1977.

Haley, B.R., 1976, Geologic map of Arkansas: U.S. Geological Survey, 1 sheet.

Holland, T.W, 1987, Use of water in Arkansas, 1985, Arkansas Geological Commission Water Resources Summary Number 16, 27 p.

Holland, Terrance W. and Ludwig, A. H., Use of Water in Arkansas, 1980, Arkansas Geological Commission in cooperation with the U.S. Geological Survey, 1981.

Hines, M.S., Flow Duration and Low-Flow Frequency Determinations of Selected Arkansas Streams, Water Resources Circular No. 12, U.S. Geological Survey in cooperation with the Arkansas Geological Commission.

Hosman, R.L., 1982, Outcropping Tertiary units in southern Arkansas: U.S. Geological Survey Miscellaneous Investigations Series Map I-1405, 1 sheet.

Hosman, R.L., and others, 1968, Tertiary aquifers in the Mississippi embayment: U.S. Geological Survey Professional Paper 448-D, 29 p.

Klein, Howard, Baker, R.C., and Billingsley, G.A., 1950, Ground-water resources of Jefferson County, Arkansas, Arkansas Univ. Inst. Sci. and Technology, Research Series 19, 44 p.

Lakes of Arkansas, Arkansas State Water Plan, Department of Commerce, Arkansas Soil and Water Conservation Commission, 1981.

Lamonds, A.G., 1972, Water-resources reconnaissance of the Ozarks Plateaus province, northern Arkansas: U.S. Geological Survey Hydrologic Investigations Atlas HA-383.

Lamonds, A.G., Hines, M.S., and Plebuch, R.O., 1969, Water resources of Randolph, and Lawrence Counties, Arkansas: U.S. Geological Survey Water-Supply Paper 1879-B, 45 p.

Leopold, L. B., Water, a Primer, W. H. Freeman and Company, 1974, San Francisco, Ca.

Ludwig, A. H., U. S. Geological Survey, personal communication, November 19, 1986.

MacDonald, H.C., Jeffus, H.M., Steele, K.F., Coughlin, T.L., Kerr, K.M., and Wagner, G.H., 1976, Groundwater pollution in northwest Arkansas: Arkansas Agricultural Experiment Station, University of Arkansas, Fayetteville, Special Report 25, 4 p.

Natural Disaster Response Plan, US Army Corps of Engineers, Little Rock District, April 1986.

Neely, Jr., Braxtel L., National Water Summary, Arkansas, Surface-Water Resources, United States Geological Survey, U.S. Printing Office, 1985, Washington, D. C.

Nimrod Reservoir Regulation Manual, 1951, Corps of Engineers, U.S. Army, Little Rock District, July 1951.

Nonpoint Source Pollution Assessment Summaries for the Arkansas River Basin, State of Arkansas, Arkansas Soil and Water Conservation Commission with assistance from the Arkansas Department of Pollution Control and Ecology, the 76 Arkansas Conservation Districts, and U.S.D.A., Soil Conservation Service, June, 1979.

Peterson, James C., Broom, M. E. and Bush, W. V., Geohydrologic Units of the Gulf Coastal Plain in Arkansas, Water Resources Investigations Report 85-4116, U.S. Geological Survey in Cooperation with the Arkansas Department of Pollution Control and Ecology and the Arkansas Geological Commission, 1985.

Plafcan, Maria, and Fugitt, D.T., 1987, Water-level maps of the alluvial aquifer in eastern Arkansas, 1985: U.S. Geological Survey Water-Resources Investigations Report 86-4178, 1 sheet.

Potts, R.R., 1987, Water quality and quantity in abandoned underground coal mines of west-central Arkansas and use of surface electrical resistivity in attempting quality determinations: U.S. Geological Survey Water-Resources Investigations Report 87-4127, 35 p.

Resource Inventory Data System (RIDS), USDA, Soil Conservation Service, 1977, unpublished.

Riggs, H. C., 1972, Low-flow Investigations: U. S. Geological Survey Techniques of Water Resources Investigations, Book 4, Chapter B1, p. 18.

Searcy, J. K., 1959, Flow-Duration Curves, Manual of Hydrology: Part 2 Low-flow Techniques, U. S. Geological Survey Water-Supply Paper, 1542-A, p. 33.

Steele, K.F., MacDonald, H.C., and Grubbs, R.S., 1975, Composition of groundwater in northwest Arkansas: Arkansas Farm Research, Arkansas Agricultural Experiment Station, University of Arkansas, v. 25, p. 15.

Stephens, J.W., and Halberg, H.N., 1961, Use of water in Arkansas: 1960: Arkansas Geological and Conservation Commission Special Ground-Water Report 4, 8 p.

Terry, J.E., Bryant, C.T., Ludwig, A.H., and Reed, J.E., 1979, Water-resources appraisal of the south-Arkansas lignite area: U.S. Geological Survey Open-file Report 79-924, 162 p.

Terry, J. E., Morris, E. E., Petersen, J. C., and Darling, M. E., Water Quality Assessment of the Illinois River Basin, Water Resources Investigations Report 83-4092, Prepared by United States Department of the Interior, Geological Survey in cooperation with Arkansas Department of Pollution Control and Ecology.

Tennant, Donald L., Instream Flow Regimens for Fish, Wildlife, Recreation, and Related Environmental Resources, U.S. Fish and Wildlife Service, Billings Montanna, 1975.

Use of Water in Arkansas, 1960, U. S. Geological Survey cooperation with the Arkansas Geological Commission.

Trelease, F. J., Water Law, Third Edition, West Publishing Company, 1979, St. Paul, Mn.

U.S. Army Corps of Engineers, Little Rock District, File Data.

U.S. Environmental Protection Agency, 1986a, Maximum contaminant levels (sub-part b of Part 141, natinal interim primary drinking water regulations) U.S. Code of Federal Regulations, Title 40, parts 100 to 149, revised as of July 1, 1986, p. 524-528.

U.S. Environmental Protection Agency, 1986b, Secondary maximum contaminant levels (section 143.3 of part 143, national secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1982, 374 p.

Wagner, G.H., Steele, K.F., MacDonald, H.C., and Coughlin, T.L., 1976, Water quality as related to linears, rock chemistry, and rain water chemistry in a rural carbonate terrain: Journal of Environmental Quality, v. 5, no. 4, p. 444-451.

Water Borne Commerce of the United States, Waterways and Harbors - Gulf Coast, Mississippi River System and Antilles, Department of the Army, Corps of Engineers, 1969-1984.

Water Resources Development in Arkansas, 1981 by the U. S. Army Corps of Engineers, U. S. Army Engineer Division, Southwestern, 1 January 1981, pp. 9-30.

APPENDIX A

COMMENTS ON THE DRAFT REPORT

TO: EARL Smith - AS&WCC
FROM: H. Seifert - ARK Health Dept.

DRAFT
Comments on AR ~~State~~ Water Plan
AR River Basin

Page 67, last ¶ — Dardanelle has not changed to a surface water source. It still relies on wells.

Page 119, Table 3-14 —

Faulkner County - probably need to add Guy
Franklin County — " " " " Clarksville
" " " delete Greenwood
Logan County - Magazine now purchases from Booneville
Scranton " " " Subiaco
Perry County — Houston now purchases from Perryville
Pope County — probably need to add Dover & Hector
Scott County — Needs to be changed to SEBASTIAN COUNTY judging by the listed water systems.
Lavaca now purchases from Ft. Smith
Mansfield " " " So. Sebastian Co. WU,
probably need to add Ft. Smith to list

Page 173, 2nd ¶ - Lists 'municipal water source' as an item to be considered in developing stream priorities, but does not include this in the stream priority matrix.

Page 175, Table 3-35 — Spadra Creek listed w/ LOW protection score, even though it is the primary water —

source for Clarksville.

Also, the matrix developed gives the same priority to the AR River as it does to the Mulberry River — — somehow this doesn't seem to equate.

Page 209, last ¶ — Needs to be updated as several cities listed no longer rely on their old well system w/ hi solids.

- Houston purchases from Perryville
- Magazine " " Booneville
- Ratcliff " " Booneville
- Hartford " " So. Sebastian Co. WUA

APPENDIX 5

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 08/04/86 --- ALL DISTRICTS

WATER SYSTEM NAME	PWS ID#	MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
ALMA WATERWORKS ALMA, AR	0000144	2,160,000 SURFACE	1,800,000	83.0%	FILTRATION	PLANNING
BELLA VISTA P.O.A. BELLA VISTA, AR	0000039	1,440,000 SURFACE PURCHASED	1,382,000	96.0%	SOURCE-QUANTITY	PLANNING
BLYTHEVILLE WATERWORKS BLYTHEVILLE, AR	0000365	5,200,000 GROUND	5,500,000	106.0%	FILTRATION	
BULL SHOALS WATER BULL SHOALS, AR	0000352	220,000 GROUND	175,000	80.0%	SOURCE-QUANTITY	
CLINTON WATERWORKS CLINTON, AR	0000564	1,800,000 SURFACE	1,800,000	100.0%	FILTRATION	
COMMUNITY WATER ASSOCIATION HIGDEN, AR	0000101	1,000,000 SURFACE	1,200,000	120.0%	FILTRATION	
CONWAY CO. REGIONAL WATER DIST MORRILTON, AR	0000119	1,300,000 GROUND	1,800,000	138.0%	SOURCE-QUANTITY	SEE NOTE (1)
DECATUR WATERWORKS DECATUR, AR	0000052	1,044,000 GROUND & SURFACE	1,004,000	96.0%	FILTRATION	
DENNARD WATER ASSOCIATION CLINTON, AR	0000461	729,166 SURFACE PURCHASED	789,000	108.0%	SOURCE-QUANTITY	
DEQUEEN WATER WORK DEQUEEN, AR	0000520	2,700,000 SURFACE	2,530,000	94.0%	FILTRATION	

(1) New source has been completed. Raw water transmission line and new treatment plant are under construction.

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 12/26/86 —— ALL DISTRICTS

WATER SYSTEM NAME	PWS ID#		MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
EL DORADO WATERWORKS EL DORADO, AR	0000550	GROUND	13,176,000	11,000,000	83.0%	SOURCE-QUANTITY	
ENOLA-MOUNT VERNON WATER ASS'N ENOLA, AR	0000499	GROUND	173,000	152,000	88.0%	FILTRATION	
EUDORA WATERWORKS EUDORA, AR	0000083	GROUND	1,000,000	840,000	84.0%	COAGULATION/SEDIMENTATION	
FORREST CITY WATERWORKS FORREST CITY, AR	0000004	GROUND	5,000,000	4,300,000	86.0%	FILTRATION	SEE NOTE (1)
FORT SMITH WATERWORKS FT. SMITH, AR	0000507	SURFACE	37,000,000	32,900,000	89.0%	FILTRATION/SOURCE	SEE NOTE (2)
GREEN ACRES MOBILE HOME PARK FAYETTEVILLE, AR	0000679	GROUND	22,000	20,000	91.0%	SOURCE-QUANTITY	
GUY WATERWORKS GREENBRIAR, AR	0000192	GROUND	70,000	69,000	99.0%	SOURCE-QUANTITY	
HEBER SPRINGS WATER & SEWER HEBER SPRINGS, AR	0000104	SURFACE	3,040,000	2,500,000	82.0%	RAW WATER PUMPING	
HECTOR WATERWORKS HECTOR, AR	0000442	SURFACE	144,000	120,000	83.0%	FILTRATION	
HUNTSVILLE WATERWORKS HUNTSVILLE, AR	0000348	SURFACE	1,152,000	1,079,000	94.0%	FILTRATION	

(1) Request pending to revise treatment scheme to raise plant capacity.

(2) Maximum Firm Yield of existing sources is 21,000,000 MGD.

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 12/26/86 --- ALL DISTRICTS

	WATER SYSTEM NAME	PWS ID#		MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
A	JEFFERSON-SAMPLES-DEXTER WATER JEFFERSON, AR	0000276	GROUND	32,000	25,600	80.0%	HIGH SERVICE PUMPING	
[illegible]	JUDSONIA WATERWORKS JUDSONIA, AR	0000582	SURFACE	610,000	550,000	90.0%	FILTRATION	
[illegible]	KINGSWOOD ESTATES WATERWORKS ELIZABETH, AR	0000030	GROUND	15,000	12,000	80.0%	SOURCE-QUANTITY	
	LAKESHORE ESTATES WATER ASSN MARION AR	0000726	GROUND PURCHASED	300,000	300,000	100.0%	PURCHASE CONTRACT	
A	LINCOLN WATERWORKS LINCOLN, AR	0000572	SURFACE	648,000	632,500	98.0%	COAGULATION/SEDIMENTATION	
	LITTLE RIVER COUNTRY CLUB WINTHROP, AR	0000467	GROUND	10,000	10,000	100.0%	RAW WATER PUMPING	
	LONOKE WATERWORKS LONOKE, AR	0000343	GROUND	648,000	800,000	123.0%	FILTRATION	
A	MAYFLOWER WATERWORKS MAYFLOWER, AR	0000193	GROUND	575,000	500,000	87.0%	COAGULATION/SEDIMENTATION	
	MC LAUGHLIN VILLAGE MHP NASHVILLE, AR	0000712	GROUND	15,000	15,000	100.0%	SOURCE-QUANTITY	
	MONTICELLO WATER DEPARTMENT MONTICELLO, AR	0000184	GROUND	5,600,000	4,700,000	84.0%	RAW WATER PUMPING	

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 12/26/86 --- ALL DISTRICTS

WATER SYSTEM NAME	PWS ID#	MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
MOUNTAIN HOME WATERWORKS MOUNTAIN HOME, AR	0000025	4,000,000 SURFACE	4,086,000	102.0%	COAGULATION/SEDIMENTATION	
MOUNTAIN TOP WATER ASS'N HEBER SPRINGS, AR	0000454	360,000 SURFACE PURCHASED	350,000	97.0%	HIGH SERVICE PUMPING	
NEWPORT WATERWORKS NEWPORT, AR	0000264	2,000,000 GROUND	1,670,000	84.0%	COAGULATION/SEDIMENTATION	
NORTH WHITE CO. WATER ASS'N JUDSONIA, AR	0000583	216,000 SURFACE PURCHASED	210,000	97.0%	SOURCE-HYDRAULIC CAPACITY	
OLA WATERWORKS OLA AR	0000604	290,000 SURFACE	240,000	83.0%	FILTRATION	
OZAN WATERWORKS OZAN, AR	0000227	30,000 GROUND	30,000	100.0%	SOURCE-QUANTITY	
OZARK WATERWORKS OZARK, AR	0000201	2,250,000 SURFACE	2,250,000	100.0%	FILTRATION	
PFEIFFER WATER ASSOCIATION BATESVILLE, AR	0000251	350,000 SURFACE PURCHASED	350,000	100.0%	SOURCE-HYDRAULIC CAPACITY	
PLUMERVILLE WATERWORKS PLUMERVILLE, AR	0000121	170,000 GROUND	170,000	100.0%	SOURCE-QUANTITY	
QUITMAN WATERWORKS QUITMAN, AR	0000105	79,000 GROUND	63,000	80.0%	SOURCE-QUANTITY	

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 12/26/86 --- ALL DISTRICTS

WATER SYSTEM NAME	PWS ID#	MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
ROCK MOORE WATER ASSOCIATION BATESVILLE, AR	0000252	230,000 GROUND & SURFACE PURCHASED	240,000	104.0%	HIGH SERVICE PUMPING	
RUDDLEHILL WATER ASSOCIATION BATESVILLE, AR	0000253	200,000 SURFACE PURCHASED	200,000	100.0%	HIGH SERVICE PUMPING	
RUSSELLVILLE WATERWORKS RUSSELLVILLE, AR	0000446	7,000,000 SURFACE	6,300,000	90.0%	FILTRATION/SOURCE	SEE NOTE (1)
S.W.WHITE COUNTY WATER ASS'N SEARCY, AR	0000185	288,000 SURFACE PURCHASED	250,000	87.0%	PURCHASE CONTRACT	
SALESVILLE WATERWORKS SALESVILLE, AR	0000036	50,000 GROUND	42,000	84.0%	SOURCE-QUANTITY	
SARDIS WATER ASSOCIATION BAUXITE, AR	0000493	720,000 GROUND	870,000	121.0%	FILTRATION	SEE NOTE (2)
SHIRLEY WATERWORKS SHIRLEY, AR	0000565	27,000 GROUND	27,000	100.0%	SOURCE-QUANTITY	SEE NOTE (3)
SILOAM SPRINGS WATERWORKS SILOAM SPRINGS, AR	0000056	4,000,000 SURFACE	3,700,000	93.0%	FILTRATION	
SUBIACO ACADEMY WATERWORKS SUBIACO, AR	0000334	220,000 SURFACE	220,000	100.0%	HIGH SERVICE PUMPING	
SULPHUR SPRINGS WATERWORKS SULPHUR SPRINGS,AR	0000057	150,000 GROUND	125,000	83.0%	SOURCE-QUANTITY	

(1) Maximum Firm Yield of source is 2,000,000 MGD

(2) Additional Filtration Capacity is under construction.

(3) Final Engineering Plans for connection to Community Water System are being prepared.

SYSTEMS WITH A MAXIMUM DEMAND GREATER THAN 80 % OF CAPACITY

REPORT DATE 12/26/86 --- ALL DISTRICTS

WATER SYSTEM NAME	PWS ID#	MAXIMUM CAPACITY	MAXIMUM DEMAND	%	LIMITING FACTOR	STATUS
SUMMIT WATERWORKS SUMMIT, AR	0000355	65,000 GROUND	54,000	83.0%	SOURCE-QUANTITY	
SYLVAN SHORES S/D WATERWORKS EUREKA SPRINGS, AR	0000045	48,000 GROUND	44,000	92.0%	SOURCE-QUANTITY	
USAF HOSPITAL/SGPB BLYTHEVILLE AR	0000364	1,500,000 GROUND	1,400,000	93.0%	SOURCE-QUANTITY	
VALLEY VIEW WATER ASSOCIATION JONESBORO, AR	0000134	1,000,000 GROUND	800,000	80.0%	RAW WATER PUMPING	
VAN BUREN COUNTY W. U. A. CLINTON, AR	0000727	3,000,000 SURFACE PURCHASED	2,400,000	80.0%	PURCHASE CONTRACT	
VILONIA WATERWORKS VILONIA, AR	0000195	628,000 GROUND & SURFACE PURCHASED	738,000	118.0%	SOURCE-QUANTITY	
YELLVILLE WATERWORKS YELLVILLE, AR	0000356	360,000 SURFACE	360,000	100.0%	FILTRATION	

Arkansas Game & Fish Commission

2 Natural Resources Drive Little Rock, Arkansas 72205

August 26, 1987

Mr. Randy Young, Director
Arkansas Soil & Water
Conservation Commission
One Capitol Mall
Suite 2D
Little Rock, AR 72201

Dear Mr. Young:

The following are staff comments concerning the draft report on the Arkansas River Basin for the State Water Plan. Please consider them along with the other state agencies comments in the writing of the final report for this basin.

Under the "Minimum Streamflow" section, the fact that instream flow requirements for fish and wildlife as outlined by the Arkansas Method (Filipek et al 1987) are occasionally higher than even natural levels should surprise no one knowledgeable about Arkansas streams, their hydrology, and the biologic systems associated with these streams. Occasionally (and sometimes more frequently), lowflow situations (drought) in Arkansas streams occur which stress and decrease stream fish populations, sometimes significantly. After such events, it may take years for that stream fish population to recover to adequate levels. Therefore, even some "natural" lowflow events are deleterious to fish and wildlife populations and should be buffered using water withdrawal controls, not worsened by allowing pumping until occasional lowflows become frequent occurrences.

The statements on page 74 of the same section about the Arkansas Method's flow recommendations not providing for excess flow are misleading. First, in two of the four examples given, the Arkansas Method flows allow for diversion during most months and especially during July, August, and September, which are months of high irrigation diversion in Arkansas. These two streams - the

Arkansas and Petit Jean Rivers - are where most of the diversion in the basin occurs, not in the James Fork and Flint Creek. Second, since the Arkansas Method's flows are being compared against median flows, it should be noted that the higher half of the flows for any given month in the example charted are not even being considered in the report's analysis. This higher half of the stream's flow would provide much water for irrigation and withdrawal above and beyond fish and wildlife requirements. Third, the same statement (whether misleading or not) can be made for the Arkansas Soil and Water Commission's (ASWCC) method in two of the four examples (James Fork and the Petit Jean River) during most of the peak irrigation season.

Flow recommendations made in this draft report by ASWCC and the Corps of Engineers for the Arkansas River at Murray Lock and Dam during the lowflow season are 30% less than the flows occurring in that river during a minor drought (or the 2Q10). It is also notable that flows agreed upon and required by an interstate compact with Oklahoma are somewhat higher that the Arkansas Method's recommendations but significantly higher than the ASWCC's recommendations. This in itself casts some doubts on the realism of the ASWCC's "method" for arriving at instream flows.

The Arkansas Game and Fish Commission would like to commend the Corps of Engineers on the realization that in the Arkansas River Basin, with the exception of the Arkansas River itself, surface water is not a totally dependable primary water source without some type of on-farm or on-site water storage project. Storage of high seasonal flows is necessary to provide adequate water later in the year, as is conjunctive use of groundwater resources. On-farm water storage projects seem especially feasible when the amount of flooding in the basin is taken into consideration. Use of winter high water inflows during the summer lowflow season is being efficient in an area with flashy flows and less than adequate low flows.

Some statements made in the report under "Database Problems--Determining Instream Flow Requirements (Fish and Wildlife)" are incorrect. Comparisons of monthly flow percentages recommended by the Tennant Method versus the Arkansas Method will show that during some months the Arkansas Method's recommendations are higher than Tennant's and during some months, especially during the lowflow season, the Arkansas Method's recommendations are lower than Tennant's recommendations (Tennant 1975). Comparison of flow reservation made in other systems from the Arkansas Method and flow reservations made using the Instream Flow Incremental Methodology (IFIM) and the Wetted Perimeter Method show substantial agreement.

Flow recommendations (%'s) from the Arkansas Method are not absolutely comparable to Tennant's recommendations (%'s) as some people have assumed since Tennant uses a percentage of the mean annual flow while the Arkansas Method uses a percentage of the mean monthly flow. The Arkansas Method recommends flows necessary for maintenance of stream fish populations, not flows for excellent or improvement habitat. The flows recommended by this draft report are too low to maintain existing stream fish populations. Justification of these (ASWCC's) degrading flows is biologically unfounded (Tennant 1975).

One major deficiency (perhaps the primary) in this draft basin plan is the lack of an organized and operable mechanism for enforcing any type of surface water allocation plan. The importance of a water allocation procedure cannot be overstated since such a plan is the fulcrum upon which many other aspects of a state water plan are balanced.

Water is available in the Arkansas River Basin from several large Corps of Engineers projects. All possible avenues for use of existing stored water should be pursued before new, major water storage projects are even considered.

Verification of the Arkansas Method by using Instream Flow Incremental Methodology and other techniques has and is being done in the state. Additional funds and manpower for this type of work, however, are needed.

While the priority matrix for determining instream flows for fish and wildlife mentioned in the draft has some potential, much fine tuning of this particular alternative would be necessary before consideration for implementation.

I hope that several of the corrections and comments of the draft from us and other agencies are included in the final product. Thank you for the opportunity to review this document. We will be happy to answer any questions you might have on the contents of this correspondence.

Cordially,

Steve N. Wilson
Director

SNW:SF:kr

LITERATURE CITED

Filipek, S.P., W.E. Keith and J. Giese, 1987. The Status of the instream flow issue in Arkansas, 1987. Academy of Science, North Little Rock, Arkansas. In Press.

Tennant, D.L., 1975. Instream flow regimens for fish, wildlife, recreation and related environmental resources. U.S. Fish and Wildlife Service Billings, MT. 30 pp.

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

June 12, 1987

PHONE: (501) 562-7444

Mr. J. Randy Young, Director
Arkansas Soil and Water Conservation Commission
One Capitol Mall, Suite 2D
Little Rock, Arkansas 72201

Dear Mr. Young:

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 - Arkansas River Basin. The seriousness with which we view the long term directions set out by the State Water Plan and the potential effects of this plan on the water resources of our state cannot be overstated. It is with these concerns that we make these constructive comments.

The following comments concern the groundwater section: (1) The report attempts to discuss and develop a plan based on surface water drainage basins. It is well documented that groundwater aquifers and recharge areas are not congruent with surface drainages. In its recent publication on groundwater problems, USGS abandoned the surface drainage basins as a vehicle for dividing its report and this resulted in a much more logical, concise and comprehendable document. The groundwater section of each basin report of the State Water Plan reflects the confusion between surface water drainage and groundwater aquifers. In none of the reports is the analysis of groundwater resources given the proper review the subject deserves considering its importance as sources of drinking water, industrial, and agricultural supply. (2) While it is true that aquifer recharge requirements are not known for each aquifer, elaborate models are not needed for entire aquifers to figure recharge requirements as they relate to minimum stream flows. Recharge as a percentage of streamflow can be figured by either physical or chemical means using methods and formulas available in basic hydrology texts. The applicable principle is that to maintain base flow in a stream, the water table in the adjoining aquifer has to be sufficiently high to allow for lateral movement into the stream bed. That depth can be readily ascertained and pumping limits established so that sufficient recharge is maintained. To allow the water table to fall below the streambed has the result of eliminating the flow entirely when runoff is absent, thus making minimum streamflow questions academic. (3) It should be made clear to all readers of this document that there is a significant paucity of data on the quantity and quality of groundwater in Arkansas and that much of the available data is self supplied by the users and may be heavily biased by their preconception of the uses of the data. (4) An additional source of data which is available concerning groundwater quality is the CERCLA industrial monitoring data available through STORET.

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

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

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

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

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

Sincerely,

Phyllis Moore

Phyllis Moore, Ph.D.
Director

PM/WEK/sy

Harold K. Grimmett
Director

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

Bill Clinton
Governor

Date: June 19, 1987
Subject: Arkansas River Basin
ANHC Job #SWCC-7 (COELR-219)
Dated May 19, 1987
Received May 21, 1987

RECEIVED
JUN 22 1987
SOIL AND WATER
CONSERVATION COMMISSION

Mr. Randy Young, Chairman
Technical Review Committee
Suite 2-D
#1 Capitol Mall
Little Rock, Arkansas 72201

Dear Mr. Young:

The staff of the Arkansas Natural Heritage Commission has reviewed the draft state water plan for the Arkansas River Basin.

As in previous draft plans, the discussion of minimum streamflow (beginning on p. 74) in this document fails to offer any documentation or clear statement of justification for the conclusions reached concerning fish and wildlife requirements or "minimums." Far from establishing a "more realistic streamflow" (p. 79), the Arkansas Soil and Water Conservation Commission (ASWCC) method yields fish and wildlife "minimums" that correspond to dry or nearly dry streams during the critical July-October period. This may not be true in every case, but it is clearly true for Flint Creek at Springtown (Fig. 3-4a). If all the streams in the Arkansas River Basin were graphed similarly, many others no doubt would exhibit the same extraordinarly low flow rate as a supposed fish and wildlife "minimum" from July through October. Where is the evidence that such low streamflows could in any way be adequate for fish and wildlife?

If the intent behind the ASWCC method was to adopt Tennant's findings in some form, it should be noted that the 10 percent figure he used applied to short-term survival, not maintenance of good survival habitat over the long run. In other words, 10 percent of the mean annual or seasonal flow may suffice as a minimum standard for fish and wildlife for a limited period of time, but it will not insure protection of the resource for very long. The draft water plan makes no reference to the length of time a stream might remain at or near "minimum discharge." Presumably, this period could be as long as a month or even several months.

It is highly likely that many aquatic species will be affected adversely if flows of basin streams should be reduced to the point that might be permitted or at least encouraged by implementation (adoption) of the proposed standard. Reproduction and growth of fishes and aquatic invertebrates, cleansing of aquatic habitats, and recharge of groundwater tables all depend upon substantial flows of water, flows that exceed the minimum instream flow recommendations of this plan. Even if the intent is never to allow streamflows to drop as low as the ASWCC-derived minimums, the implication is that anything above such minimums is acceptable. For many streams, this implication could spell disaster.

Two statements on page 74 of the draft plan must be questioned. First, the fact that "fish and wildlife recommendations at certain points were greater than some of the U.S.G.S. measured low flows" is no less true for the fish and wildlife recommendation offered by ASWCC and the Corps of Engineers. An examination of Figures 3-4b and 3-4c confirms this. All that can be concluded in either case (that is, using either method) is that sometimes there was less water in the streams of the Arkansas River basin than would be desirable for fish and wildlife. This does not mean that the standard should be lower! Second, the statement that the recommended flows according to the Arkansas method "did not provide any excess flow when compared to the median daily discharge" seems clearly contradicted by Figures 3-4a and 3-4d. Neither statement provides any justification whatsoever for the "revised minimum streamflow" discussion that immediately follows.

The alternative method for determining instream flow requirements presented on pages 172 through 175 is an improvement over methods previously proposed by the authors of this and other draft water basin plans, and we support the general direction taken. We note that although the Natural Heritage Commission was consulted by Barnes, no mention of this is made in the discussion and no indication is made that the Corps utilized the list and locations of endangered aquatic species which we provided in October of 1986. A copy of the same printout is attached for reference.

Sincerely,

Bill Pell

Bill Pell
Stewardship Chief

cc: Kay Arnold
Craig Uyeda
John Giese

LEGEND

STATUS CODES

C1 - Category 1; the FWS states it currently has substantial information on hand that supports listing these species as Threatened or Endangered.

C2 - Category 2; the FWS states that further biological research and field study will be necessary in order to determine if these species should be listed as Threatened or Endangered.

3C - These species have been reviewed by the FWS and the determination has been made that special designation is not warranted.

LE - Listed Endangered; the FWS has listed these species as Endangered.

LT - Listed Threatened; the FWS has listed these species as Threatened.

Please note: A Natural Heritage Commission Occurrence Number has been included for reference. If you should have questions regarding a particular occurrence you may refer to this number when communicating with the Natural Heritage Commission.

Arkansas Natural Heritage Commission

DATA FOR ARKANSAS STATE WATER PLAN
AQUATIC SPECIES OF SPECIAL CONCERN
(OCCURRENCES WITHIN HYDROLOGIC UNITS)

OCC. NO.	SCIENTIFIC NAME	COMMON NAME	T/R	S	QUAD. NAME	STATUS
** WATERSHED: 11110103						
001	AMBLYOPSIS ROSAE	OZARK CAVEFISH	018N032W	33	GALLATIN 7.5	LT
002	AMBLYOPSIS ROSAE	OZARK CAVEFISH	018N031W	01	BENTONVILLE SOUTH 7.5	LT
004	AMBLYOPSIS ROSAE	OZARK CAVEFISH	019N031W	36	BENTONVILLE SOUTH 7.5	LT
001	AMBYSTOMA ANNULATUM	RINGED SALAMANDER	016N0031	33	WHEELER 7.5	
012	AMBYSTOMA ANNULATUM	RINGED SALAMANDER	017N0030	35	FAYETTEVILLE 7.5	
013	AMBYSTOMA ANNULATUM	RINGED SALAMANDER	018N0029	11	SONORA 7.5	
021	AMBYSTOMA ANNULATUM	RINGED SALAMANDER	018N0031	13	SPRINGDALE 7.5	
029	AMBYSTOMA ANNULATUM	RINGED SALAMANDER	016N0030	23	FAYETTEVILLE 7.5	
001	CAECIDOTEA ANCYLA	ISOPOD	014N032W	10	PRAIRIE GROVE 7.5	
004	CEMOPHORA COCCINEA COPEI	NORTHERN SCARLET SNAKE	016N0030	09	FAYETTEVILLE 7.5	
001	ETHEOSTOMA CRAGINI	ARKANSAS DARTER	017N030W	33	FAYETTEVILLE 7.5	
002	ETHEOSTOMA CRAGINI	ARKANSAS DARTER	018N031W	10	CENTERTON 7.5	
003	ETHEOSTOMA CRAGINI	ARKANSAS DARTER	018N032W	27	GALLATIN 7.5	
004	ETHEOSTOMA CRAGINI	ARKANSAS DARTER	018N032W	34	GALLATIN 7.5	
005	ETHEOSTOMA CRAGINI	ARKANSAS DARTER	017N031W	17	ROBINSON 7.5	
001	ETHEOSTOMA MICROPERCA	LEAST DARTER	019N0031	36	BENTONVILLE SOUTH 7.5	
002	ETHEOSTOMA MICROPERCA	LEAST DARTER	017N0031	31	WHEELER 7.5	
003	ETHEOSTOMA MICROPERCA	LEAST DARTER	018N0032	36	ROBINSON 7.5	
004	ETHEOSTOMA MICROPERCA	LEAST DARTER	018N031W	10	CENTERTON 7.5	
005	ETHEOSTOMA MICROPERCA	LEAST DARTER	016N031W	18	WHEELER 7.5	
001	EURYCEA TYNERENSIS	OKLAHOMA SALAMANDER	017N0032	07	GALLATIN 7.5	C2
003	EURYCEA TYNERENSIS	OKLAHOMA SALAMANDER	019N0033	35	GENTRY 7.5	C2
006	EURYCEA TYNERENSIS	OKLAHOMA SALAMANDER	017N032W	18	GALLATIN 7.5	C2
007	EURYCEA TYNERENSIS	OKLAHOMA SALAMANDER	017N030W	20	SPRINGDALE 7.5	C2

DATA FOR ARKANSAS STATE WATER PLAN
AQUATIC SPECIES OF SPECIAL CONCERN
(OCCURRENCES WITHIN HYDROLOGIC UNITS)

OCC. NO.	SCIENTIFIC NAME	COMMON NAME	T/R	S	QUAD. NAME	STATUS
008	NERODIA CYCLOPION CYCLOPION	GREEN WATER SNAKE	017N030W	20	SPRINGDALE 7.5	
002	NOTROPIS CAMURUS	BLUNTFACE SHINER	016N031W	30	WHEELER 7.5	
002	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	017N033W	01	GALLATIN 7.5	
002	RANA SYLVATICA	WOOD FROG	0			
017	RANA SYLVATICA	WOOD FROG	015N032W	23	PRAIRIE GROVE 7.5	
020	RANA SYLVATICA	WOOD FROG	014N032W	21	LINCOLN 7.5	
006	REGINA GRAHAMII	GRAHAM'S CRAYFISH SNAKE	017N030W	33	FAYETTEVILLE 7.5	
007	REGINA GRAHAMII	GRAHAM'S CRAYFISH SNAKE	016N030W	09	FAYETTEVILLE 7.5	
001	STYGOBROMUS OZARKENSIS	OZARK CAVE AMPHIPOD	018N031W	01	BENTONVILLE SOUTH 7.5	C2
007	TERRAPENE ORNATA ORNATA	ORNATE BOX TURTLE	018N033W	33	GALLATIN 7.5	
** WATERSHED: 11110104						
002	GOMPHUS OZARKENSIS	OZARK CLUBTAIL DRAGONFLY	013N0031	26	STRICKLER 7.5	
001	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	017N033W	32	WATTS 7.5	
001	PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	009N032W	23	FORT SMITH 7.5	
003	PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	009N032W	05	FORT SMITH 7.5	
001	PSEUDOSINELLA DUBIA	SPRINGTAIL	013N031W	23	WINSLOW 7.5	
008	RANA SYLVATICA	WOOD FROG	013N031W	26	STRICKLER 7.5	
001	REGINA RIGIDA SINICOLA	GULF CRAYFISH SNAKE	007N032W	02	BARLING 7.5	
001	RIMULINCOLA DIVALIS	BEETLE	013N031W	26	WINSLOW 7.5	
** WATERSHED: 11110105						
001	HETERODON NASICUS GLOYDI	DUSTY HOGNOSE SNAKE	001S0032	10	MOUNTAIN FORK 7.5	
004	PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	003N029W	21	WALDRON 7.5	
005	PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	008N032W	17	FORT SMITH 7.5	
001	PLETHODON OUACHITAE	RICH MOUNTAIN SALAMANDER	001S030W	31	MENA 7.5	C2
002	PLETHODON OUACHITAE	RICH MOUNTAIN SALAMANDER	001S032W	10	MOUNTAIN FORK 7.5	C2

DATA FOR ARKANSAS STATE WATER PLAN
AQUATIC SPECIES OF SPECIAL CONCERN
(OCCURRENCES WITHIN HYDROLOGIC UNITS)

OCC. NO.	SCIENTIFIC NAME	COMMON NAME	T/R	S	QUAD. NAME	STATUS
003	PLETHODON OUACHITAE	RICH MOUNTAIN SALAMANDER	001S031W	07	RICH MOUNTAIN 7.5	C2
004	PLETHODON OUACHITAE	RICH MOUNTAIN SALAMANDER	001S031W	17	RICH MOUNTAIN 7.5	C2
015	PLETHODON OUACHITAE	RICH MOUNTAIN SALAMANDER	001S032W	11	MOUNTAIN FORK 7.5	C2
003	PLETHODON SERRATUS	OUACHITA RED-BACKED SALAMANDER	001S031W	17	RICH MOUNTAIN 7.5	
** WATERSHED: 11110201						
001	DANELLA PROVONSHAI	MAYFLY	012N025W	24	OARK 7.5	
001	HIODON ALOSOIDES	GOLDEYE	008N0031	27	BARLING 7.5	
003	NOTROPIS CAMURUS	BLUNTFACE SHINER	012N030W	34	MOUNTAINBURG 7.5	
001	POLYODON SPATHULA	PADDLEFISH	008N030W	21	LAVACA 7.5	3C
001	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	009N027W	11	OZARK 7.5	
002	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	009N027W	23	OZARK 7.5	
003	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	010N027W	10	WATALULA 7.5	
003	RANA SYLVATICA	WOOD FROG	012N027W	01	CASS 7.5	
004	RANA SYLVATICA	WOOD FROG	0			
006	RANA SYLVATICA	WOOD FROG	012N028W	04	BIDVILLE 7.5	
016	RANA SYLVATICA	WOOD FROG	010N027W	33	OZARK 7.5	
019	RANA SYLVATICA	WOOD FROG	013N030W	26	WINSLOW 7.5	
002	REGINA SEPTEMVITTATA	QUEEN SNAKE	011N028W	22	CRAVENS 7.5	
006	REGINA SEPTEMVITTATA	QUEEN SNAKE	012N025W	24	OARK 7.5	
005	SCAPHIOPUS HOLBROOKII HURTERII	HURTER'S SPADEFOOT	009N026W	06	OZARK 7.5	
001	STERNOTHERUS CARINATUS	RAZORBACK MUSK TURTLE	012N030W	35	MOUNTAINBURG 7.5	
** WATERSHED: 11110202						
001	CAMBARUS CAUSEYI	CRAYFISH	012N0020	08	FORT DOUGLAS 7.5	
003	LIRCEUS BICUSPIDATUS	ISOPOD	010N023W	32	CLARKSVILLE 7.5	
005	LIRCEUS BICUSPIDATUS	ISOPOD	007N021W	32	CHICKALAH MOUNTAIN EAST 7.5	

DATA FOR ARKANSAS STATE WATER PLAN
AQUATIC SPECIES OF SPECIAL CONCERN
(OCCURRENCES WITHIN HYDROLOGIC UNITS)

OCC. NO.	SCIENTIFIC NAME	COMMON NAME	T/R	S	QUAD. NAME	STATUS
007	LIRCEUS BICUSPIDATUS	ISOPOD	010N023W	29	CLARKSVILLE 7.5	
002	MOXOSTOMA MACROLEPIDOTUM	SHORTHEAD REDHORSE	009N022W	33	KNOXVILLE 7.5	
003	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	009N026W	30	OZARK 7.5	
002	PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	009N024W	19	HARTMAN 7.5	
004	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	009N026W	34	OZARK 7.5	
006	RANA AREOLATA CIRCULOSA	NORTHERN CRAWFISH FROG	008N020W	31	RUSSELLVILLE WEST 7.5	
002	RANA SYLVATICA	WOOD FROG	012N021W	21	FORT DOUGLAS 7.5	
004	RANA SYLVATICA	WOOD FROG	013N023W	12	FALLSVILLE 7.5	
001	REGINA SEPTEMVITTATA	QUEEN SNAKE	010N019W	29	DOVER 7.5	
002	TERRAPENE ORNATA ORNATA	ORNATE BOX TURTLE	008N028W	20	BRANCH 7.5	
003	TERRAPENE ORNATA ORNATA	ORNATE BOX TURTLE	008N028W	20	CHARLESTON 7.5	
** WATERSHED: 11110203						
002	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREEFROG	007N0017	07	HATTIEVILLE 7.5	
010	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREEFROG	007N018W	12	HATTIEVILLE 7.5	
006	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	006N020W	25	HOLLA BEND 7.5	
007	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	004N015W	10	FOURCHE 7.5	
008	PSEUDACRIS STRECKERI STRECKERI	STRECKER'S CHORUS FROG	005N015W	12	GLEASON 7.5	
005	RANA AREOLATA CIRCULOSA	NORTHERN CRAWFISH FROG	006N020W	19	DARDANELLE 7.5	
** WATERSHED: 11110204						
006	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREE FROG	005N022W	28	DANVILLE MOUNTAIN 7.5	
002	LAMPROPELTIS TRIANGULUM AMAURA	LOUISIANA MILK SNAKE	006N025W	22	BLUE MOUNTAIN 7.5	
004	LIRCEUS BICUSPIDATUS	ISOPOD	006N025W	13	MAGAZINE MOUNTAIN NE 7.5	
013	LIRCEUS BICUSPIDATUS	ISOPOD	004N021W	14	OLA 7.5	
002	MESODON CLENCHI	CALICO ROCK OVAL	007N021W	32	CHICKALAH MOUNTAIN EAST 7.5	C2

DATA FOR ARKANSAS STATE WATER PLAN
AQUATIC SPECIES OF SPECIAL CONCERN
(OCCURRENCES WITHIN HYDROLOGIC UNITS)

OCC. NO.	SCIENTIFIC NAME	COMMON NAME	T/R	S	QUAD. NAME	STATUS
001	MESODON MAGAZINENSIS	MAGAZINE MOUNTAIN SHAGREEN	006N025W	21	BLUE MOUNTAIN 7.5	C2
001	PARAVITREA AULACOGYRA	STRIATE SUPERCOIL	006N025W	22	BLUE MOUNTAIN 7.5	
004	PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	005N025W	08	BLUE MOUNTAIN DAM 7.5	
018	PLETHODON SERRATUS	OUACHITA RED-BACKED SALAMANDER	006N025W	22	BLUE MOUNTAIN 7.5	
009	SCAPHIOPUS HOLBROOKII HURTERII	HURTER'S SPADEFOOT	006N021W	20	DARDANELLE 7.5	
001	STYGOBROMUS ELATUS	ELEVATED SPRING AMPHIPOD	006N025W	22	BLUE MOUNTAIN 7.5	C2
** WATERSHED: 11110205						
004	REGINA SEPTEMVITTATA	QUEEN SNAKE	008N013W	29	DAMASCUS 7.5	
** WATERSHED: 11110206						
007	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREEFROG	004N017W	18	THORNBURG 7.5	
001	PLETHODON FOURCHENSIS	FOURCHE MOUNTAIN SALAMANDER	001N028W	35	ODEN 15	C2
010	PLETHODON FOURCHENSIS	FOURCHE MOUNTAIN SALAMANDER	001N029W	35	Y CITY 7.5	C2
** WATERSHED: 11110207						
004	ANODONTA SUBORBICULATA	FLAT FLOATER	001N012W	22	LITTLE ROCK 7.5	
007	CEMOPHORA COCCINEA COPEI	NORTHERN SCARLET SNAKE	002S0011	18	WOODSON 7.5	
003	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREEFROG	002S012W	23	SPRING LAKE 7.5	
004	HYLA AVIVOCA AVIVOCA	BIRD-VOICED TREEFROG	002S013W	02	SPRING LAKE 7.5	
007	RANA SYLVATICA	WOOD FROG	0			
002	REGINA RIGIDA SINICOLA	GULF CRAYFISH SNAKE	002N011W	36	MC ALMONT 7.5	

United States Department of the Interior

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

June 4, 1987

Mr. Randy Young, Director
Arkansas Soil and Water
Conservation Commission
#1 Capitol Mall, Suite 2D
Little Rock, Arkansas 72201

Dear Randy,

The draft Arkansas River Basin Report has been reviewed by A.H. Ludwig, B.L. Neely, and E.E. Gann. Review comments were made in the margins and on the attached page.

We appreciate the opportunity to review the draft report. Please contact this office if there are any questions.

Sincerely,

E.E. Gann
District Chief

Enclosures

EEG:bll

STATE WATER PLAN

ARKANSAS RIVER BASIN

GENERAL COMMENTS

The ground-water section of the report was reviewed by A.H. Ludwig. Numerous comments are included along with the text.

The report will require considerable revision in order to be technically correct and contain pertinent information. The descriptions of the geologic framework of the area and the designation of accounts of ground water available from each unit are, in many cases, not applicable to the specified study area and are therefore misleading. The author should discuss only the units within the area and relate yields to these areas. While it is understood that irrigation supplies obtained from the alluvial aquifer are extremely important in the basin, the majority of the area is underlain by rocks that have only limited water-yielding capability. The water-deficient areas also require some consideration as to their problems.

The report needs to be strengthened editorially also. Many paragraphs have topic sentences indicating one subject when the paragraph goes off on another subject. This problem creates confusion and misunderstanding for the reader.

THE NATURAL STATE ®

Arkansas