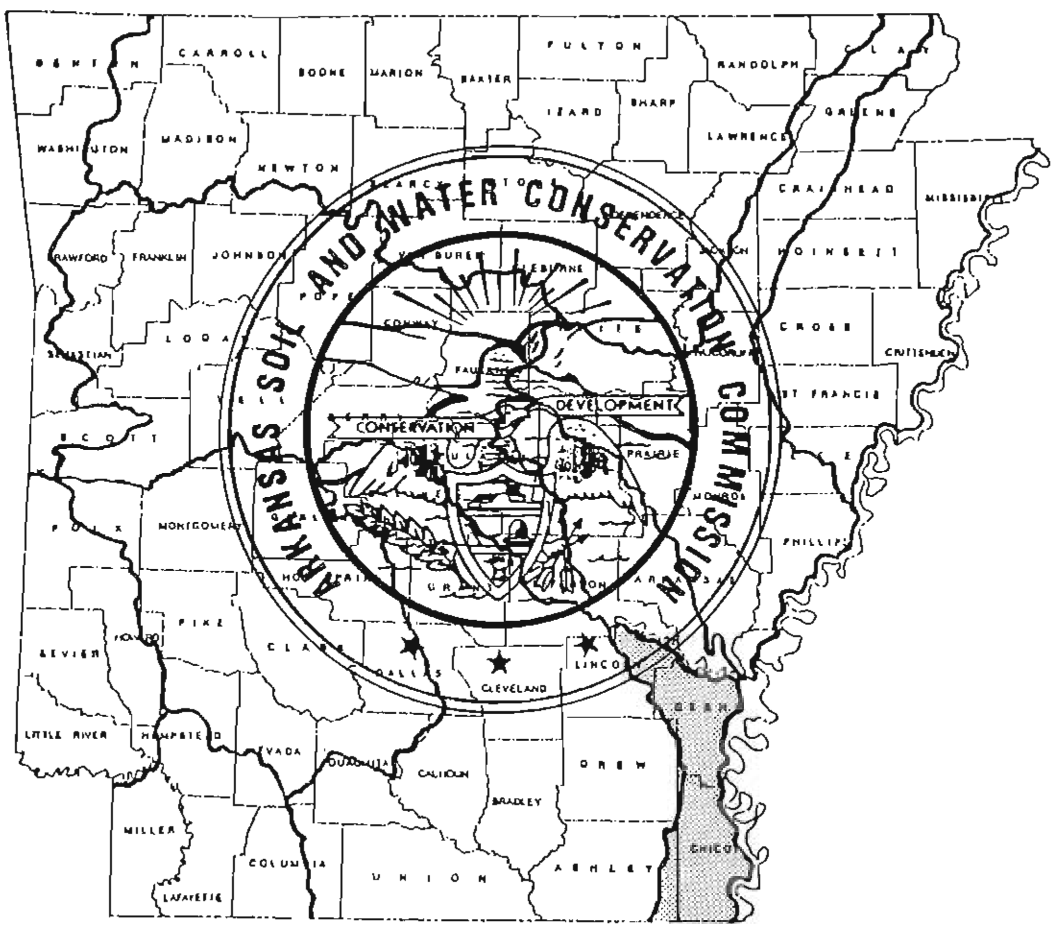
ARKANSAS STATE WATER PLAN

SUPPLEMENT TO THE BOEUF-TENSAS BASIN ADDRESSING REQUIREMENTS OF ACT 1051 OF 1985



DECEMBER 1988

ARKANSAS SOIL AND WATER CONSERVATION COMMISSION

STATE OF ARKANSAS

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PREFACE

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

The first State Water Plan was published in 1975 with five appendices that addressed specific problems and needs in the state. As more data have become available, it is apparent that the ever-changing nature of water-resource problems and potential solutions requires the planning process to be dynamic. Therefore, periodic revisions to the State Water Plan are necessary for the document to remain valid. Specific objectives in revising the 1975 State Water Plan are to incorporate data available from recent research, evaluate new and existing problems, and present specific solutions and recommendations.

In 1985, the Arkansas General Assembly passed Act 1051 which was established to determine the present and future requirements of the water users of the State. As a result of this Act, the Arkansas Soil and Water Conservation Commission was mandated to: (1) inventory the surface water and ground water resources within the state; (2) determine water needs for fish and wildlife, navigation, public water supply, industry, agriculture, and all other users; (3) delineate critical water areas; (4) determine the safe yield of streams and aquifers; (5) establish minimum streamflows; and (6) determine excess surface water. The requirements of Act 1051 will be addressed in each of the basin reports of the revised State Water Plan.

The first report of the revised State Water Plan was published in 1984 and addressed the Boeuf-Tensas Basin. Since the Boeuf-Tensas Basin report was published prior to the passage of Act 1051, preparation of this supplemental report was necessary to satisfy the requirements of Act 1051 of 1985 for the Boeuf-Tensas Basin.

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ABSTRACT

The Arkansas State Water Plan is the basic document for defining water policy in the State of Arkansas. The purpose of this supplemental report to the State Water Plan is to satisfy the requirements of Act 1051 of 1985 for the Boeuf-Tensas Basin in southeastern Arkansas. Act 1051 requirements which are addressed in the report for the Boeuf-Tensas Basin include: instream flow requirements, minimum streamflow, excess surface water, safe yield of streams and aquifers, and critical surface water and ground water areas.

Instream flow requirements for water quality, fish and wildlife, navigation, interstate compacts, aquifer recharge, aesthetics, and riparian use are determined so that streamflow available for use within the basin as well as the amount of excess water available for interbasin transfer (non-riparian use) could be quantified. Based on existing and projected water needs of the Boeuf-Tensas Basin, there is no excess streamflow available for other uses, such as interbasin transfer. In fact, future water needs of users within the basin may not be satisfied without importation of water due to the estimated surface-water deficit of approximately 470,000 acre-feet per year.

The two principal streams in the Boeuf-Tensas Basin, the Boeuf River and Bayou Macon, have been designated as critical surface water areas based on quantity problems. Pumping for irrigation has, at times in the past, contributed to no-flow conditions for the Boeuf River and Bayou Macon.

There are three principal aquifers within the Boeuf-Tensas Basin. These aquifers are (descending from land surface) the alluvial aquifer, the Cockfield aquifer, and the Sparta aquifer. Portions of all three aquifers have been delineated as critical ground water use areas because of water-quality problems and, in one instance, excessive water-level declines in the Sparta aquifer. The most significant problem in the basin is saline water intrusion from deeper aquifers. This problem is greatly magnified by improperly constructed wells and excessive pumping from the shallower aquifers.

Recommended solutions to alleviate the major surface water and ground water problems in the Boeuf-Tensas Basin include: diversion of water from the Arkansas River to supplement available streamflow, particularly during the irrigation season; employment of a conjunctive use management strategy to reduce ground water quantity and quality problems; implementation of Best Management Practices to reduce surface water quality degradation from nonpoint pollution sources; and use of land treatment measures and enforcement of floodplain management to reduce flooding problems. Implementation of these recommended solutions will contribute to more efficient management of the water resources of the Boeuf-Tensas Basin.

INTRODUCTION

The Boeuf-Tensas Basin encompasses approximately 864,000 acres of land in the southeastern corner of the State. <2>. The majority of the basin, as shown in Figure 1, is in Chicot and Desha Counties; however, parts of Ashley, Drew, Jefferson, and Lincoln Counties are also included in the basin.

Climate of the area is characterized by hot summers and mild winters. Precipitation is usually in the form of rain, with very light and infrequent snowfall. Average annual precipitation ranges from approximately 51 inches in the northern part of the basin to approximately 54 inches in the southern part of the basin <13>. (Numbers in angle brackets refer to the references found in the bibliography.)

The Boeuf-Tensas Basin is a highly developed agricultural region that lies within the Mississippi embayment of the Coastal Plan province <15>. The topography of the area is relatively level which contributes to the suitability of this area for agriculture. In fact, cropland accounts for approximately 85 percent of the total land use in the basin. The 735,000 acres of cropland in the basin represent about 9.4 percent of the total cropland in the State <2>.

Irrigation for the production of food and fiber accounts for about 90 percent of the total water use in the basin, most of which comes from ground water. Water use in the study area totaled approximately 400 MGD (million gallons per day) in 1980. <2>. By the year 2030, the amount of water use in the study area is projected to increase to approximately 1110 MGD <2>.

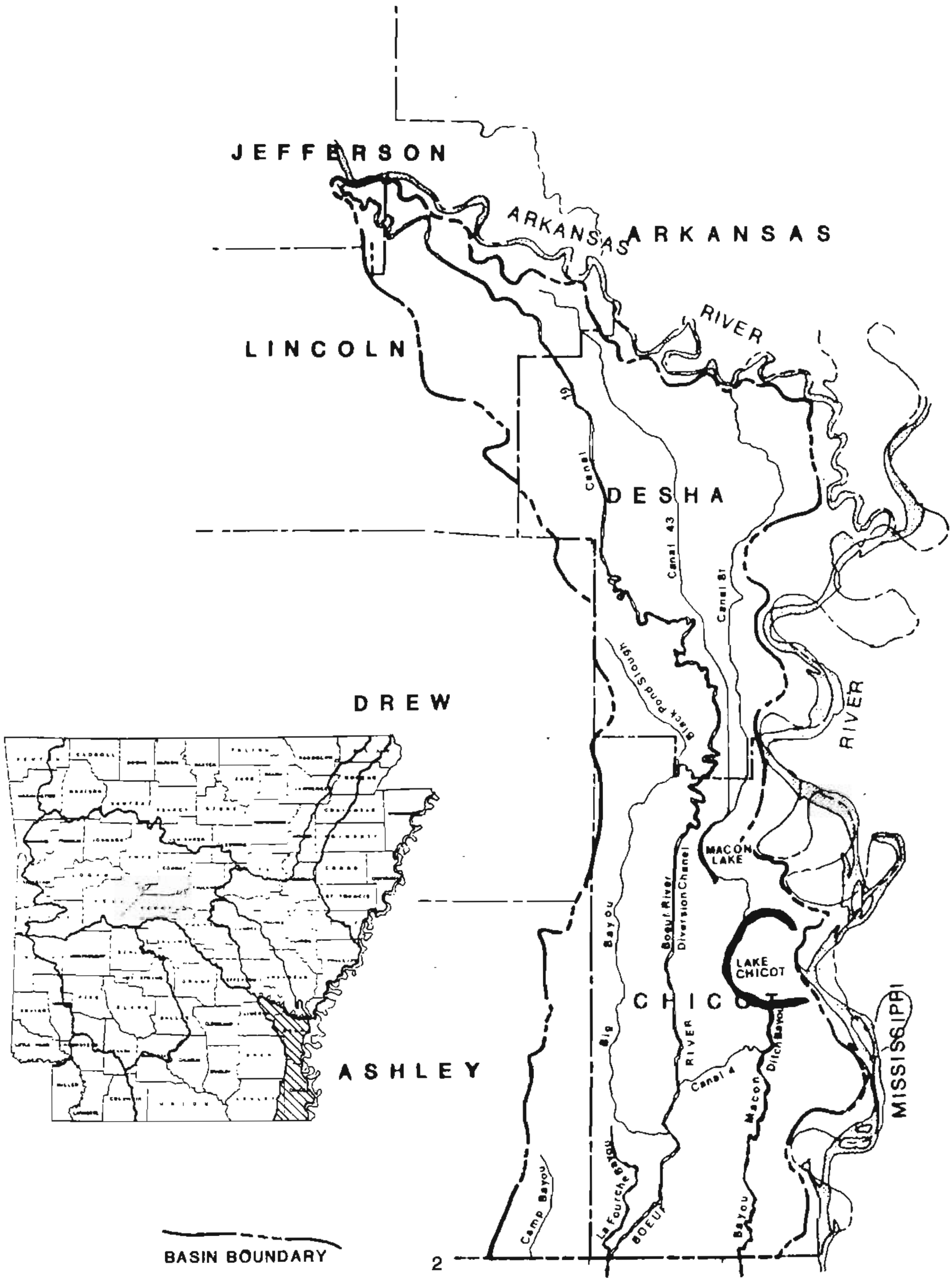
There area bout 140 lakes in the basin that impound approximately 79,000 acre-feet of water. Lake Chicot is the largest impoundment in the basin with a surface area of about 5,200 acres <2>.

The two principal streams in the Boeuf-Tensas Basin are the Boeuf River and Bayou Macon. Generally, streams in the basin are meandering and sluggish. The stream channels have relatively flat slopes and are interspersed with abandoned channels and water courses. There is an interchange of flow between streams in the basin under varying streamflow conditions due to the interconnecting system of bayous and drainage ditches that presently exist in the basin. The total surface-water yield from the streams and rivers in the basin is approximately 1.12 million acre-feet of water on an average annual basis.

Water quality of the streams and impoundments in the Boeuf-Tensas Basin is generally satisfactory for irrigation purposes. Concentrations of suspended sediment, fecal coliform bacteria, and nutrients from non-point sources in the basin restrict the use of surface water for other purposes such as domestic water supplies <2>.

Geologic units of Quaternary Age are present on the surface of the Boeuf-Tensas Basin. Quaternary alluvial and terrace deposits generally consist of coarse sand and gravel at the base grading upward to sand, silt, and clay. Alluvial deposits are covered by a clay cap which is approximately 20 feet thick throughout the basin. Thicknesss of Quaternary deposits rarely exceeds 150 feet.

figure 1
BOEUF-TENSAS BASIN



Tertiary Age deposits are present in the subsurface of the Boeuf-Tensas Basin. These deposits are characterized by formations composed of interbedded fine to medium sand, carbonaceous clay, and lignite alternating with clay confining beds.

Ground water in the Boeuf-Tensas is primarily obtained from Quaternary alluvial deposits and two artesian aquifers, the Cockfield aquifer and Sparta aquifer of Tertiary Age <2>. The alluvial aquifer commonly yields 1,000 to 2,000 GPM (gallons per minute) to wells in the basin. However, because the water is often highly mineralized, the alluvial aquifer has been developed almost exclusively for agricultural uses. The Cockfield and Sparta Sand Formations provide the majority of water for municipal water supply systems in the basin.

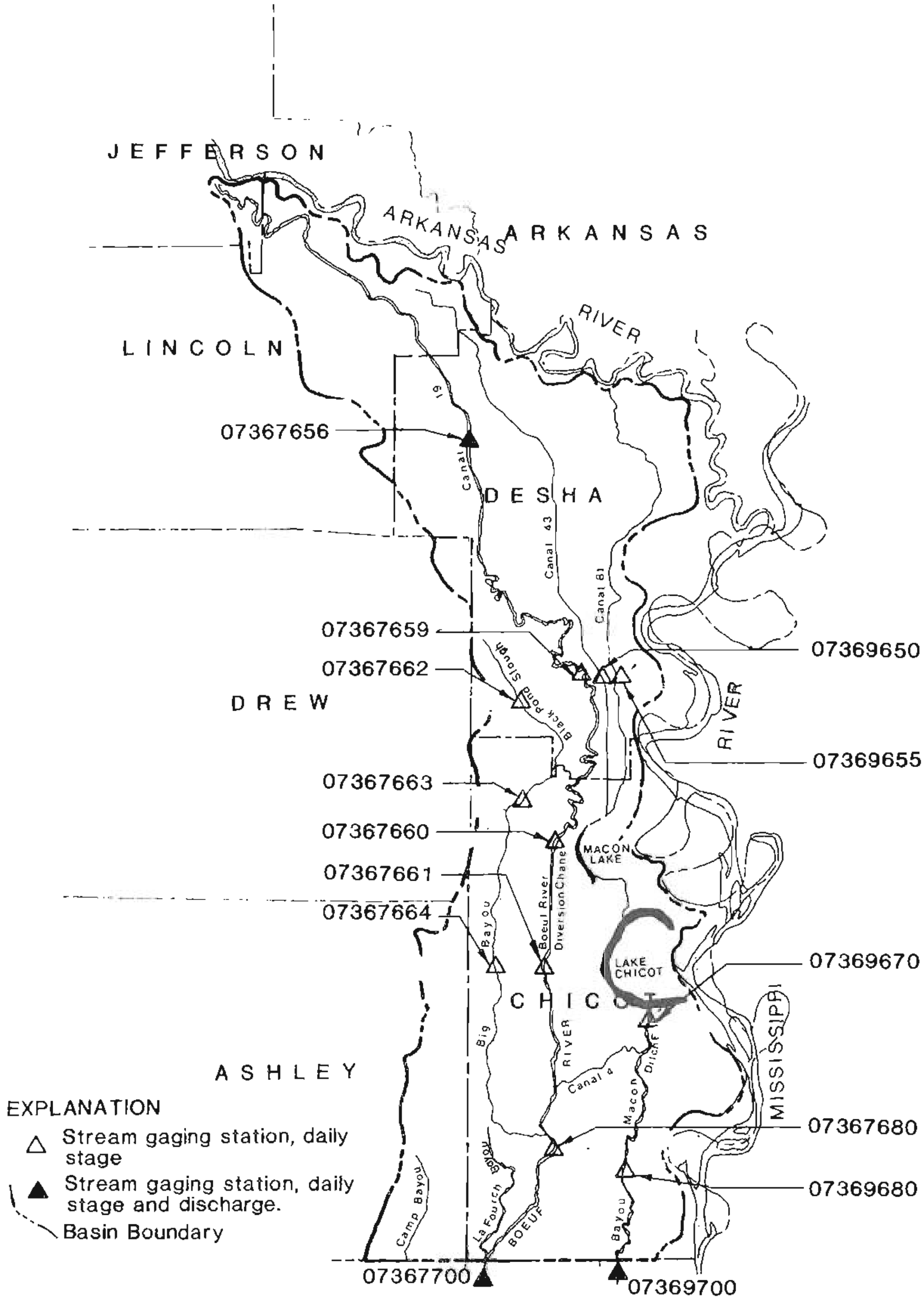
The purpose of this supplemental report is to satisfy the requirements of Act 1051 of 1985 for the Boeuf-Tensas Basin. Information in subsequent sections of the report addresses: (1) instream flow requirements; (2) minimum streamflow; (3) excess surface water; (4) safe yield of streams and aquifers; and (5) critical surface water and ground water areas. Data from the 1984 Boeuf-Tensas report <2> and additional data were compiled in order to quantify the needs of water users in the basin. This information will provide a guide for the future use, management, and development of the water resources of the Boeuf-Tensas Basin.

SURFACE WATER

Streamflow Data Collection Network

Streamflow data are collected in the Boeuf-Tensas Basin primarily by the U.S. Army Corps of Engineers and the U.S. Geological Survey. Locations of streamflow data collection sites are shown in Figure 2. Information for the two U.S. Geological Survey gaging stations, which are located in Louisiana, is summarized in Table 1. Additional gaging station data collected by the U.S. Army Corps of Engineers are provided in Table 2.

figure 2
GAGING STATION LOCATIONS IN THE BOEUF-TENSAS BASIN



SOURCE: Modified from Broom and Reed, 1973. ⟨5⟩

TABLE I

SUMMARY OF U.S. GEOLOGICAL SURVEY STREAMFLOW DATA-COLLECTION SITES IN THE BOEUF-TENSAS BASIN

USGS STATION NUMBER	NAME	DRAINAGE AREA (MI)	PERIOD OF RECORD (WATER YEARS)	EXTREMES FGR PERIOD OF RECORD: MAXIMUM DISCHARGE (CFS) AND DATE	EXTREMES FGR PERIOD OF RECORD: MINIMUM DISCHARGE (CFS) AND DATE	AVERAGE DISCHARGE (CFS) AND YEARS OF RECORD USED TO COMPUTE DISCHARGE	REMARKS
07367700	BOEUF RIVER NEAR AR-LA STATE LINE	785	DATLY OISCHARGE: 1958-68; DAILY DISCHARGE BELOW 200 CFS ONLY: 1969-79	16,500 2-11-66	NO FLOW AT TIMES IN 1966, 1974, 1977, AND 1978; RESULT OF PUMPING FOR IRRIGATION	949 (1958-68)	DIVERSIONS ABOVE AND BELOW STATION FOR IRRIGATION. INTERCONNECTING SYSTEM OF BAYOUS AND DRAINAGE DITCHES PRODUCES AN INTERCHANGE OF FLOW UNDER VARYING CON-DITIONS. IN EXTREME FLOODS, CONSIDERABLE FLOW BYPASSES STATION.
07369700	BAYOU MACON NEAR KILBOURNE, LA	504	DAILY DISCHARGE: 1958-68; DAILY DISCHARGE BELOW 200 CFS ONLY: 1969-85	4,740 5-5-58	NO FLOW 6-11-63, RESULT OF PUMPING FOR IRRIGATION	508 (1958-68)	LARGE OIVISIONS ABOVE STATION FOR IRRIGATION. INTERCONNECTING SYSTEM OF BAYOUS AND DRAINAGE DITCHES PRODUCES AN INTERCHANGE OF FLOW UNDER VARYING CONDITIONS.

SOURCE: CARLSON AND OTHERS, 1985 <6>

TABLE 2

SUMMARY OF SELECTED U.S. ARMY CORPS OF ENGINEERS STREAMFLOW DATA-COLLECTION SITES IN BOEUF-TENSAS BASIN

STATION NUMBER	NAME	DRAINAGE AREA (MI²)	PERIOD OF RECORD (WATER YEARS) 1/	BANKFULL GAGE HEIGHT (FEET)	MAXIMUM ANNUAL PEAK GAGE HEIGHT (FEET)	MAXIMUM ANNUAL PEAK DISCHARGE (CFS)	MINIMUM ANNUAL PEAK GAGE HEIGHT (FEET)	MINIMUM ANNUAL PEAK DISCHARGE (CFS)	AVERAGE DISCHARGE (CFS) AND YEARS OF RECORD USED TO COMPUTE DISCHARGE
07367656	CANAL 19 NR. DUMAS	162	1960-68	2/	29.10	4,050	19.60	1,140	227 (1960-68)
07367659	CANAL 19 NR. ARKANSAS CITY	266	1947-56	22.00	26.41	2,260	22.90	1,120	311
			1957-70		26.30	5,050	16.10	1,400	(1947-68)
07367660	DIVERSION CANAL, BOEUF RIVER AT MACON LAKE	303	1947-56	2/	17.90	1,780	9.90	646	242
			1957-68		17.40	7,420	9.60	2,630	(1947-68)
07367661	BOEUF RIVER NR. LAKE VILLAGE	355	1947-56	24.00	22.50	2,800	17.00	1,600	319
			1957-68		18.50	8,280	7.10	1,750	(1947-68)
07367662	BLACK POND SLOUGH NR. MCGEHEE	11	--	--	--	--	--	--	17.1 (1952-68)
07367663	BIG BAYOU NR. DERMOTT	60	1952-56	13.40	15.60	982	12.80	635	80.8
			1957-68		15.00	3,330	5.00	830	(1952-68)
07367664	BIG BAYOU NR. LAKE VILLAGE	102	1947-55	19.0	16.4	1,870	14.5	1,350	130
			1956-68		16.7	3,280	8.1	1,180	(1947-68)
07367690	BOEUF RIVER NR. EUDORA	--	1939-55	21.0	21.52	9,830	16.8	4,080	--
			1956-70		20.15	15,300	6.34	2,600	
07369650	CANAL 81 NR. ARKANSAS CITY	157	1947-58	28.0	29.50	1,730	24.80	952	274
			1959-68		27.10	3,600	18.10	1,070	(1947-68)
07369655	CANAL 43 NR. ARKANSAS CITY	138	1947-56	26.0	25.9	2,970	19.3	1,260	209
			1957-69		24.4	3,120	16.1	2,120	(1947-68)
07369670	DITCH BAYOU NR. LAKE VILLAGE	404	1946-68	27.0	25.5	6,000	14.5	1,020	671 (1946-68)
07369680	BAYOU MACON AT EUDORA	--	1932, 1938-64	18.0	27.43	5,100	13.96	1,200	--
			1965-68		22.08	--	10.36	--	

1/ PERIOD OF RECORD AFTER CHANNEL IMPROVEMENTS SHOWN SEPARATELY.

2/ NOT DEFINED; BANKFULL STAGE NEVER REACHED DURING PERIOD OF RECORD.

SOURCE: BROOM AND REED, 1973 <5>

Streamflow Characteristics

The Boeuf-Tensas Basin is characterized by sluggish, meandering streams. The stream channels have relatively flat slopes and are interspersed with abandoned channels and water courses. Considerable stream channel improvements such as deepening and straightening of the channels have been made to facilitate drainage of the land. In addition, an extensive network of canals was developed by the U. S. Army Corps of Engineers in the 1940's. The flood control projects included the construction of canals 19, 43, 81, and the Boeuf River Diversion Canal <5>. Due to the interconnecting system of bayous and drainage ditches that presently exists in the Boeuf-Tensas Basin, there is an interchange of flow between streams in the basin under varying streamflow conditions.

The Boeuf River in Arkansas has a drainage area of approximately 780 square miles. The length of the main channel to the State line is 145 miles as measured along Canal 19, the Boeuf River Diversion Canal, and the Boeuf River. The slope of the main channel averages about 0.8 foot per mile <5>. Bayou Macon has a drainage area of about 500 square miles in Arkansas. The length of the main channel is 101 miles, as measured to the State boundary along Canal 43, Macon Lake, Lake Chicot, Ditch Bayou, and Bayou Macon. The slope of the main channel along this reach averages about 1.0 foot per mile <5>.

In the Boeuf-Tensas Basin, streamflow is generally highest during December through May because of the large amount of precipitation during this period. Similarly, streamflow is generally lowest during June through November due to a decrease in precipitation and increases in agricultural water use and evapotranspiration that occur during the growing season. The mean monthly and mean annual discharges at selected gaging stations in the basin are shown in Table 3.

Annual and seasonal variability of streamflow in the Boeuf-Tensas Basin affect the water-supply potential of streams on a year-round basis. The percentage of time specified stream discharges are available is one factor that determines the water-supply potential of a stream without storage. The percentage of time which specified discharges have been equaled or exceeded during a given period can be shown by flow-duration curves or tables. Seasonal and period-of-record flow-duration curves for two streams in the basin have been developed by Broom and Reed <5> and selected points from the curves are summarized in Table 4. The period-of-record duration curve was developed using all daily mean discharge data for the period of record; whereas, the seasonal flow-duration curve was determined by using only daily mean discharge for the normal irrigation season, May through September. The data in Table 4 indicate that streamflow of the Boeuf River and Bayou Macon is generally lower during the irrigation season than at other times of the year as was previously shown by the mean monthly discharge data in Table 3. It should be noted that computation of mean daily discharge at the gaging stations on the Boeuf River and Bayou Macon was discontinued in 1968, therefore, the flow-duration curves for these two gaging stations were developed using streamflow data prior to 1970. These curves may not be representative of current streamflow conditions due to increases in surface-water and ground-water withdrawals for irrigation since 1970. In addition, streamflow at these two sites may be significantly affected by the recent construction of a pumping station upstream of Lake Chicot. Inflow to Lake Chicot from Connerly Bayou is, at times, diverted to the Mississippi River to maintain a relatively stable lake stage and to improve the water quality of Lake Chicot. Therefore, the water-supply potential of the Boeuf River and Bayou Macon may be significantly different than the flow-duration data in Table 4 indicate.

TABLE 3

FLOW CHARACTERISTICS OF SELECTED STREAMS

STATION		YEARS USED FOR	MEAN MONTHLY AND MEAN ANNUAL DISCHARGE (CUBIC FEET PER SECOND)												
NUMBER	NAME	COMPUTATION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
07367656	CANAL 19 NEAR DUMAS	1960-68	75.7	95.9	331	302	366	385	345	333	146	116	107	123	227
07367659	CANAL 19 NEAR ARKANSAS CITY	1947-68	96.0	178	311	487	701	508	472	484	146	104	81.0	164	311
07367660	DIVERSION CANAL, BOEUF RIVER AT MACON LAKE	1947-68	56.8	171	264	373	544	423	367	400	89.5	72.7	46.3	122	242
07367661	BOEUF RIVER NEAR LAKE VILLAGE	1947-68	79.1	194	308	529	748	576	484	464	130	108	65.3	177	319
07367662	BLACK POND SLOUGH NEAR McGEHEE	1952-68	5.70	18.6	19.0	25.3	41.3	25.0	19.9	20.6	8.50	7.60	6.80	9.10	17.1
07367663	BIG BAYOU NEAR DERMOTT	1952-68	11.3	64.9	95.8	134	204	136	98.5	123	26.2	20.6	16.0	48.3	80.8
07367664	BIG BAYOU NEAR LAKE VILLAGE	1947-68	22.1	77.8	115	237	333	222	165	180	60.1	50.2	23.0	89.4	130
07367700	BOEUF RIVER NEAR ARKANSAS-LOUISIANA STATE LINE	1958-68	228	813	1118	1429	1919	1513	1340	1474	415	338	187	687	949
07369650	CANAL 81 NEAR ARKANSAS CITY	1947-68	109	191	241	371	537	397	339	352	188	210	181	189	274
07369655	CANAL 43 NEAR ARKANSAS CITY	1947-68	53.1	116	163	339	497	414	259	377	76.5	60.1	35.9	97.8	209
07369670	DITCH BAYOU NEAR LAKE VILLAGE	1946-68	204	279	484	920	1471	1247	1111	1053	547	399	217	241	671
07369700	BAYOU MACON NEAR KILBOURNE, LOUISIANA	1958-68	216	317	555	683	879	832	745	833	357	242	183	274	508

SOURCE: BROOM AND REED, 1973 < >

TABLE 4

DURATION OF DAILY FLOW AT SELECTED GAGING STATIONS

[FLOW: UPPER FIGURE IS SEASONAL, MAY 1 TO SEPT. 30, DURATION VALUE; LOWER FIGURE IS PERIOD-OF-RECORD DURATION VALUE]

STATION NUMBER	STATION NAME	PERIOD OF RECORD	FLOW, IN CUBIC FEET PER SECOND, WHICH WAS EQUALED OR EXCEEDED FOR INDICATED PERCENTAGE OF TIME: 99	95	90	80	70	60	50	40	30	20	10	5	1	0.5
07367700	BOEUF RIVER NEAR ARKANSAS-LOUISIANA STATE LINE	1958-88	4	32	48	70	88	110	140	180	250	440	1200	2500	11000	--
			18	43	54	72	94	130	180	280	500	1000	2400	4500	13000	--
07369700	BAYOU MACON NEAR KILBOURNE, LOUISIANA	1959-65, 1968	17	42	56	76	94	120	150	190	290	500	920	1600	3800	4100
			24	40	56	84	110	150	210	320	600	900	1400	2000	3500	4000

SOURCE: BROOM AND REED, 1973 (5)

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". <28> Instream flow requirements are established at a level at which the flow regime best meets the individual and collective instream uses. Instream uses of water include uses of water in the stream channel for navigation, recreation, fisheries, riparian vegetation, aesthetics, and hydropower. Off-stream water withdrawals include uses such as irrigation, municipal and industrial water supplies, and cooling water.

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to determine instream flow requirements for: (1) water quality, (2) fish and wildlife, (3) navigation, (4) interstate compacts, (5) aquifer recharge, and (6) needs of all other users in the basin such as industry, agriculture, and public water supply. Determination of the amount of water required to satisfy instream needs in the Boeuf-Tensas 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 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 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 sections on instream flow requirements pertains to this first approach. The second approach was to determine the amount of water necessary to satisfy minimum instream flow requirements to determine the streamflow available for use within the basin. This second approach is described in more detail in the minimum streamflow section of the report.

Computations of instream flow requirements at selected locations in the basin are based on available streamflow data. It should be noted, however, that collection of daily discharge data at most of the gaging stations in this basin was discontinued prior to 1970. Therefore, if significant changes have occurred in the use of streamflow for irrigation since 1970, the instream flow requirements may need to be recomputed based on streamflow data that represent the current streamflow conditions. Instream flow requirements may also need to be recomputed for the gaging stations downstream of Lake Chicot which may be affected by operation of the pumping station on Connerly Bayou.

Water-Quality Requirements

The $7Q_{10}$ low-flow characteristic is a common criterion used by State and Federal agencies to determine the permissible rate of waste disposal into a given stream since one of the most important factors influencing the concentration of dissolved solids in streamflow is the volume of water available for dilution. The Arkansas Department of Pollution Control and Ecology is responsible for the management of water-quality conditions in the Boeuf-Tensas Basin. The $7Q_{10}$ discharge for streams and rivers in the basin is the minimum flow at which the ADPC&E is responsible for maintaining streamflow contaminant concentrations at acceptable levels. The ADPC&E continues to monitor point-source discharges below the $7Q_{10}$ discharge and requires concentrations of certain pollutants to be maintained below critical levels. However, because sufficient water is not available at times during the year to dilute the effluent discharges, streamflow water quality may not meet the quality standards during all times of the year.

A considerable amount of water is diverted from streams in the basin during the irrigation season. Because the amount of water withdrawn is dependent upon need, water withdrawals during low-flow periods are extremely variable. Therefore, the $7Q_{10}$ low-flow characteristics have not been quantified for most streams in the basin. The $7Q_{10}$ discharges for two gaging station locations in the basin have been determined by Lee <17 >. The discharges required to meet water-quality standards at the two locations are as follows:

Boeuf River near Arkansas-Louisiana state line - 1.0 cfs
Bayou Macon near Kilbourne, Louisiana - 7.7 cfs

Fish and Wildlife Requirements

Several methods are currently 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 <25> developed a method (often referred to as the "Montana Method") which requires limited field work and utilizes historic hydrologic records to estimate instream flow requirements for fish and other aquatic life by correlating the condition of the aquatic habitat with the percent of the average flow present in the stream. The Montana Method was tested by field studies which involved physical, chemical, and biological analyses conducted on 11 streams in three states. Additional analyses of hundreds of additional flow regimens in 21 different states substantiated the correlation between the condition of the aquatic habitat and the percent of the average flow present in the stream. Tennant's comprehensive study resulted in the following conclusions:

(A) "Ten percent (10%) of the average flow: This is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Channel widths, depths, and velocities will all be significantly reduced and the aquatic habitat degraded. The stream substrate may be about one-half exposed, except in wide, shallow riffle or shoal areas where exposure could be higher. Most side channels will be severely or totally dewatered. Most gravel bars will be substantially dewatered, and islands will usually no longer function as wildlife nesting, denning, nursery, and refuge habitat. Streambank cover for fish and fur animal denning habitat will be severely diminished. Many wetted areas will be so shallow they no longer will serve as cover, and fish will generally be crowded into the deepest pools. Riparian vegetation may suffer from lack of water. Large fish may have difficulty migrating upstream over many riffle areas. Water temperature may become a limiting factor, especially in the lower reaches of the stream in July and August. Invertebrate life will be severely reduced."

(B) "Thirty percent (30%) of the average flow: This is a base flow recommended to sustain good survival habitat for most aquatic life forms. Widths, depths, and velocities will generally be satisfactory. The majority of the substrate will be covered with water, except for very wide, shallow riffle or shoal areas. Most side channels will carry some water. Most gravel bars will be partially covered with water and many islands will provide wildlife nesting, denning, nursery, and refuge habitat. Streambanks will provide cover for fish and wildlife denning habitat in many reaches. Many runs and most pools will be deep enough to serve as cover for fishes. Riparian vegetation should not suffer from lack of water. Large fish should have no trouble moving over most riffle areas. Water temperatures are not expected to become limiting in most stream segments. Invertebrate life is reduced but not expected to become a limiting factor in fish production."

(C) "Sixty percent (60%) of the average flow: This is a base flow recommended to provide excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. Channel widths, depths, and velocities will provide excellent aquatic habitat. Most of the normal channel substrate will be covered with water, including many shallow riffle and shoal areas. Side channels that normally carry water will have adequate flows. Few gravel bars will be exposed, and the majority of islands will serve as wildlife nesting, denning, nursery, and refuge habitat. The majority of streambanks will provide cover for fish and safe denning areas for wildlife. Most pools, runs, and riffles will be adequately covered with water and provide excellent feeding and nursery habitat for fishes. Riparian vegetation will have plenty of water. Fish migration is no problem in any riffle areas. Water temperatures are not expected to become limiting in any reach of the stream. Invertebrate life forms should be varied and abundant."

Tennant's recommended flows are generally applicable for both cold and warm water streams. However, it is suggested that the recommended flow regimens be altered to fit different hydrologic cycles or to coincide with vital periods of the life cycle of fishes.

Filipek and others <10> have developed a new method, termed the "Arkansas method", which utilizes some of Tennant's basic principles. This new method was developed due to limitations in the application of the Montana method to Arkansas streams. The Arkansas method divides the water year into three seasons based on the physical and biological processes that occur in the stream. The three physical/biological seasons as well as the flow recommended for fisheries during each season are described in Table 5. The instream flow requirements, as determined by the Arkansas method, are those that apply to fish populations only and represent the point at which fisheries begin to be impacted. The method assumes that when instream flows meet the needs for fisheries, instream requirements for other wildlife forms are probably also satisfied.

The Arkansas method was applied to mean monthly discharge data (previously summarized in Table 3) to determine the instream flow requirements for fish and wildlife at selected streamflow gaging stations in the Boeuf-Tensas Basin with the results compiled in Table

TABLE 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 RECOMMENDED	SIXTY PERCENT OF THE MEAN MONTHLY FLOW	SEVENTY PERCENT OF THE MEAN MONTHLY FLOW	FIFTY PERCENT 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) WATER TEMPERATURES. -HIGH DISSOLVED OXYGEN CONTENT. HIGH FLOWS AND INCREASING WATER TEMPERATURES SPUR SPAWNING RESPONSE IN FISH TO SPAWN: 1) IN CHANNEL 2) IN OVERBANK AREA OR 3) UPRIVER AFTER MIGRATION. FEEDING ALSO ACTIVATED BY HIGH SPRING FLOWS.	-LOW AVERAGE MONTHLY FLOWS. -HIGH WATER TEMPERATURES. -LOW DISSOLVED OXYGEN CONTENT COMMON. HIGH WATER TEMPERATURES INCREASE PRIMARY, SECONDARY AND TERTIARY PRODUCTION. LOW FLOWS CONCENTRATE PREDATORS (FISH) WITH PREY (INVERTEBRATES, FORAGE FISH).
LIMITING FACTORS	REDUCED FLOWS AT THIS TIME OF YEAR CAUSE: DECREASE IN BENTHIC PRODUCTION DUE TO ACCUMULATED SEDIMENT ON SUBSTRATE. DECREASE IN FISH SPAWNING HABITAT DUE TO REDUCED FLUSHING. DECREASE IN AQUIFER RECHARGE.	REDUCED FLOWS 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; FISHKILLS. INCREASE CONCENTRATION OF POLLUTANTS AND SEDIMENT IN WATER. ADDITIONAL DECREASE IN GROUNDWATER TABLE.

SOURCE: FILIPEK AND OTHERS, 1985 (10)

TABLE 6

MONTHLY AND ANNUAL INSTREAM FLOW REQUIREMENTS FOR FISH AND WILDLIFE (ARKANSAS METHOD) AT SELECTED GAGING STATIONS IN THE BOEUF-TENSAS BASIN

STATION NUMBER	NAME	MONTHLY AND ANNUAL INSTREAM FLOW REQUIREMENTS FOR FISH AND WILDLIFE (CFS) OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
07367656	CANAL 19 NR. DUMAS	37.8	57.5	199	181	220	231	242	233	102	58.0	53.5	61.5	140
07367659	CANAL 19 NR. ARKANSAS CITY	48.0	107	187	292	421	305	330	339	102	52.0	40.5	82.0	192
07367660	DIVERSION CANAL, BOEUF RIVER AT MACON LAKE	25.4	103	158	224	326	254	257	280	62.6	36.4	23.2	61.0	151
07367661	BOEUF RIVER NR. LAKE VILLAGE	39.6	116	185	317	449	346	339	325	91.0	54.0	32.6	88.5	198
07367662	BLACK POND SLOUGH NR. MCGEHEE	2.85	11.2	11.4	15.2	24.8	15.0	13.9	[illegible]	5.95	3.80	3.40	4.55	10.5
07367663	BIG BAYOU NR. DERMOTT	5.65	38.9	57.5	80.4	122	81.6	69.0	86.1	10.3	10.3	8.00	24.2	50.2
07367664	BIG BAYOU NR. LAKE VILLAGE	11.0	46.7	69.0	142	200	133	116	126	42.1	25.1	11.5	44.7	80.6
07367700	BOEUF RIVER NR. AR-LA STATE LINE	114	488	671	857	1151	908	938	1032	290	169	93.5	344	588
07369650	CANAL 81 NR. ARKANSAS CITY	54.5	115	145	223	322	238	237	246	132	105	90.5	94.5	167
07369655	CANAL 43 NR. ARKANSAS CITY	26.6	69.6	97.8	203	298	246	181	264	53.6	30.0	18.0	48.9	128
07369870	DITCH BAYOU NR. LAKE VILLAGE	102	167	290	552	863	748	778	737	383	200	108	120	422
07369700	BAYOU MACON NR. KILBOURNE, LA	108	190	333	410	527	499	522	583	250	121	91.5	137	314

6. The flows required to satisfy instream needs for fish and wildlife on an annual basis were also determined for the gaging stations in the basin and are shown in Table 6. The annual instream flow requirements for fish and wildlife were computed by averaging the monthly instream flow requirements for the year.

Instream flow requirements for fish and wildlife are not available for many locations in the basin due to the limited number of gaging stations in the Boeuf-Tensas Basin. If instream flow requirements for fish and wildlife are needed at ungaged locations on streams, streamflow data should be collected at the ungaged locations prior to determination of fish and wildlife instream needs. The procedure of adjusting mean monthly discharges based on a ratio of the drainage areas (as described in the Lower Ouachita Basin report of the State Water Plan <3>) is not applicable for streams in the Boeuf-Tensas Basin. One assumption of the drainage area ratio method is that streamflow yield (discharge per square mile) is uniform between different reaches of a stream. However, in the Boeuf-Tensas Basin streamflow yield may be significantly different between stream reaches due to the interchange of flow between watersheds and to the withdrawal of streamflow for irrigation use. Therefore, estimates of discharge at ungaged locations may be significantly different than actual stream discharge.

According to a report submitted to the Arkansas Soil and Water Conservation Commission by Filipek and others <11>, the recommended instream requirements as determined by the Arkansas method are designed "to maintain existing fisheries, many of which are at optimal levels". Therefore, to protect stream fisheries and to satisfy water needs for fish and wildlife in the Boeuf-Tensas 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

There are no instream flow requirements for navigation for streams in the Boeuf-Tensas Basin.

Interstate Compact Requirements

The Boeuf-Tensas Basin is included in Reach IV of the Red River Compact. This compact is an agreement among the states of Arkansas, Oklahoma, Texas, and Louisiana. The purpose of the compact is to promote comity among these participating states by cooperating in the equitable apportionment and development of the water in specific river basins as provided by the interstate compact agreements. The following information is from sections of the Red River Compact which is defined in "Arkansas Water Law" <1>.

ARTICLE VII
APPORTIONMENT OF WATER -REACH IV
ARKANSAS AND LOUISIANA

Subdivision of Reach IV and allocation of water therein.

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

SECTION 7.01. Subbasin 1 - Intrastate streams - Arkansas, reads in part as follows:

(a) This subbasin includes those streams and their tributaries above last downstream major damsites originating in Arkansas and crossing the Arkansas-Louisiana state boundary before flowing into the Red River in Louisiana. There are no major damsites designated in the Boeuf-Tensas Basin.

(b) Arkansas is apportioned the waters of this subbasin and shall have unrestricted use thereof.

SECTION 7.02. Subbasin 2 - Interstate Streams -Arkansas and Louisiana.

(a) This subbasin shall consist of Reach IV less subbasin 1 as defined in Section 7.01 (a) above.

(b) The State of Arkansas shall have free and unrestricted use of the water of this reach subject to the limitation that Arkansas shall allow a quantity of water equal to forty (40) percent of the weekly runoff originating below or flowing from the last downstream major damsite to flow into Louisiana. Where there are no designated last downstream damsites, Arkansas shall allow a quantity of water equal to forty (40) percent of the total weekly runoff originating above the state boundary to flow into Louisiana. Use of water in this subbasin is subject to low flow provisions of subparagraph 7.03 (b).

SECTION 7.03. Special Provisions.

(a) Arkansas may use the beds and banks of segments of Reach IV for the purpose of conveying its share of water to designated downstream diversions.

(b) The State of Arkansas does not guarantee to maintain a minimum low flow for Louisiana in Reach IV. However, when the use of water in Arkansas reduces the flow of the Boeuf River to 40 cfs and (or) Bayou Macon to 40 cfs at the Arkansas-Louisiana state boundary, the State of Arkansas pledges to take affirmative steps to regulate the diversions of runoff originating or flowing into Reach IV in such a manner as to permit an equitable apportionment of the runoff as set out herein to flow into the State of Louisiana.

According to the provisions outlined in the Red River Compact for Reach IV, all streams in the Boeuf-Tensas Basin are considered to be interstate streams and are subject to the interstate compact requirements. To comply with Section 7.02 (b) of the Compact, Arkansas shall allow forty percent of the total weekly runoff from these interstate streams to flow into Louisiana. The Engineering Advisory Committee to the Red River Compact Commission is in the process of determining each state's responsibilities for compliance with the compact. Although the compact compliance requirements have not been identified for Reach IV of the Red River Basin, requirements have been designated for Reach II, Subbasin 5. It is believed that similar procedures will be proposed for Reach IV.

At the present time, the amount of water required to satisfy interstate compact requirements can not be quantified for several reasons. The first reason is that compact compliance is based on a percentage of the total runoff in a basin. Runoff, as defined in the compact, includes flow in the streams and water that has been diverted from the streams for other uses. The amount of water that is diverted from streams is not accurately quantified, therefore, the amount of runoff in the basins is unknown. The second reason the interstate compact requirements can not be quantified is because the requirements are based on the previous week's streamflow and diversions. Therefore, the compact requirements change from week to week, depending on the runoff available in a basin the previous week. Using average weekly discharge for the period of record would give an idea of the weekly discharges that could be expected at a particular location. However, the compact requirements can not be determined using these data since the requirements are based on a percentage of the actual weekly runoff for a basin.

Aquifer Recharge Requirements

Recharge to the major aquifers in the Boeuf-Tensas Basin is primarily from precipitation and percolation in the outcrop area; however, some recharge to the alluvial aquifer also occurs locally along streams. Streams in the Boeuf-Tensas Basin and the alluvial aquifer are hydraulically connected and water in the aquifer and streams is part of a single integrated aquifer-stream system <5>. As a consequence, flow may alternate from the stream to the aquifer or from the aquifer to the stream depending on the head distribution in the aquifer and the stage of the stream. Therefore, some recharge to the alluvial aquifer is provided by streams in the basin as well as by precipitation and percolation.

Broom and Reed <5> and Peralta, et al <21> have estimated the amount of flow that is exchanged between the streams and the alluvial aquifer in the Boeuf-Tensas Basin. Determination of the stream-aquifer interflow has indicated that, at times, streams in the basin are sources of recharge to the aquifer. However, streams such as the Boeuf River and Bayou Macon that exhibit sustained baseflow are evidence that formations in these drainage basins are not accepting recharge from streams during dry-weather conditions. The baseflow of these streams is sustained by water that is discharged from the formations. Therefore, in these basins, there would be no aquifer recharge requirements. However, if ground water levels were drawn down below the level of the streambed, the aquifer recharge requirements would then need to be considered.

A groundwater model of the alluvial aquifer is currently being developed by the U.S. Geological Survey. This investigation will provide information on groundwater-surface water relationships, which will contribute to quantification of the aquifer recharge requirements where applicable.

Riparian Use Requirements

Section 2 of Act 1051 of 1985 requires the Arkansas Soil and Water Conservation Commission to determine surface water needs of public water supplies, industry, and agriculture. In 1985, surface water use for agriculture and industry totaled approximately 107 MGD (120,100 acre-feet/yr) of water in the Boeuf-Tensas Basin, as determined from U.S. Geological Survey file data. There was no surface water use for public water supplies in the basin in 1985. Of the total amount of surface water diverted for agriculture and industry, 7.49 MGD (8,400 acre-feet/yr) were used for livestock and fish and minnow farms, 86.3 MGD (97,100 acre-feet/yr) were used for irrigation, and 13.5 MGD (15,100 acre-feet/yr) were used for industry. These figures represent current riparian needs in the Boeuf-Tensas Basin.

The amount of water diverted from each of the major streams in the Boeuf-Tensas Basin was not determined for this 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. Because the water diverted for the uses mentioned above has already been removed from the streams and is not available, it was not included in the computations for total surface-water yield and excess streamflow of the basin.

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

Aesthetic Requirements

Instream flow requirements, as previously defined, include water that is necessary to maintain the existing in-place uses of water in or along a stream channel. Recreational activities, such as fishing and hunting, in the Boeuf-Tensas Basin represent another use of water in the streams in addition to those uses previously addressed. Instream flow requirements established for fish and wildlife (50, 60, or 70 percent of the appropriate mean monthly discharge) should be adequate to maintain fishing and hunting activities in the basin.

Current Available Streamflow

Determination of the current available streamflow in the Boeuf-Tensas Basin is necessary so that excess streamflow (that amount of water available for interbasin transfer) can be quantified. The flows required to satisfy the instream needs previously identified were compared with average annual discharges to determine the amount of streamflow that is currently available from streams in the basin. The information in Table 7 was compiled to provide a generalized summary of the current water available on an average annual basis for the two major streams in the basin. It should be noted that, for the purpose of this compilation, the instream flow requirements for the interstate compact were computed as 40 percent of the average annual discharge. The actual interstate compact requirements, however, may be significantly different than those listed in the table since the actual requirements are determined from the previous week's streamflow and diversions.

The instream flow requirements for the different categories are not additive. The highest instream need represents the amount of water required to satisfy all the existing instream needs at the two gaging stations. The instream needs for fish and wildlife were the governing instream flow requirements for both streams listed in Table 7. Therefore, to determine the amount of water that is currently available at these locations, the flows required for fish and wildlife were subtracted from the average annual discharges. On an average annual basis, 361 cfs is currently available for other uses from the Boeuf River near the state line, and 194 cfs is currently available for other uses from Bayou Macon near Kilbourne, La.. These results may, however, be somewhat misleading. Due to seasonal streamflow variability, most of the water is available during the winter and spring months with considerably less water available during the low-flow months. To illustrate the effect that streamflow variability can have on the determination of available streamflow, the streamflow that is currently available on a monthly basis was determined for the Boeuf River near the state line (Table 8) and Bayou Macon near Kilbourne (Table 9). The governing fish and wildlife instream requirements were subtracted from the mean monthly discharges to determine the streamflow available on a monthly basis. As previously determined, the Boeuf River near the state line has 361 cfs of water available for other uses on an average annual basis. However, on a mean monthly basis, the available water ranges from 93.5 cfs in August to 768 cfs in February. Similarly, the streamflow at Bayou Macon that is currently available on a monthly basis ranges from 91.5 cfs in August to 352 cfs in February. The data in Tables 8 and 9 show that the majority of the current available streamflow of the Boeuf River near the state line and Bayou Macon near Kilbourne occurs during the period of December through May.

TABLE 7
STREAMFLOW FROM THE BOEUF RIVER AND
BAYOU MACON (AT THE STATE LINE) THAT IS CURRENTLY
AVAILABLE FOR OTHER USES

	AVERAGE ANNUAL DISCHARGE (CFS)	INSTREAM FLOW REQUIREMENTS (CFS) WATER QUALITY	*FISH AND WILDLIFE	INTERSTATE COMPACTS	CURRENT AVAILABLE STREAMFLOW (CFS)
07367700 BOEUF RIVER NR ARKANSAS-LOUISIANA STATE LINE	949	1.0	588	380	361
07369700 BAYOU MACON NR KILBOURNE, LA	508	7.7	314	203	194

*GOVERNING INSTREAM FLOW REQUIREMENT WHICH REPRESENTS THE AMOUNT OF WATER REQUIRED TO SATISFY EXISTING NEEDS AT THE TWO GAGING STATIONS.

TABLE 8

STREAMFLOW FROM THE BOEUF RIVER (NEAR THE STATE LINE) THAT IS CURRENTLY AVAILABLE ON A MONTHLY BASIS FOR OTHER USES

	MEAN MONTHLY DISCHARGE (CFS)	INSTREAM FLOW REQUIREMENTS (CFS) CURRENT WATER QUALITY	*FISH AND WILDLIFE	INTERSTATE COMPACTS	AVAILABLE STREAMFLOW (CFS)
OCTOBER	228	1.0	114	91.2	114
NOVEMBER	813	1.0	488	325	325
DECEMBER	1118	1.0	671	447	447
JANUARY	1429	1.0	857	572	572
FEBRUARY	1919	1.0	1151	768	768
MARCH	1513	1.0	908	605	605
APRIL	1340	1.0	938	536	402
MAY	1474	1.0	1032	590	442
JUNE	415	1.0	290	166	125
JULY	338	1.0	169	135	169
AUGUST	187	1.0	93.5	74.8	93.5
SEPTEMBER	687	1.0	344	275	343

*GOVERNING INSTREAM FLOW REQUIREMENT WHICH REPRESENTS THE AMOUNT OF WATER REQUIRED TO SATISFY EXISTING NEEDS

TABLE 9

STREAMFLOW FROM BAYOU MACON NEAR KILBOURNE, LA THAT IS CURRENTLY AVAILABLE ON A MONTHLY BASIS FOR OTHER USES

	MEAN MONTHLY DISCHARGE (CFS)	INSTREAM FLOW REQUIREMENTS (CFS) WATER QUALITY	*FISH AND WILDLIFE	INTERSTATE COMPACTS	CURRENT AVAILABLE STREAMFLOW (CFS)
OCTOBER	216	7.7	108	86.4	108
NOVEMBER	317	7.7	190	127	127
DECEMBER	555	7.7	333	222	222
JANUARY	683	7.7	410	273	273
FEBRUARY	879	7.7	527	352	352
MARCH	832	7.7	499	333	333
APRIL	745	7.7	522	298	223
MAY	833	7.7	583	333	250
JUNE	357	7.7	250	143	107
JULY	242	7.7	121	96.8	121
AUGUST	183	7.7	91.5	73.2	91.5
SEPTEMBER	274	7.7	137	110	137

*GOVERNING INSTREAM FLOW REQUIREMENT WHICH REPRESENTS THE AMOUNT OF WATER REQUIRED TO SATISFY EXISTING NEEDS

The current available streamflows computed in Tables 7, 8, and 9 do not represent the amount of water that is available for interbasin transfer. Before interbasin transfer of water can be considered, the projected water needs of the basin must be addressed. The previous determinations of current available streamflow do not account for the projected water needs of the basin because data identifying the projected water needs for individual streams in the basin are not currently available. However, the projected water needs of the entire basin have been estimated and are accounted for in the excess streamflow section of the report for the determination of the total amount of water in the Boeuf-Tensas Basin that is available for interbasin transfer.

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. A minimum streamflow is established to protect instream needs, particularly during low-flow conditions which may occur naturally or during periods of significant use from the stream. The minimum streamflow also represents a critical low-flow condition below which some minimum instream need will not be met. The minimum streamflow is not a target level or a flow that can be maintained for an extended period of time without serious environmental consequences. Therefore, the minimum streamflow also represents the discharge at which all withdrawals from the stream will cease. Because of the critical low-flow conditions which may exist at the minimum streamflow level, allocation of water based on the establishment of water-use priorities should be in effect long before this point is reached. Allocation of water should help to maintain streamflow above the established minimum discharge.

Minimum streamflows for streams in the Boeuf-Tensas Basin were determined based on the instream flow requirements as previously described in the report with the exception of fish and wildlife requirements. The instream flow requirements for fish and wildlife were re-evaluated to determine instream needs that represent minimum conditions. This was necessary because recommended instream flow requirements for fish and wildlife using the Arkansas Method (Arkansas Game and Fish Commission) are viewed as representing desirable conditions and not minimum instream flow needs.

To determine minimum instream flow requirements for fish and wildlife, the following procedure was used. Tennant <25> 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. However, to account for the seasonal variability of streamflow in the basin, the year was divided into three seasons as identified in the Arkansas Method <10>. The minimum instream flow requirements for fish and wildlife were then established for each of the three seasons as the discharge that is equal to 10 percent of the average seasonal flows.

In addition to requirements for fish and wildlife, instream flow requirements for water quality, navigation, interstate compacts, aquifer recharge, and aesthetics were also considered in the determination of minimum streamflows. Because 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 selected locations in the basin and are presented in Table 10. It should be noted that the discharges required to meet water-quality standards have not been quantified for most streams in the basin. However, the water-quality instream flow requirements for two gaging station locations in the basin have been quantified and were significantly lower than the instream flow requirements for fish and wildlife at the two locations. Therefore, it was assumed that the water-quality requirements would not be the governing instream requirements at the other locations listed in Table 10. The instream flows required to satisfy the interstate compact were also not quantified for the reasons previously explained in the instream flow requirements section of the report. Therefore, the minimum streamflows in the Boeuf-Tensas Basin are those flows that appear in Table 10 or 40 percent of the weekly runoff, whichever is greater. The instream flows required for interstate compact compliance may be the governing instream flow requirement for streams in the basin throughout much of the year.

The minimum streamflows established for two gaging station locations in the basin were compared with daily discharge data for the period of record to analyze the frequency that streamflow at the two locations has been less than the minimum streamflows. As shown in Figure 3, the flow of Bayou Macon near Kilbourne, LA for the period of record (1958-68) was generally higher than the minimum flow established for July thru October. In fact, the flow of Bayou Macon has been less than the minimum streamflow during the period of July-October only approximately one percent of the time for the period of record. The minimum streamflows established for Bayou Macon for the other two seasons were less than the median daily discharge and, at times, were less than the minimum daily discharge for the period of record at the gaging station.

Comparison of daily discharge data for the period of record with minimum streamflows for the Boeuf River near the Arkansas-Louisiana state line (Figure 4) showed similar results for most months of the year. However, the minimum streamflow for November was generally higher than the median daily discharge for the period of record. This indicates that at least 50 percent of the time for the period of record, flow of the Boeuf River during November was less than the minimum streamflow established. The percentage of time that the minimum streamflows at these two locations have been exceeded during the period of record is shown in Table 11.

The establishment of minimum streamflows may have significant effects on the different water users in the basin. Agricultural riparian users will be affected by the establishment of minimum streamflows if streamflow levels are below the minimum streamflows for extended periods of time. In such cases, water must either be conserved or storage reservoirs must be constructed in anticipation of the times when the flow of a stream falls below the minimum level. Instream water uses will also be affected by the establishment of minimum streamflows. Although some level of flow protection will be beneficial to fish and wildlife, minimum streamflows are clearly not desirable conditions.

TABLE 10
MINIMUM STREAMFLOW BY SEASON IN THE BOEUF-TENSAS BASIN

STATION NUMBER	STATION NAME	SEASON NOV-MAR (CFS)	SEASON APR-JUN (CFS)	SEASON JUL-OCT (CFS)
07367656	CANAL 19 NEAR DUMAS	30	28	10
07367659	CANAL 19 NEAR ARKANSAS CITY	44	37	11
07367660	DIVERSION CANAL, BOEUF RIVER AT MACON LAKE	36	29	7.4
07367661	BOEUF RIVER NEAR LAKE VILLAGE	47	36	11
07367662	BLACK POND SLOUGH NEAR McGEHEE	2.6	1.6	0.7
07367663	BIG BAYOU NEAR DERMOTT	13	8.3	2.4
07367664	BIG BAYOU NEAR LAKE VILLAGE	20	14	4.6
07367700	BOEUF RIVER NEAR ARKANSAS-LOUISIANA STATE LINE	136	108	36
07369650	CANAL 81 NEAR ARKANSAS CITY	35	29	17
07369655	CANAL 43 NEAR ARKANSAS CITY	31	24	6.2
07369670	DITCH BAYOU NEAR LAKE VILLAGE	88	90	26
07369700	BAYOU MACON NEAR KILBOURNE, LOUISIANA	65	64	23

figure 3
COMPARISON OF SEASONAL MINIMUM STREAMFLOW WITH MINIMUM AND MEDIAN DAILY DISCHARGE
OF BAYOU MACON NEAR KILBOURNE, LOUISIANA FOR THE PERIOD OF RECORD (1958-1968)

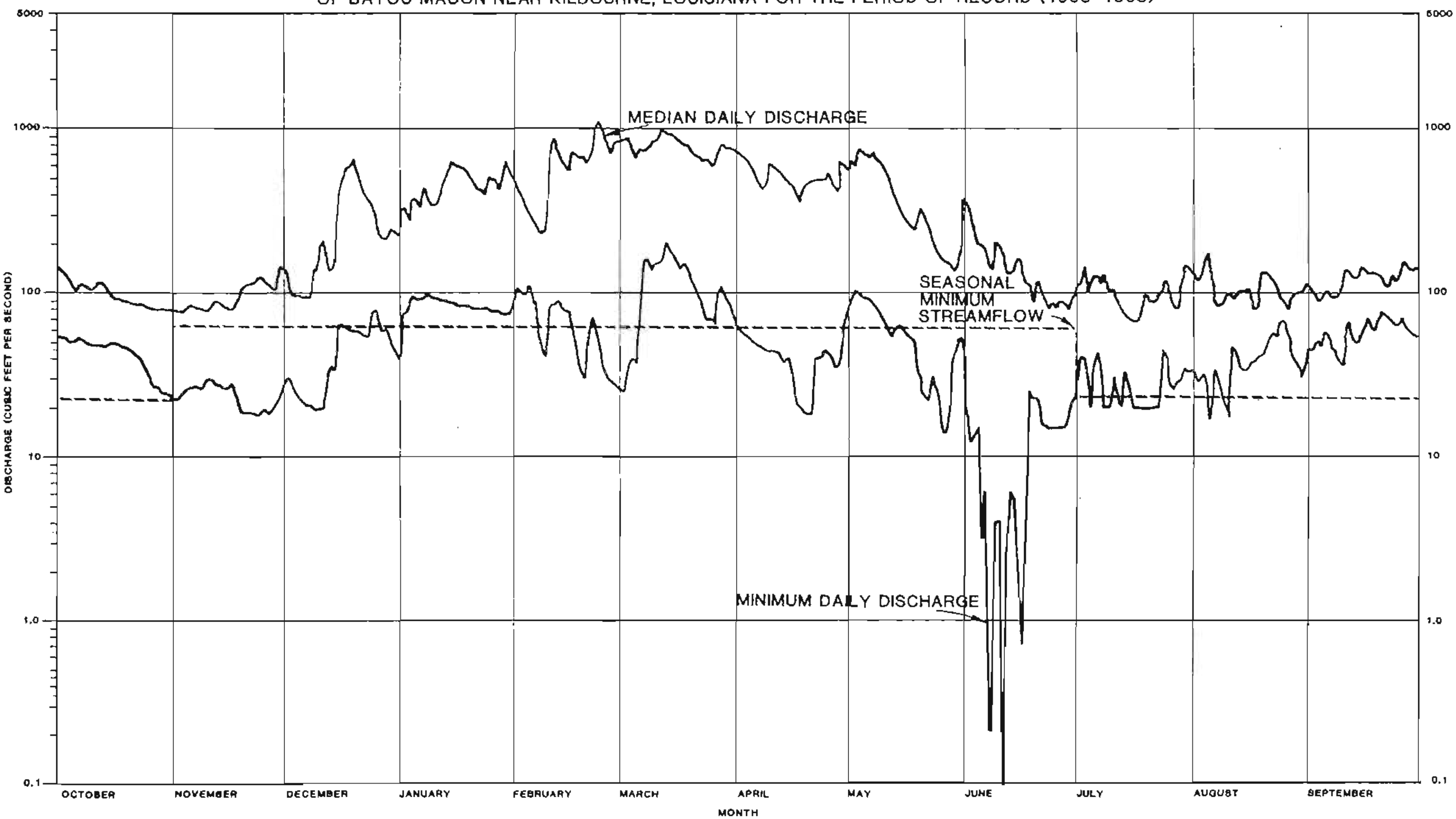


figure 4

COMPARISON OF SEASONAL MINIMUM STREAMFLOW WITH MINIMUM AND MEDIAN DAILY DISCHARGE OF THE BOEUF RIVER NEAR THE ARKANSAS-LOUISIANA STATE LINE FOR THE PERIOD OF RECORD (1958-1968)

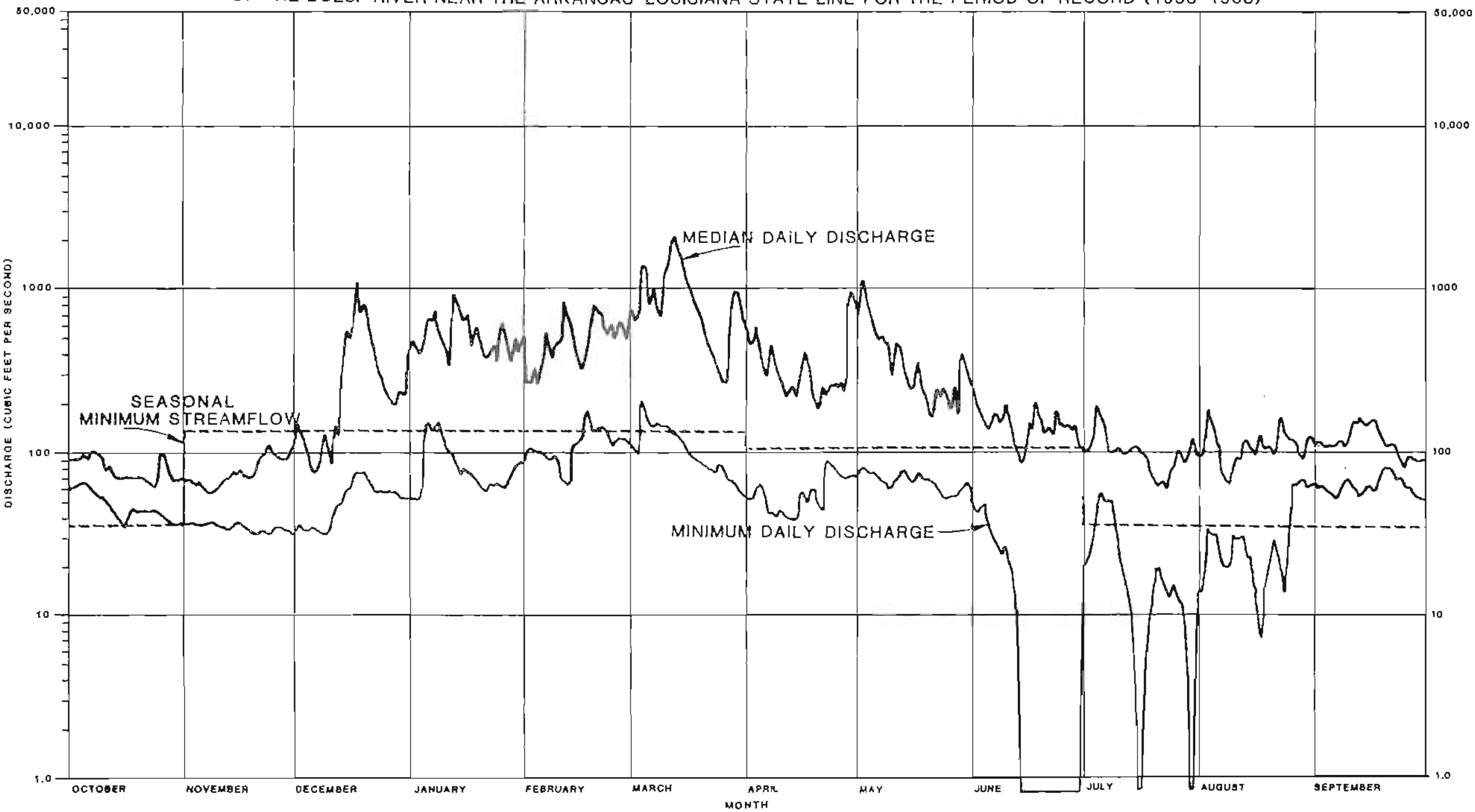


TABLE 11

PERCENT OF TIME THAT DISCHARGES FOR TWO SITES IN THE BASIN EXCEED THE SEASONAL MINIMUM STREAMFLOWS

STATION		PERCENT OF TIME DISCHARGE EXCEEDED MINIMUM STREAMFLOW, BY SEASON		
NUMBER	NAME	NOV-MAR	APR-JUN	JUL-OCT
07367700	BOEUF RIVER NEAR THE ARKANSAS-LOUISIANA STATE LINE	70%	76%	94%
07369700	BAYOU MACON NEAR KILBOURNE, LOUISIANA	90%	86%	99%

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 on a dependable basis which could be used as a surface-water supply.

Seasonal and annual variability of streamflow affect the dependability of water available for development. Flow-duration curves, which show the percentage of time that specified discharges have been equaled or exceeded indicate the dependability of streamflow available at a particular location based on the period of record. As previously discussed, flow-duration curves for the Boeuf River and Bayou Macon have been developed by Broom and Reed <5> with the data summarized in Table 4. To quantify the safe yield of streams in the basin, the amount of water available on a dependable basis has been designated as the discharge which has been equaled or exceeded 95 percent of the time for the available period of record. This flow represents the discharge which can be expected at selected stream locations on a dependable basis, however, not all of this flow is actually available for use. Minimum streamflows, which have been established for streams in the Boeuf-Tensas Basin and have been previously defined in the report, represent discharge that is not available for use. Therefore, the safe yield of a stream or river is defined as the discharge which can be expected 95 percent of the time minus the discharge necessary to maintain the minimum flow in the stream during the low-flow season (July-October). The safe yield was computed for the Boeuf River and Bayou Macon with the following results:

07367700 - BOEUF RIVER NEAR THE AR-LA STATE LINE

43 CFS = FLOW WHICH WAS EQUALED OR EXCEEDED 95% OF THE TIME
- 36 CFS = MINIMUM STREAMFLOW (JULY-OCTOBER)
7 CFS = SAFE YIELD

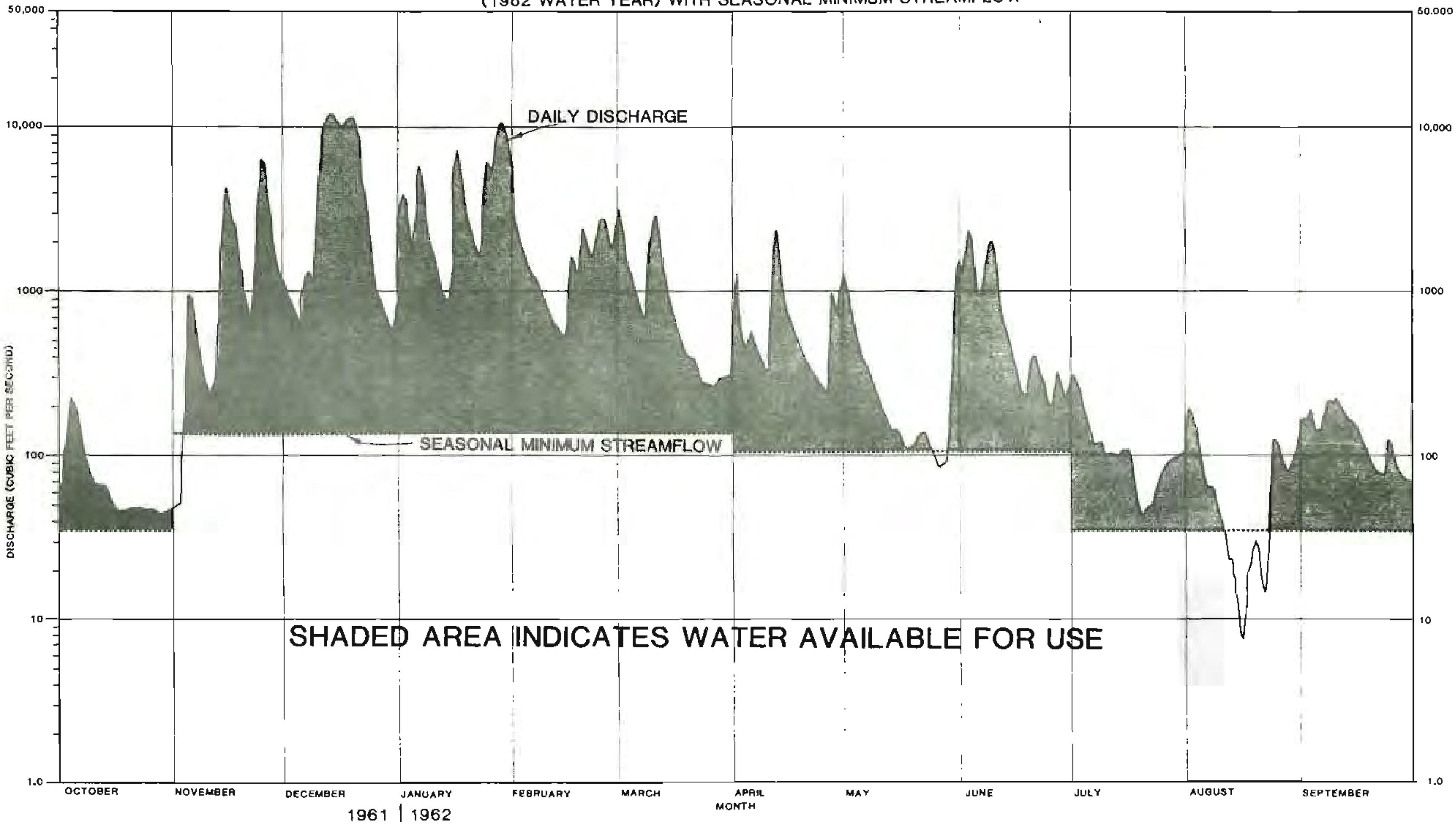
07369700 - BAYOU MACON NEAR KILBOURNE, LA

40 CFS = FLOW WHICH WAS EQUALED OR EXCEEDED 95% OF THE TIME
- 23 CFS = MINIMUM STREAMFLOW (JULY-OCTOBER)
17 CFS = SAFE YIELD

The above computations of safe yield indicate that there is relatively little water available from the two major streams in the basin for additional development without storage. A tremendous amount of water is lost when the utility of a stream such as the Boeuf River is based on a safe yield of 7 cfs. This is illustrated in Figure 5 in which the shaded area between the daily discharge (1962 water year) and the seasonal minimum streamflow represents the water available for use from the Boeuf River during one selected water year.

figure 5

COMPARISON OF DAILY DISCHARGE FOR THE BOEUF RIVER NEAR THE ARKANSAS-LOUISIANA STATE LINE (1962 WATER YEAR) WITH SEASONAL MINIMUM STREAMFLOW



In order to assess the amount of water that is potentially available for future development in the Boeuf-Tensas Basin, the potential development for the Boeuf River and Bayou Macon was estimated based on the mean annual discharge with the following results:

	(1) MEAN ANNUAL DISCHARGE (CFS)	POTENTIAL DEVELOPMENT (2) 0.60 X (1) (CFS)	(3) 0.6463 X (2) (MGD)
07367700 BOEUF RIVER NEAR ARK-LA STATE LINE	949	569	368
07369700 BAYOU MACON NEAR KILBOURNE, LA	508	305	197

Article VII of the Red River Compact requires that "Arkansas shall allow a quantity of water equal to 40 percent of the weekly runoff originating below or flowing from the last downstream major damsites" to flow into Louisiana. In order to determine the potential development, a quantity of water equal to 40 percent of the mean annual discharge is estimated to be necessary to satisfy interstate compact requirements and other instream needs. Therefore, the remaining 60 percent of the mean annual discharge is potentially available for development.

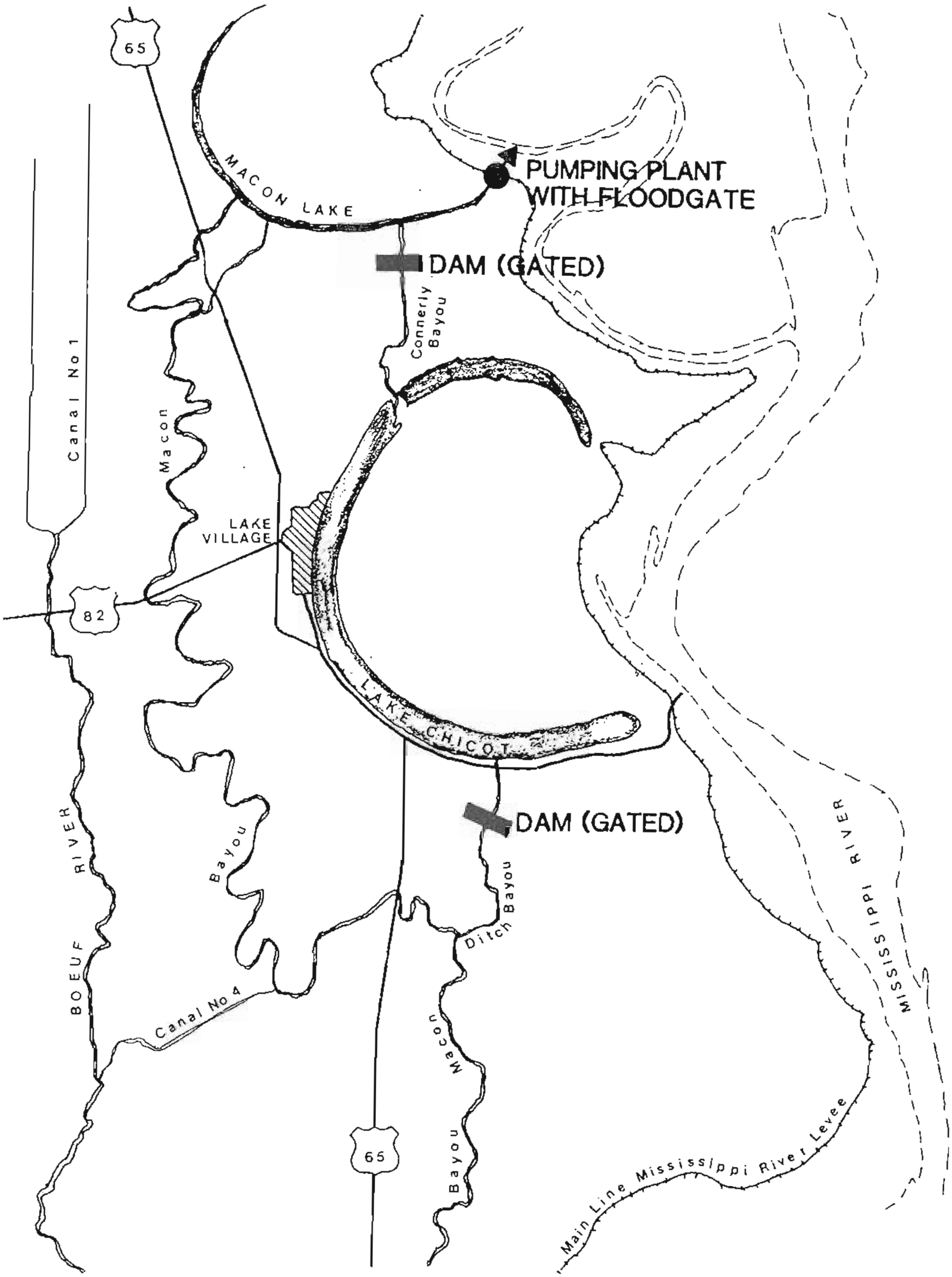
Approximately 565 MGD of water is potentially available from the Boeuf-Tensas Basin. The water available for use must be stored during the high-flow winter months for later use during the irrigation season. However, due to the topography of the Boeuf-Tensas Basin, there are no suitable sites for construction of large-scale

impoundments to store the available water.

Lake Chicot

Lake Chicot, an oxbow lake located in Chicot County adjacent to the Mississippi River, is the largest natural lake in Arkansas. The lake is approximately 13 miles long and one-half mile wide with an average depth of about 20 feet. <26> Lake Chicot receives little inflow from areas immediately adjacent to the lake because it is surrounded by a natural levee. However, Connerly Bayou, which carries the runoff from approximately 350 square miles, drains into the northern part of Lake Chicot (See Figure 6). The upper one-fourth of the lake is separated from the remainder of the lake and receives only limited inflow due to the presence of a dam constructed by the Arkansas Game and Fish Commission just above the mouth of Connerly Bayou. At the southern end of the lake, outflow from the lake discharges into Ditch Bayou.

figure 6
LAKE CHICOT PROJECT



SOURCE: Modified from U.S. Army Corps of Engineers, Vicksburg District, 1966 ⟨26⟩

Prior to the 1920's, Lake Chicot was an attractive setting for water-based recreation. Since that time, clearing of the land for row crops, construction of levees, and other events have led to a significant increase in the turbidity of the lake. The inflow of fine suspended sediment from Connerly Bayou into Lake Chicot has caused a significant change in the appearance, the ecology, and the recreational use of the lake. In an attempt to remedy the degradation of Lake Chicot, Section 203 of the Flood Control Act of August 13, 1968 authorized the Corps of Engineers to construct a pumping plant and related works to reduce the turbidity of the lake and to stabilize the lake level. <27>

The Lake Chicot project (See Figure 6) was designed to improve the water quality of the lake by diverting turbid inflows from Connerly Bayou to the Mississippi River. Inflows to the lake from Connerly Bayou are controlled by two sluice gates in the Connerly Bayou structure. The turbid inflows are diverted away from Lake Chicot by closing the Connerly Bayou gates and directing the water to the Lake Chicot pumping plant. The plant discharges the diverted water into an abandoned Mississippi River channel. During low stages on the Mississippi River, water flows by gravity through the gates in the pumping plant. When stages on the Mississippi River are higher than the diverted flows, the gates are closed and a combination of 12 pumps with a total capacity of 6,500 cfs are used to lift the water over the levee. The gated dam in Connerly Bayou has a crest elevation of 116 feet NGVD which allows water to flow over the dam and into Lake Chicot when the discharge to the pumping plant exceeds the capacity of the plant. The gates can also be opened to allow inflow to Lake Chicot when desirable. The water level in Lake Chicot is regulated by the Ditch Bayou control structure at the southern end of the lake. Two sluice gates allow for downstream releases for irrigation. The 200-foot weir has a crest elevation of 106 feet NGVD which allows flood flows out of the lake. <24,27>

The objective of the current management strategy for Lake Chicot is to optimize outflows through Ditch Bayou while maintaining a relatively stable lake stage and reducing the water-quality degradation of the lake. Water-quality conditions of Connerly Bayou are currently monitored to determine when inflow to Lake Chicot should be diverted away from the lake. According to the authorized plan developed by the Corps of Engineers <26>, downstream releases of water through the Ditch Bayou structure during low-flow conditions should sustain the base flow of Ditch Bayou and Bayou Macon.

Excess Streamflow

Excess streamflow (defined in Section 5 of Act 1051 of 1985) is twenty-five percent of that amount of water available on an average annual basis above the amount required to satisfy the existing and projected water needs of the basin. In order to determine the excess streamflow in the Boeuf-Tensas Basin, the amount of water in the streams and rivers on an average annual basis was first calculated based on U.S. Geological Survey streamflow data. Mean annual discharge at the Arkansas-Louisiana state line was estimated for the two major streams in the basin (Boeuf River and Bayou Macon) based on streamflow data for two gaging stations in Louisiana. Mean annual discharge for the remaining ungaged area of the basin was estimated based on data for gaging stations on the Boeuf River and Bayou Macon. The sum of all estimated mean annual discharges at the state line indicated a surface-water yield of approximately 1.12 million acre-feet of water from the streams and rivers of the Boeuf-Tensas Basin on an average annual basis.

To determine the excess streamflow in the basin, the surface-water yield of 1.12 million acre-feet must be adjusted to account for the water needed to satisfy existing water needs for instream flow requirements. Because the instream flow requirements are not additive, the highest instream need represents the amount of water required to satisfy all the existing instream needs. The instream flow requirements for fish and wildlife were previously identified in the Current Available Streamflow section of the report as the governing instream need for the Boeuf River and Bayou Macon. Therefore, from Table 7, 902 cfs or approximately 0.65 million acre-feet of water is necessary to maintain instream flow requirements in the basin on an average annual basis.

Projected surface-water needs of the basin must also be satisfied prior to determination of the amount of water that is available for other uses. In 1980, the total water use of the basin (ground water and surface water) amounted to approximately 400 MGD <2>. It has been estimated that by the year 2030 a total of approximately 1110 MGD of water will be required to meet the needs of water users in the basin <2>. In order to determine the projected surface-water needs only, it has been assumed that surface water sources will have to supply most of the water necessary to satisfy the increased demand for water in the future. Therefore, based on this premise, it was estimated that approximately 840 MGD or 0.94 million acre-feet of water will be necessary for future surface-water needs in the basin.

The available surface water in the Boeuf-Tensas Basin was calculated by subtracting the flow necessary to satisfy instream flow requirements (0.65 million acre-feet) and projected surface-water needs of the basin (0.94 million acre-feet) from the 1.12 million acre-feet of water in the basin resulting in a -0.47 million acre-feet of water. This indicates that, on an average annual basis, there is no available surface water in the basin. Therefore, there is no excess streamflow available for other uses, such as interbasin transfer. In fact, the previous computations estimated a surface-water deficit of approximately 470,000 acre-feet per year indicating that the surface-water yield of the Boeuf-Tensas Basin is projected to be inadequate to satisfy even the needs of the users within the basin. In addition, the surface-water deficit may be even more significant than the estimated 470,000 acre-feet per year depending on the amount of water that is diverted from Lake Chicot out of the basin to the Mississippi River (see Lake Chicot section).

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.

The two principal streams in the Boeuf-Tensas Basin, the Boeuf River and Bayou Macon, have been designated as critical surface water areas based on quantity problems. Pumping for irrigation has, at times in the past, contributed to no-flow conditions for the Boeuf River and Bayou Macon as indicated by historic streamflow records for the period of 1958-68 <6>. Current streamflow conditions of the Boeuf River and Bayou Macon are not well defined because continuous streamflow data are no longer collected at gaging stations on the two streams. However, since surface water use in the Boeuf-Tensas Basin has increased from approximately 32 cfs in 1965 <14> to approximately 161 cfs in 1985 (USGS file data), it can be assumed that present streamflow may also be inadequate at times to satisfy the present surface-water needs of the basin.

It is anticipated that within the next thirty years the quantity of water in the Boeuf River and Bayou Macon will also be inadequate to satisfy surface-water demands due to a significant increase in total water use that is projected for the basin <2>. In order to estimate the potential streamflow deficiency in the basin, the projected surface-water needs for the Boeuf River and Bayou Macon were estimated and then compared with flow-duration curves as shown in Figures 7 and 8. Figure 7 shows that the projected surface water needs in 2030 are equivalent to a flow rate that is equaled or exceeded only 25 percent of the time. This indicates that the flow of the Boeuf River will be inadequate approximately 75 percent of the time to satisfy projected surface-water needs. A comparison of similar data for Bayou Macon in Figure 8 indicates that the flow of Bayou Macon will be inadequate approximately 70 percent of the time to satisfy projected needs in the basin. It is apparent from these data that the Boeuf River and Bayou Macon will not provide an adequate amount of water to supply future needs of the basin.

figure 7

PROJECTED SURFACE-WATER USE COMPARED TO AVAILABILITY IN THE BOEUF RIVER BASIN

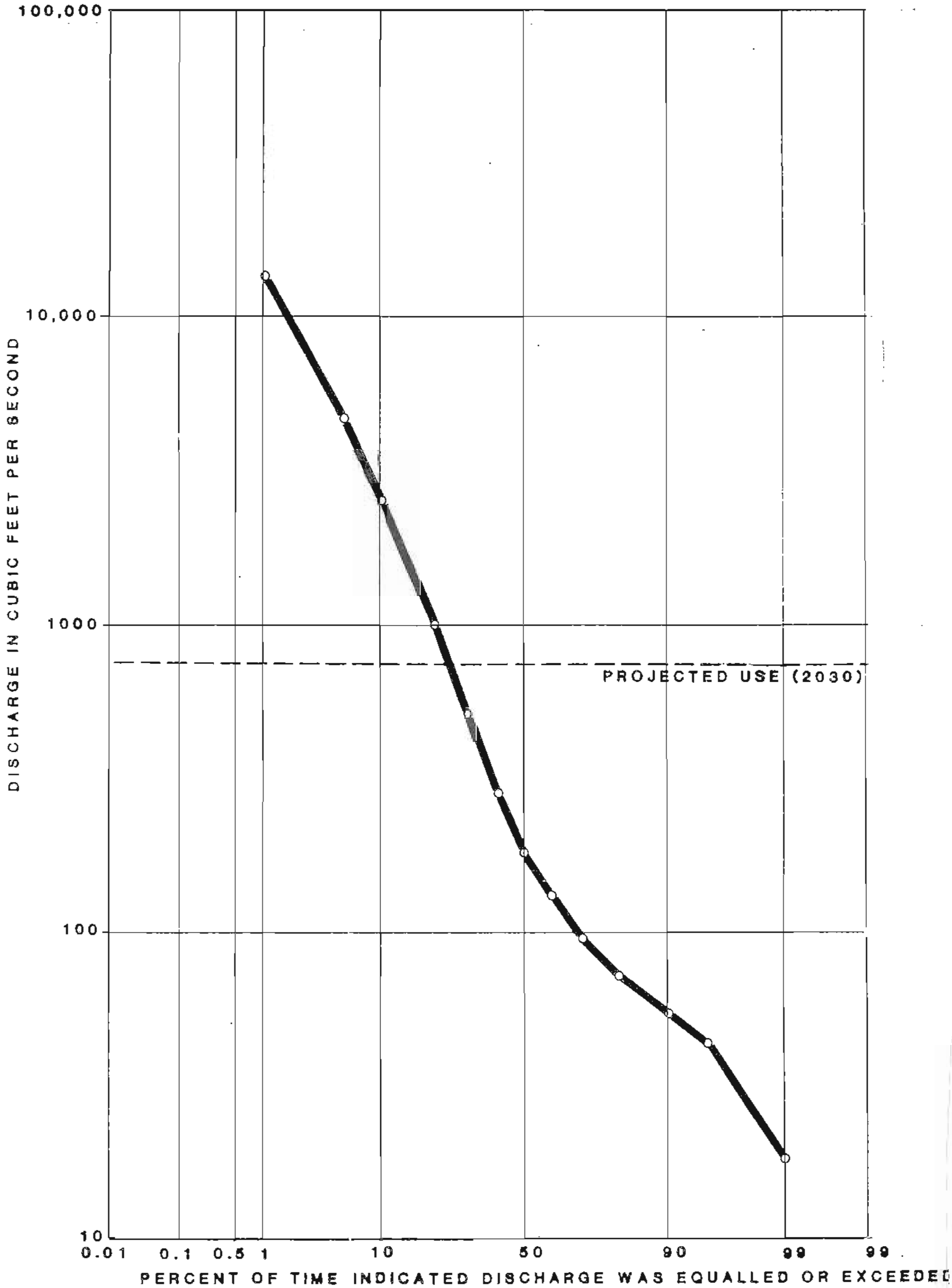
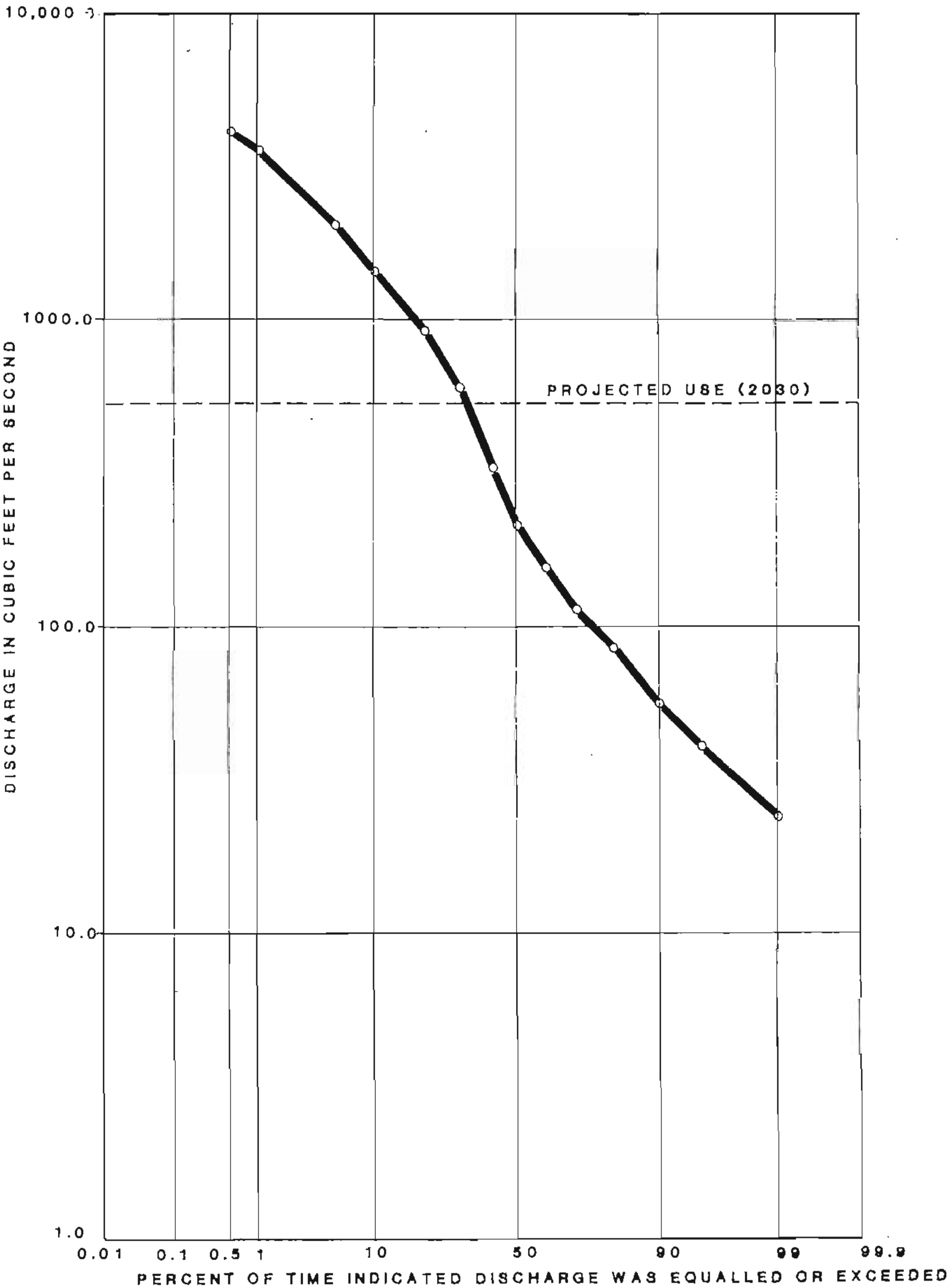


figure 8

PROJECTED SURFACE-WATER USE COMPARED TO AVAILABILITY IN THE BAYOU MACON BASIN



GROUND WATER

Quaternary alluvium and terrace deposits are present on the surface as an outcrop in the Boeuf-Tensas Basin. Formations of the Tertiary system are found only in the subsurface of the basin. Quaternary and Tertiary sediments are composed of lignite, clay, silt, sand, and gravel which are present in layers dipping generally to the southeast. Geologic units of the Boeuf-Tensas Basin are described in more detail in the following section. See Table 12 for a generalized stratigraphic column of the basin.

Ground water is found in great abundance in the Boeuf-Tensas Basin. Among the geologic units in the basin, only three are used as sources of ground water. These formations are the Quaternary alluvium, Cockfield Formation, and Sparta Sand. The primary factor limiting ground water use in the basin is water-quality degradation. In the southern half of the basin, the three major aquifers contain water with excessively high concentrations of chloride. Only a small part of the northern half of the basin is contaminated, but saline water intrusion threatens to migrate into this area also.

Quaternary Alluvium

Geology

The Boeuf-Tensas Basin is underlain by alluvial deposits which are Quaternary in age. The alluvium consists of clay, silt, sand, and gravel which is deposited by streams within the basin. The upper strata of the alluvium consist of clay, silt, and fine sand. The sediments become coarser with depth so that the lower strata are generally composed of coarse sand and gravel. <18,31,5>

Much of the gravel in the basin was deposited by glacial runoff during the Pleistocene Epoch of the Quaternary period. As glacial melting occurred in the northern Mississippi River Valley, sea levels began to rise and stream gradients decreased. Stream capacity lessened and caused the aggradation of the sediment load. These sediments consisting of clay, silt, sand, and gravel were deposited as terraces in which the sediments become coarser with increasing depth. Later glacial and fluvial activity eroded and redeposited many of these terraces. Terrace deposits which have not been eroded, remain at higher elevations than the surrounding alluvial material. This can be seen where the terrace deposits are exposed in southeastern Chicot County along Caney Bayou. <23,12>

The Quaternary alluvium is the uppermost layer of the Boeuf-Tensas Basin. It is underlain by the Jackson Group which is a confining bed of clay and fine sand. The gravel deposits at the bottom of the alluvium mark the base of the Quaternary System. The alluvium varies in thickness from less than 25 ft. to greater than 150 ft. The thickness varies depending on the erosional surface of the Jackson Group underneath the alluvium. <21,31,4>.

The surface of the alluvium is directly affected by erosion, sediment aggradation, and the activities of man. The base of the alluvium rests on the erosional surface of the Jackson Group.

The contact between the alluvium and the Jackson Group may also be affected the Desha Basin which is shown in Figure 9. The axis of the Desha Basin runs southeast to northwest through Desha County. All in the vicinity of the Desha Basin

TABLE 12

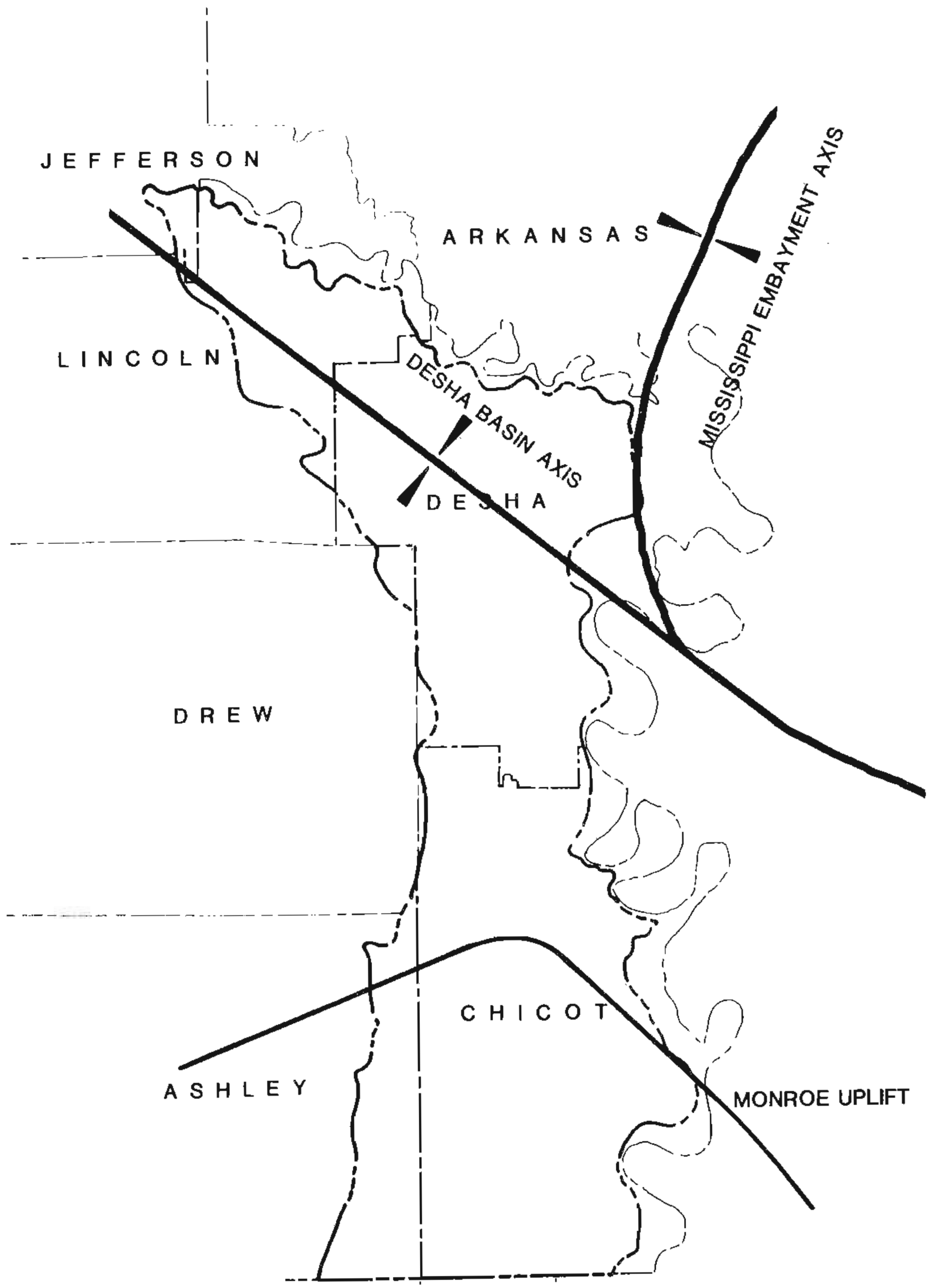
Generalized stratigraphic column of units containing fresh water

Erathem	System	Series	Group	Formation	Description	Water Supply
	Quaternary	Holocene and Pleist-ocene		Alluvium and terrace deposits	Alluvial floodplain and terrace deposits;gravel at base,grading upward to sand,silt, and clay at the surface. Maximum thickness about 200 feet in the Mis-sissippi Alluvial Plain.	Sand and gravel in the alluvial and terrace deposits comprise extensive aquifers throughout most of the Mississippi Alluvial Plain. Commonly yields 1,000 to 3,000 gallons per minute of water to wells.
Cenozoic			Jackson		Chiefly composed of clay, some lenses of fine sand. Maximum thickness about 300 feet. Confining bed.	Non-water bearing.
				Cockfield Formation	Fine lignitic sand and car-bonaceous clay; Maximum thickness less than 300 feet.	Mainly a source of domestic water supply. Locally yields up to 40C gallsons per minute of water to wells.
	Tertiary	Eocene		Cook Mountain Formation	Carbonaceous clay and some lenses of fine lignitic sand Maximum thickness about 150 feet. Confining bed.	Non-water bearing.
			Clai-borne	Sparta Sand	Fine to medium sand, some interbeds of clay. Maximum thickness nearly 900 feet.	Principal source of municipal an industrial water supply in its a of occurrence. Commonly yields 1.000 gallons per minute of wate
				Cane River Formation	Interbedded sand and clay in updip areas, mostly clay in downdip areas. Maximum thick-nees nearly 800 feet. Rela-tively uniform confining bed in downdip areas.	Source of water supply in and ne its outcrop area. Gensrally yie less than 500 gallons per minute

Source: Petersen, Broom, and Bush (22)

figure 9

GENERALIZED STRUCTURE OF THE BOEUF-TENSAS BASIN



Source: Modified from Petersen, Broom and Bush. ⟨22⟩

dip slightly toward the axis. The southern flank of this sycline dips to the northeast, away from the Monroe uplift which is located in the vicinity of the Arkansas-Louisiana State Line in the Boeuf-Tensas Basin. <22>.

Hydrology

The alluvial aquifer commonly yields 1,000 to 2,000 GPM to wells, with yields of as much as 5,000 GPM possible. Optimum yields are obtained from wells in the gravel deposits at the base of the alluvium, due to the high porosity and permeability of the gravel. Despite the fact that the alluvial strata are relatively thin and seldom exceed 150 ft., the saturated thickness is greater than 80 percent throughout the basin. This also contributes to the high yields of water to wells. <18,31>

In the Boeuf-Tensas Basin, the depth to water is about 20 ft. below land surface. This depth shows the water table to be at the approximate bottom of the clay cap. <31,23>

From 1981 to 1986, ground water levels in the alluvium generally have declined less than 2 ft. (See Figure 10) However, in the northwestern part of the basin and in western Chicot County declines of 2 to 6 ft. have been detected as shown in Figure 11. <23,9>

The saturated thickness of the alluvial aquifer in the basin is illustrated in Figure 12. The percent saturated thickness varies from 70 percent to 90 percent. The greatest saturated thickness occur along the eastern and northeastern boundaries of the basin. This is attributed to recharge from the Arkansas and Mississippi Rivers to the aquifer. <31>

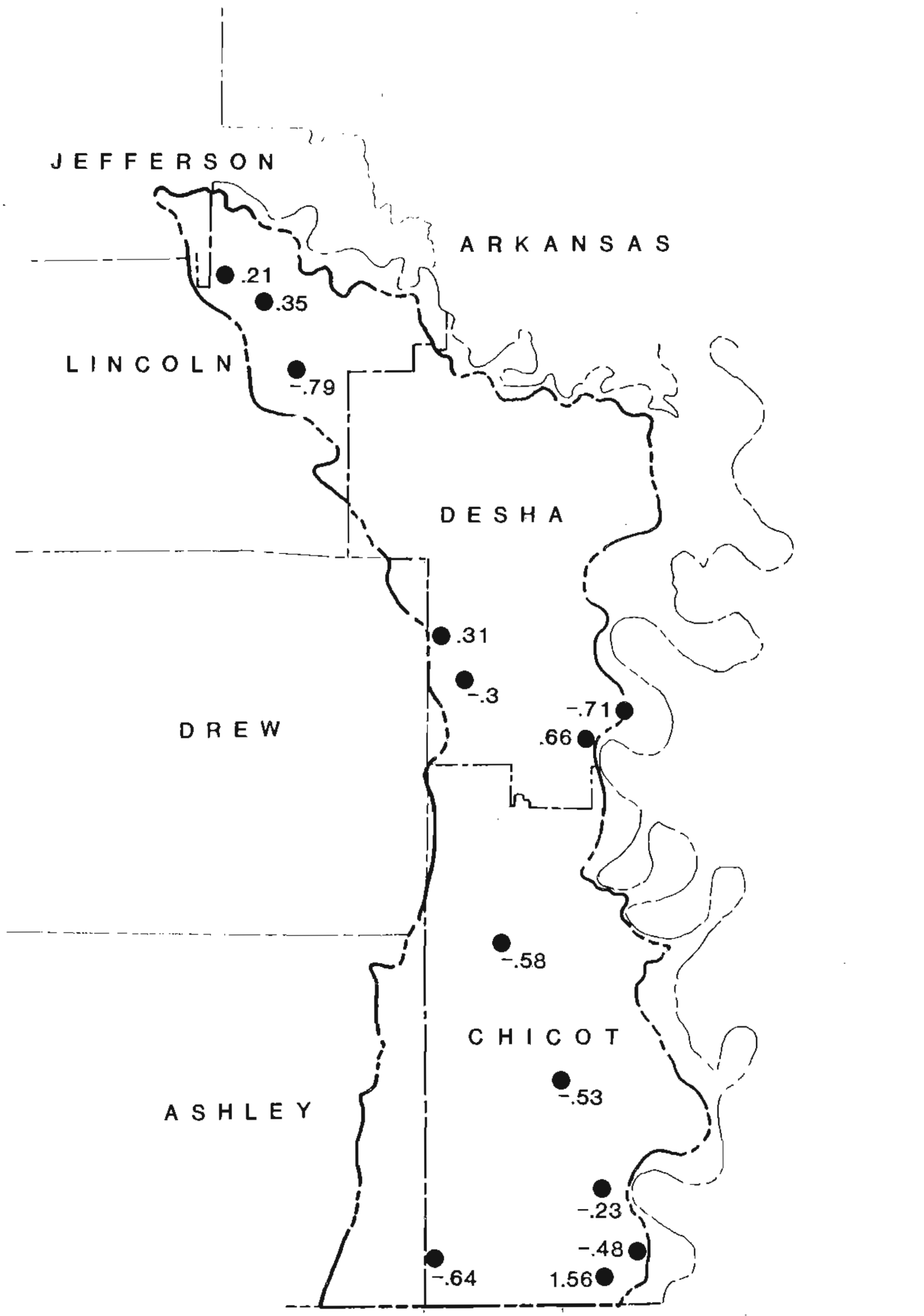
Ground water flow in the alluvium of the Boeuf-Tensas Basin is in the direction of general land slope. The hydraulic gradient is oriented toward areas where concentrated pumping has developed a cone of depression. These cones of depression are present only on a local basis in the basin. The ground water flow is also oriented toward streams during the low-flow season when streams receive water from the aquifer. The Quaternary alluvium is under water-table conditions; however, most of the area is covered by a clay cap which is approximately 20 ft. thick. This layer of highly impermeable clay acts as a confining bed where it is present, and it inhibits ground water recharge from precipitation. <22>

Recharge from streams within the basin is a major contributor of water to the aquifer. Data in Table 13 show that the Boeuf River contributes an average of 6,700 acre-ft. of water per year to the alluvial aquifer. Though Bayou Bartholomew is located just west of the Boeuf-Tensas Basin, it's contribution of 9,800 acre-ft. of water per year to the alluvial aquifer is a great source of recharge to this strata in both the Lower Ouachita and Boeuf-Tensas Basins. Bayou Macon is a discharge area for the alluvial aquifer receiving an average of 4,000 acre-ft. of water per year from the alluvium. All streams mentioned have yielded much higher amounts of water to the alluvial aquifer in selected maximum years. <21,22>

Recharge to the alluvium can also occur from the underlying Tertiary aquifers. The Cockfield and Sparta aquifers are both under artesian pressure, and vertical recharge to the overlying alluvium can occur if a conduit is established through the Tertiary confining beds. This can occur in areas where the confining beds are unusually thin or absent, where faulting has taken place, or where improperly constructed wells connect all aquifers present in the subsurface. <22>

figure 10

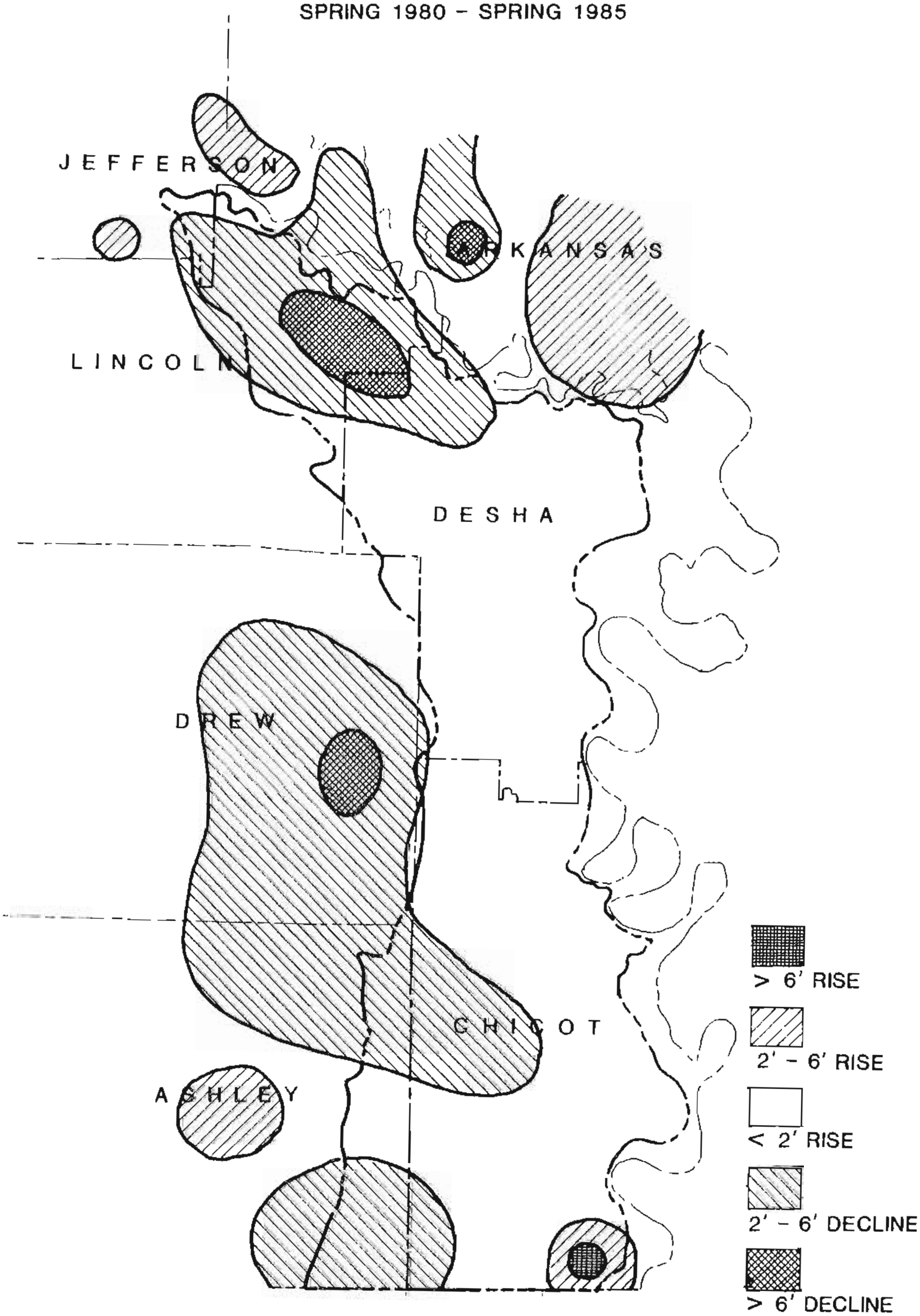
AVERAGE ANNUAL WATER LEVEL CHANGES IN THE ALLUVIAL AQUIFER
1981-1986



SOURCE: Edds and Remsing, Open File Report #86-406 ⟨9⟩

figure 11

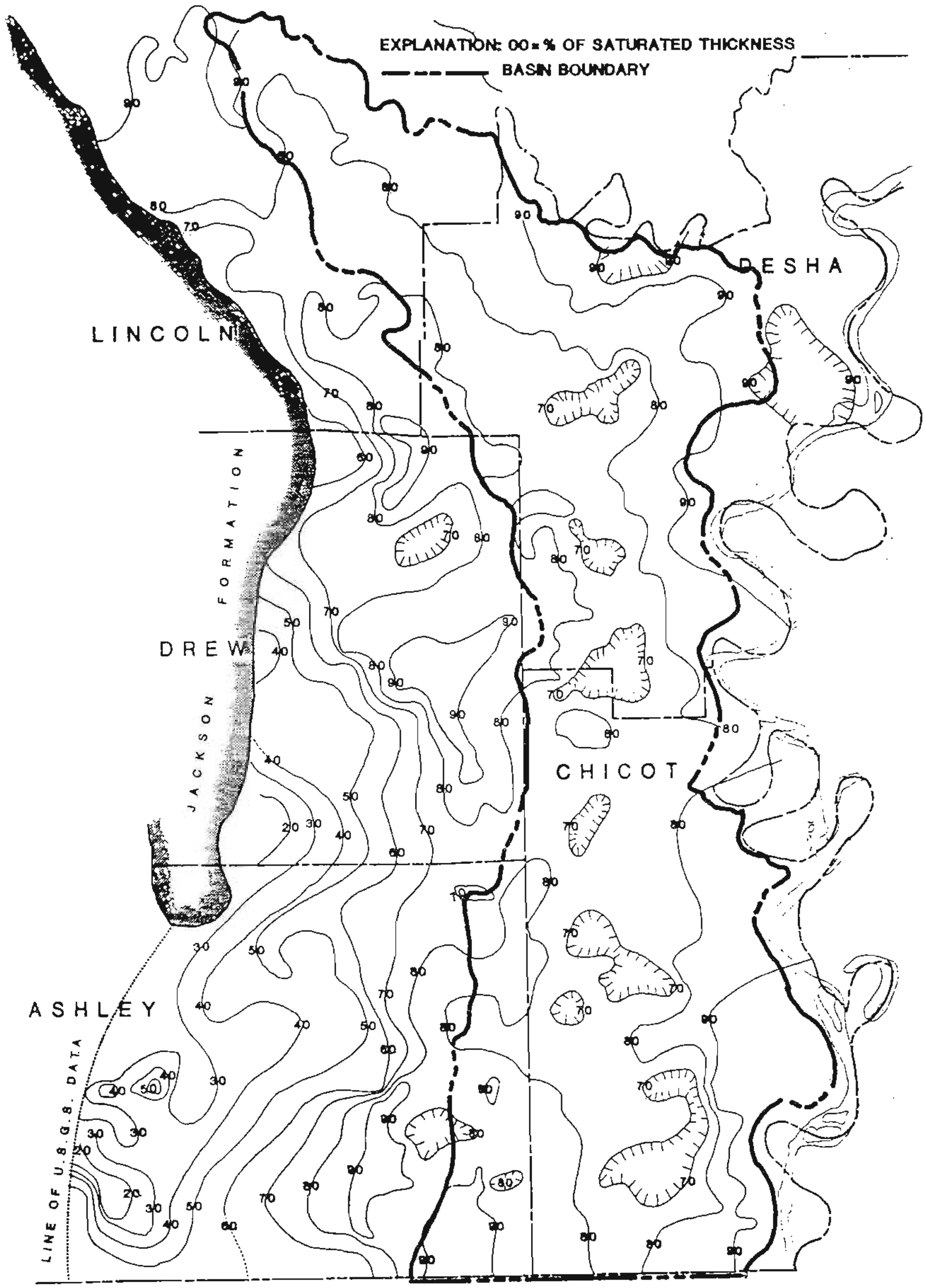
ALLUVIAL AQUIFER
WATER LEVEL CHANGE
SPRING 1980 - SPRING 1985



Source: Plafcan and Fugitt ⟨23⟩

figure 12

ALLUVIAL AQUIFER SATURATED THICKNESS



SOURCE: Arkansas Waterwell Construction Commission, Open File Data ⟨31⟩

TABLE 13

STREAM/AQUIFER INTERFLOW AFFECTING THE BOEUF-TENSAS BASIN

S/A Interflow	Maximum Recharge (ac-ft/year)	Average Recharge (ac-ft/year)
Boeuf River	-37,900	-6,700
Bayou Bartholomew	-25,800	-9,800
Bayou Macon	-14,000	+4,000

Based on data from 1973-1983. Negative value means recharge to aquifer from stream

Source: Peralta and others (21)

Ground water withdrawals from alluvial deposits in the basin in 1980 were about 238 MGD for agricultural purposes. Based on withdrawal amounts, the alluvial aquifer is by far the most significant aquifer in the Boeuf-Tensas Basin. The alluvial aquifer is not used as a source of public water supply in the basin. However, some homeowners withdraw water from the upper parts of the aquifer where the water is less mineralized. <16>

Safe Yield

Very little data exist concerning safe yield, however, Peralta has prepared a safe yield strategy for the alluvial aquifer of the Boeuf-Tensas Basin.<21>. This strategy gives its primary consideration to maximizing sustainable ground water pumping, and is suggested according to the most appropriate model and scenario techniques for the basin.

Each cell on the model grid represents nine square miles from which an optimal withdrawal amount has been assigned which will maximize use of the aquifer without depleting it. The model used to evaluate the maximum withdrawals considers aquifer characteristics such as recharge, thickness, and specific yield of the alluvial deposits in the basin.

Based on this model, optimal withdrawal from the alluvial aquifer in the Boeuf-Tensas Basin is illustrated in Figure 13. The total sustainable pumping from the aquifer in the basin is 116,000 acre-ft./yr. The potentiometric surface is allowed to decline in some cells, while in other areas, no pumping is suggested. In most of Chicot County, it is recommended that withdrawals not exceed 500 acre-ft./yr. for each cell. This is equivalent to 15 irrigation wells pumping 500 GPM continuously for approximately 15 days within each cell. In Desha County, recommended maximum withdrawals are as high as 2310 acre-ft./yr. for a cell, however, recommended withdrawals commonly range from 500 to 1100 acre-ft./yr. <21>

Water Quality

Water from alluvial deposits in the basin generally is hard, averaging 246 mg/L of calcium carbonate. Iron concentrations range from 0.07 to 20 mg/L. The average iron concentration is 8.6 mg/L which exceeds the limit of 0.3 mg/L established for drinking water standards. <12,18,29>

Chloride concentrations vary from less than 10 to 1360 mg/L which is far above the 250 mg/L standard established in the National Drinking-Water Regulations. <12,7,29>

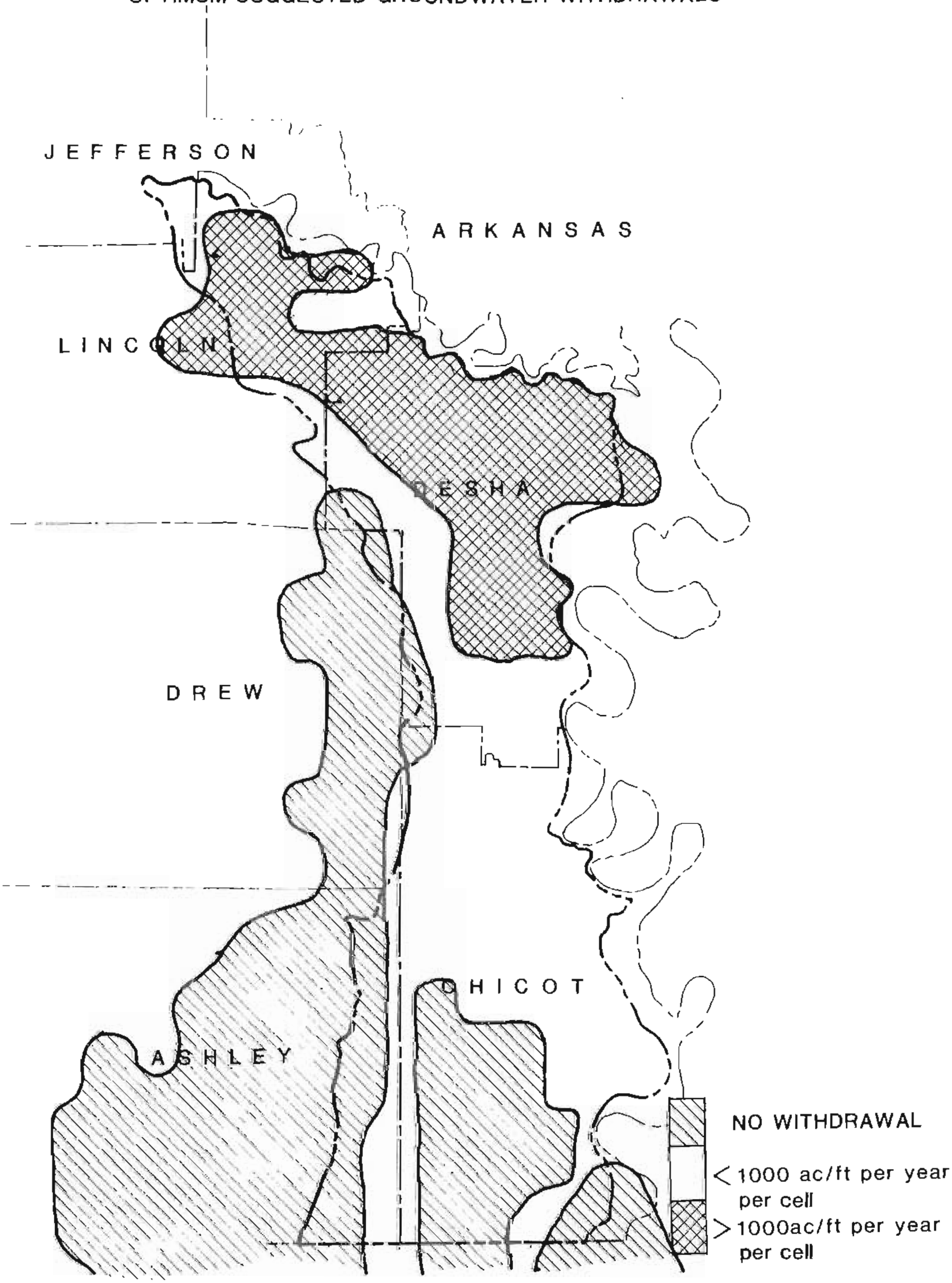
Critical Use Areas

A critical ground water use area for a water-table aquifer has been defined by the Arkansas Soil and Water Conservation Commission as an aquifer in which at least one of the following criteria applies: (A) 50% of the thickness of the formation or less is saturated, and/or (B) average annual declines of one foot or more have occurred for the preceding five year period, and/or (C) 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. Saturated thickness of the alluvial aquifer ranges from approximately 70 to 90 percent throughout the basin. Therefore, no areas in the Boeuf-Tensas Basin were delineated as critical use areas based on this criterion.

figure 13

ALLUVIAL AQUIFER

OPTIMUM SUGGESTED GROUNDWATER WITHDRAWALS



Modified from Peralta and Others ⟨21⟩

Water level declines of 6 feet or more have occurred in northwestern Desha County. However, based on the average annual water level declines in Figures 10 and 11, no critical use area was defined. Additional data are needed for evaluation of declines in the alluvial aquifer.

The occurrence of saline water in this area is a natural phenomenon, however, excessive use of the aquifer can encourage expansion of the contaminated area.

A level of 250 mg/l of chloride has been established by the U.S. Environmental Protection Agency as a reasonable goal in the National Secondary Drinking Water Regulations. EPA further stated that water containing chloride concentrations greater than 708 mg/l is not recommended for agricultural use. The primary use of water withdrawn from the alluvial aquifer in the Boeuf-Tensas Basin is for agriculture. Therefore, areas where chloride concentrations exceed 700 mg/l have been delineated as critical Ground water use areas and are shown in Figure 14. Areas where chloride concentrations exceed 250 mg/l are noted as areas of concern. <29,19>

COCKFIELD FORMATION

Geology

The Cockfield Formation is the youngest and uppermost aquifer of Tertiary age and is the second aquifer encountered in the subsurface of the Boeuf-Tensas Basin. The Cockfield is confined between the overlying Jackson Group, and the underlying Cook Mountain Formation which place the Cockfield aquifer under artesian pressure throughout the Boeuf-Tensas Basin.

The Cockfield Formation is composed of interbedded, fine to medium sand, carbonaceous clay, and lignite. The beds dip to the east except in the northwestern part of the basin where the strata dip to the north. <22,4,20>

Sediments of the Cockfield Formation are approximately 400 ft. thick. The top of the formation is generally 200 to 400 ft. below land surface.<22>

Hydrology

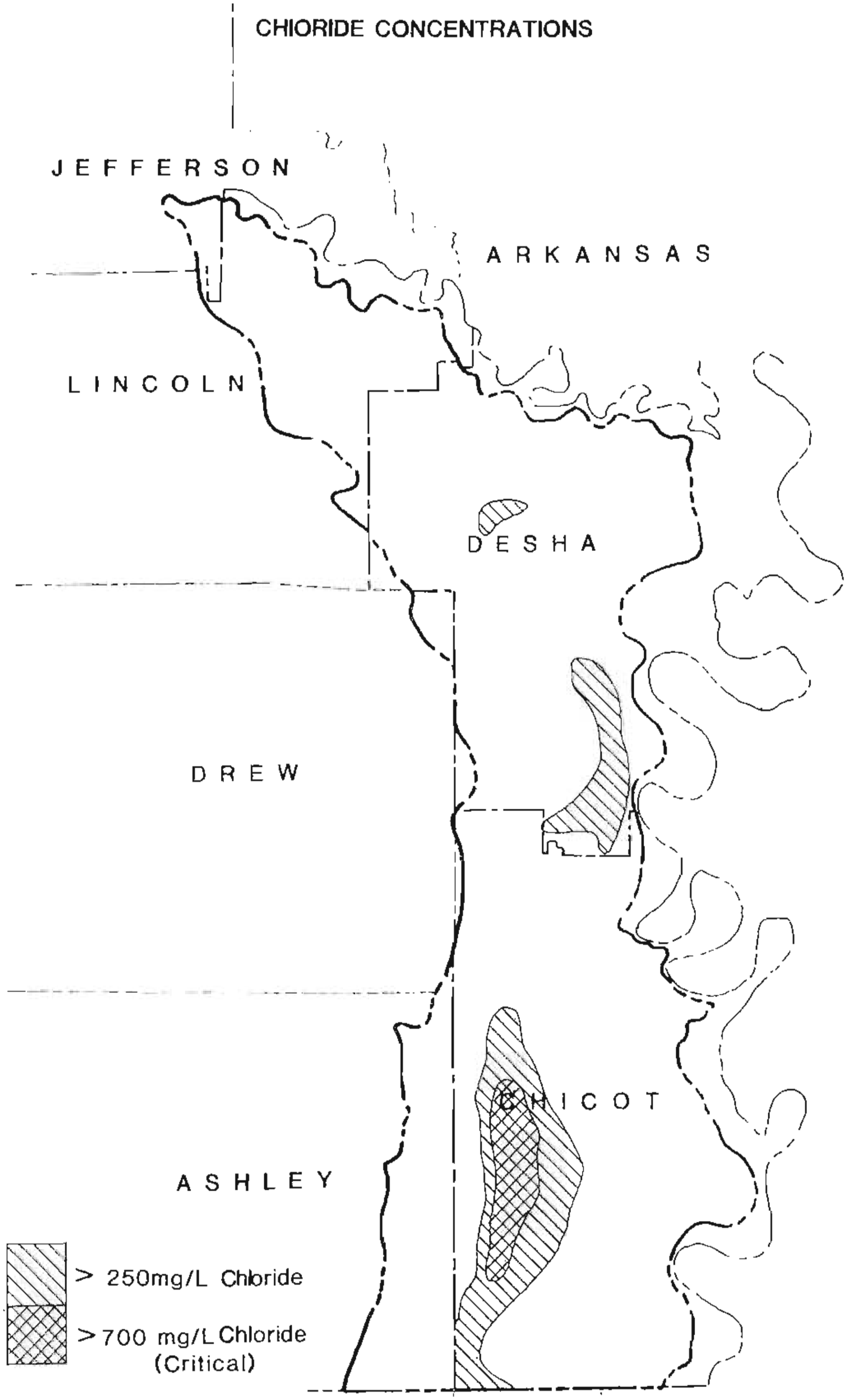
The Cockfield aquifer commonly yields 100 to 400 GPM to wells. Water level data are limited, however, wells in the Cockfield aquifer in Chicot County indicate a potentiometric surface of about 12 to 66 ft. below land surface. Average annual declines from 1981 to 1986 were from 0.26 to 0.76 ft. (See Table 14) <22,9>

The primary source of recharge to the Cockfield aquifer in the Boeuf-Tensas Basin is percolation of water at the outcrop area west of the basin in Union, Bradley, Dallas, Saline, Grant, and Cleveland Counties. <18>

Ground water flow is in the direction of the formation dip, which is east except in the vicinity of the Desha Basin Axis, where the dip is toward the north and west. <22>

figure 14

ALLUVIAL AQUIFER
CRITICAL USE AREAS
BASED ON
CHIORIDE CONCENTRATIONS



SOURCE: Modified from D. J. Fitzpatrick (USGS) Water Resources Investigation Report 85-4029 ⟨12⟩

Table 14

Measurements of water levels made in 1986 in wells completed in the aquifer in the Cockfield Formation

Well number	Altitude of land surface (feet)	Depth to water below land surface: Date	Depth to water below land surface: Feet	Altitude of water level (feet)	Net change in water level (feet): 1985-86	Net change in water level (feet): 1981-86	Remarks
				CHICOT COUNTY			
14S03W05BBA1	139	4-01	65.77	73	-2.59	-1.81	Dermott public supply.
15S03W21ABA1	122	4-01	27.77	94	-1.92	-1.88	
16S02W04BAC1	125	4-01	36.15	89	-3.73	-3.81	Lake Village public supply 1. 1984-86.
18S02W25ABB3	135	4-02	44.00	91	-0.73	-1.50	Eudora public supply 3.
18S03W14CCC1	98	4-02	11.92	86	-0.93	-1.32	

Source : Edds and Remsing <9>

The aquifer is used primarily for domestic and municipal purposes in areas of the basin where dissolved solids concentrations are not prohibitive. Based on withdrawals, the Cockfield Formation is the second most important source of ground water in the basin. In 1980, 1.85 MGD were withdrawn from the Cockfield aquifer in Chicot and Desha Counties. The communities of Dermott, Eudora and Lake Village rely on the Cockfield aquifer for potable water. <16,9,22>

Water Quality

Very little data are available for evaluation of the quality of water in the Cockfield aquifer. Figure 15 shows the total dissolved solids concentrations of water in the aquifer. In the northern half of the basin, water in the Cockfield Formation contains total dissolved solids concentrations below the 500 mg/L drinking water standard set by the Environmental Protection Agency. Chloride concentrations are as high as 1800 mg/L in the southern half of the basin. Throughout the basin, water in the Cockfield aquifer is a soft, sodium bicarbonate or sodium chloride type. <30,29>

Critical Use Areas

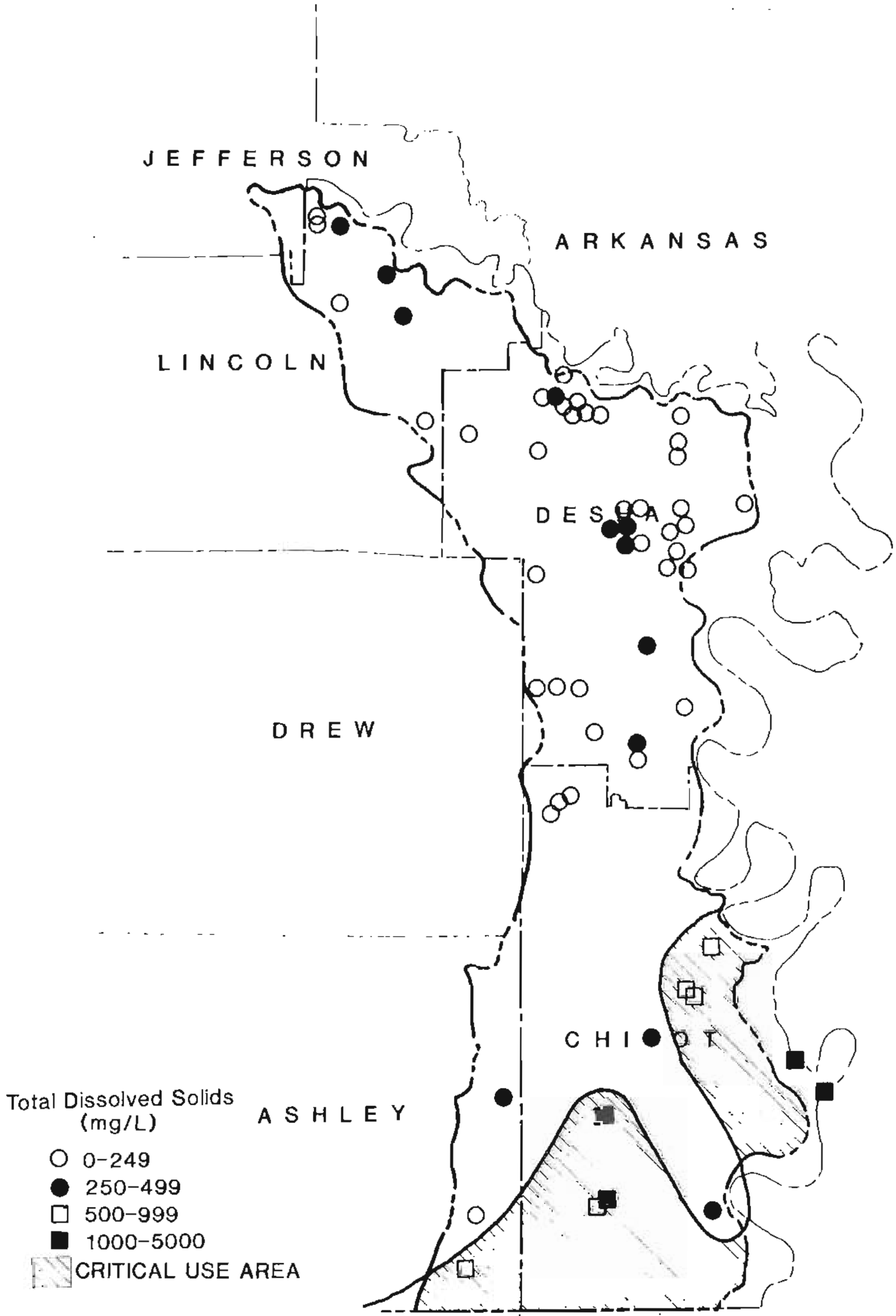
Critical use areas for an artesian aquifer are based on the following criteria: (a) potentiometric surface is below the top of the formation, and/or (B) average annual declines of one foot or more have occurred for the preceeding five years, and/or (C) Ground water quality has been degraded or trends indicate probable future degradation that would render the water unusable as a drinking water source or for the primary use of the aquifer.

Because of insufficient data, it is impossible to establish a relation between the potentiometric surface and the top of the formation. Monitoring wells in the Cockfield aquifer in Chicot County indicate potentiometric surface elevations with an altitude of 73 to 94 ft. (See Table 14). The top of the Cockfield Formation is at an altitude of approximately -100 to -250 ft; however, accurate elevations are not available due to the difficulty of distinguishing between the base of the Jackson Group and the top of the Cockfield Formation. Therefore, comparisons between the potentiometric surface and the top of the formation can not be made.

Water levels in wells in the Cockfield aquifer in Chicot County show average annual declines of 0.26 to 0.76 ft. Additional data are necessary to accurately evaluate the average annual declines of the aquifer.

The Cockfield aquifer yields good quality water in the northern two-thirds of the basin. The water quality becomes very poor in Chicot County, with total dissolved solids exceeding 1000 mg/L. Critical use areas based on total dissolved solids concentrations are outlined in Figure 15. The total dissolved solids reflect the poor water quality in the southern part of the basin.

figure 15
COCKFIELD AQUIFER
TOTAL DISSOLVED SOLIDS CONCENTRATIONS
AND CRITICAL USE AREA



Source: U.S.G.S. file data ⟨30⟩

SPARTA SAND

Geology

The Sparta Sand exists in the subsurface throughout the basin and is confined between the overlying Cook Mountain Formation and the underlying clay and sand deposits of the Cane River Formation. The Sparta Sand is a massive fine- to medium-grained sand with interbedded clay and lignite. The clay is gray to brown, sandy and lignitic. The sand and clay beds of the Sparta Sand are lenticular by nature. The clay strata are not continuous and the sand strata are hydraulically connected. These sediments combine for a total thickness of 700 to 800 ft. in the basin. <22, 4, 20>

The top of the Sparta Sand is approximately 400 ft. below mean sea level. The dip of the beds is to the east except in the northern one-third of the basin where the dip is west to northwest. Beds of the Sparta Sand do not outcrop within the Boeuf-Tensas Basin. The outcrop is to the west of the basin in Miller, Lafayette, Columbia, Nevada, Ouachita, Dallas and other counties. <22,18>

Hydrology

The Sparta aquifer commonly yields 500 to 1500 GPM to wells with some yields exceeding 3,000 GPM. These high yields are attributed to the extended thickness of the Sparta aquifer in the basin. Other contributing factors are the high percentage of sand and the hydraulically connected nature of the sands. <18,22,4,20>

Ground water flows downdip throughout the basin. No areas are known to exist where concentrated pumpage is diverting ground water flow in the aquifer. <8>

The potentiometric surface in the aquifer is 80 to 100 ft. above sea level. Therefore, any conduit through the overlying Cook Mountain Formation exposes the upper aquifers to contamination from the Sparta aquifer. <8,22>

In 1980, no water was withdrawn from the Sparta aquifer in Chicot County. In Desha County, 0.44 MGD were withdrawn from the aquifer in 1980. Along the northwestern boundary of the Boeuf-Tensas Basin, small amounts of water were taken from the aquifer. <16>

The Sparta aquifer is recharged in the outcrop areas from the percolation of precipitation into the formation. <22>.

The Sparta aquifer is very important as a source of ground water throughout out the Mississippi Embayment, yet it's usefulness in the Boeuf-Tensas basin is limited by the extremely high total dissolved solids concentrations. In the northern half of the basin, the Sparta aquifer is used as a principal source of public and industrial water supply. The communities if Watson, Dumas, Arkansas City, and McGehee rely on the Sparta aquifer for public water supply. <9, 16>

Water Quality

Water in the Sparta aquifer becomes extremely mineralized in the downdip direction with total dissolved solids concentrations exceeding 10,000 mg/L in southern Chicot County. Concentrations of dissolved solids are delineated in Figure 16. Water from ythe Sparta aquifer also has high concentrations of iron, but data for the Boeuf-Tensas Basin are limited. <8>

Critical Use Areas

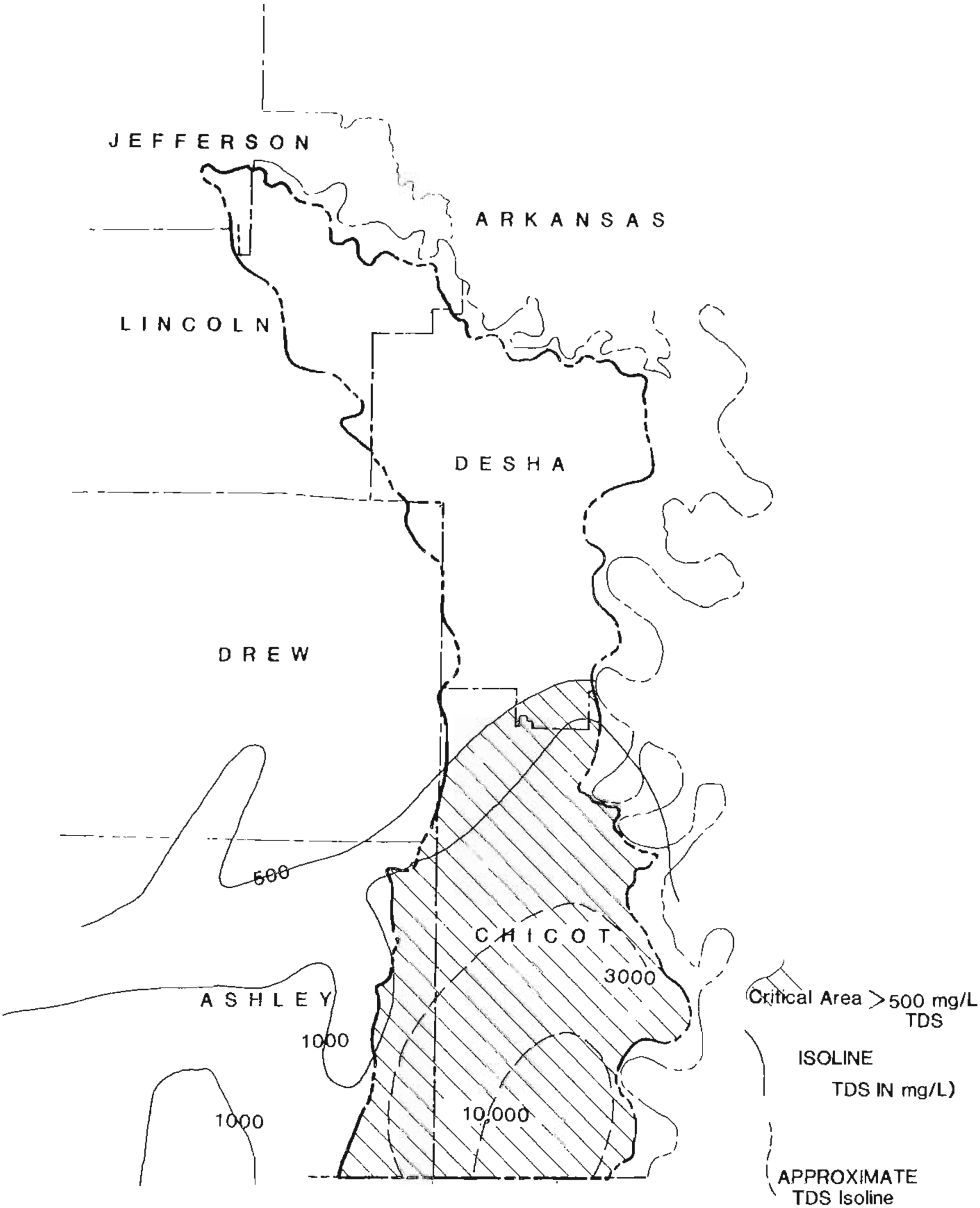
Critical ground water use areas for the Sparta Sand are delineated in Figures 16 and 17 based on the criteria for an artesian aquifer. Figure 18 illustrates that the potentiometric surface of the aquifer is several hundred feet above the top of the formation. The potentiometric surface is expected to remain high because withdrawals of such highly saline water are unlikely. However, water level declines in the northern half of the basin exceed the one foot average annual decline criteria. (See Figure 17). Therefore, this area has been delineated as a critical ground water use area.

The primary use of the Sparta Sand within the Boeuf-Tensas Basin is for municipal and public supply. Based on this fact, the critical use area has been delineated according to the National Drinking Water Regulations, which indicate 500 mg/L as the maximum concentration for total dissolved solids. Almost all Chicot County has been designated as a critical use area. Total dissolved solids concentrations decrease significantly in Desha County where the aquifer is used as a source of public supply.

figure 16

SPARTA AQUIFER

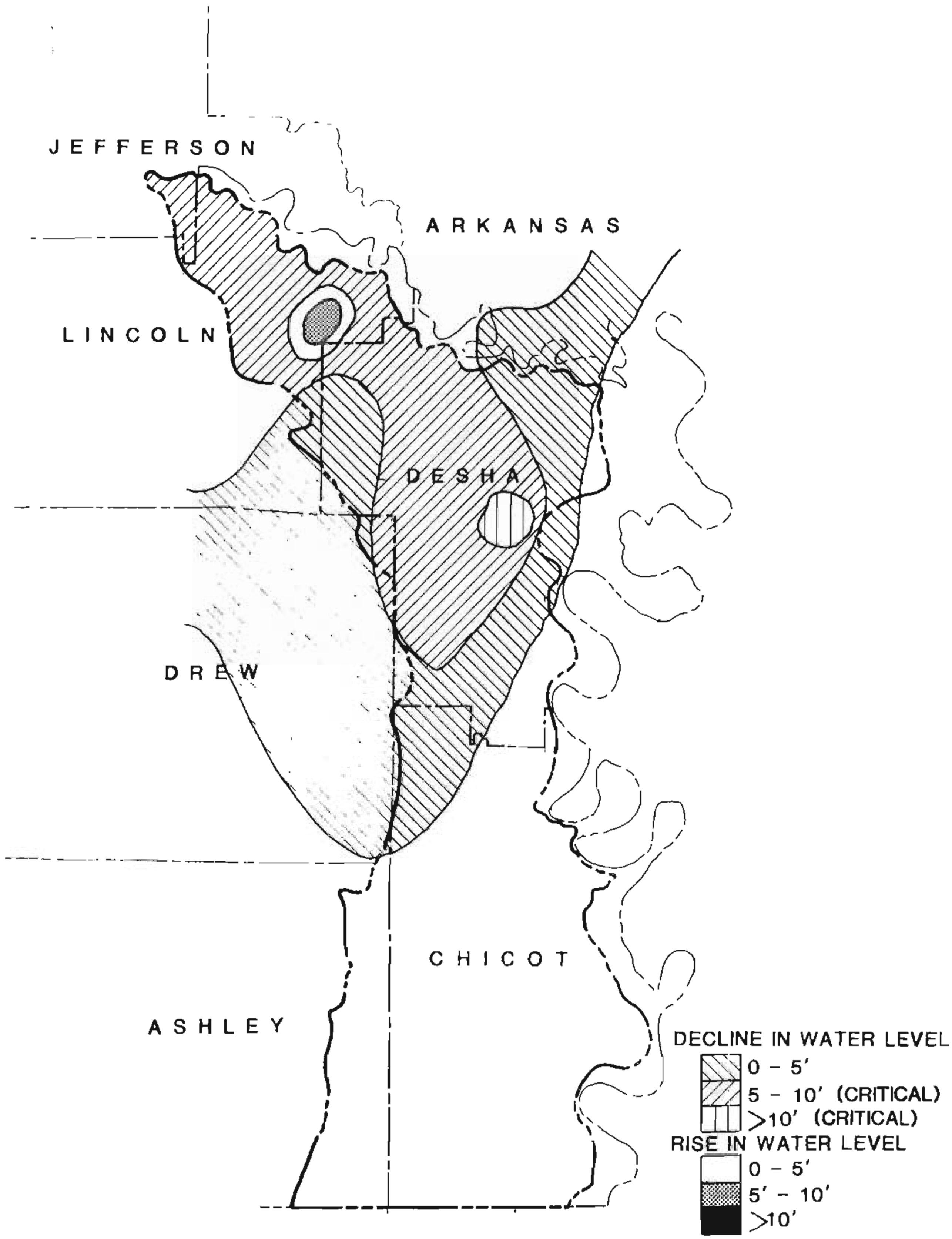
CRITICAL USE AREA BASED ON TOTAL DISSOLVED SOLIDS



Source: Petersen, Broom and Bush ⟨22⟩

figure 17

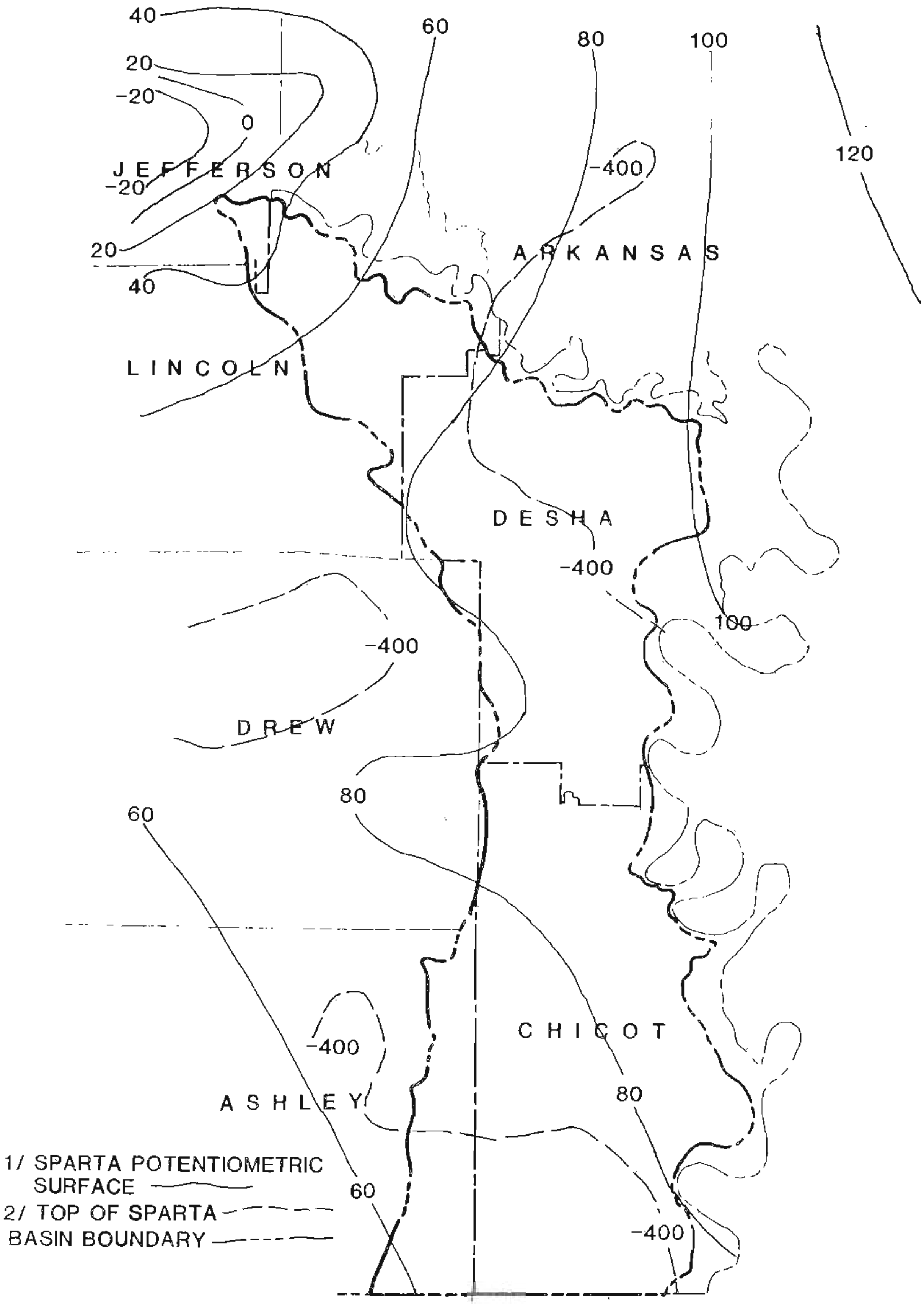
SPARTA AQUIFER
CRITICAL USE AREA BASED ON WATER LEVEL CHANGE
1980–1985



Source: Edds and Fitzpatrick ⟨8⟩

figure 18

SPARTA AQUIFER POTENTIOMETRIC SURFACE - TOP OF FORMATION



SOURCE: 1/ Modified from Edds and Fitz. ⟨8⟩
2/Modified from Petersen and others. ⟨22⟩

CONCLUSIONS AND RECOMMENDATIONS

The compilation of surface water and ground water data to address the requirements of Act 1051 of 1985 for the Boeuf-Tensas Basin has resulted in the identification of several water-resource problems in the basin. Three major problems that currently exist in the Boeuf-Tensas Basin are: (1) inadequate streamflow during the irrigation season to satisfy water-use demands; (2) contamination of the alluvial, Cockfield, and Sparta Sand aquifers by saltwater intrusion; and (3) water-level declines in the Sparta Sand formation. In addition to these problems, several other water-resource problems such as surface-water quality degradation from nonpoint source pollution, urban and rural flooding, inadequate drainage, and fish and wildlife destruction were identified in the Boeuf-Tensas Basin report <2> published in 1984.

Many different solutions to address the quantity and quality problems that currently exist in the Boeuf-Tensas Basin have been considered. In fact, two modifications in the legal framework of water management in the state that were recommended in the 1984 Boeuf-Tensas Basin report <2> have already been enacted by the Arkansas General Assembly during the 1985 legislative session. Act 1051 of 1985 authorized the interbasin transfer of surplus water and the transportation of excess surface water to nonriparians for their use. In addition, Act 1051 required the annual reporting of ground-water withdrawals in the state. These modifications in Arkansas water law provide water management agencies with additional guidelines and opportunities for more effective utilization and management of the water resources in the Boeuf-Tensas Basin and in the state. Recommended solutions to alleviate the major surface water and ground water problems in the Boeuf-Tensas Basin are briefly summarized in the following sections.

1. The major surface-water problem in the Boeuf-Tensas Basin is inadequate streamflow to satisfy water-use demands during the irrigation season. The Boeuf River and Bayou Macon have been designated as critical areas because pumping for irrigation has, at times in the past, contribute to no-flow conditions in both streams. A surface-water diversion project should be implemented to divert water from the Arkansas River to the Boeuf-Tensas Basin to alleviate the surface-water shortages in the basin. Construction of on-farm storage reservoirs to store high winter and spring flows for use during the irrigation season would also alleviate some of the water availability problems during low-flow periods.

2. The alluvial, Cockfield, and Sparta Sand aquifers in the Boeuf-Tensas Basin have been contaminated by saltwater intrusion. This ground water problem is essentially a result of natural causes, however, migration of the saltwater contamination can be affected by man's activities. Halting the migration of saltwater into freshwater zones can be accomplished by the reduction of ground water withdrawals in areas where saltwater migration is occurring and by the improvement of well construction and abandonment practices. Ground water withdrawals should be guided by a sustained yield pumping strategy in order to most effectively manage the ground water resources of the basin.

3. Water levels are declining in the Sparta Sand aquifer in the northern part of the Boeuf-Tensas Basin. Cones of depression that have developed in the areas of most intensive withdrawals indicate that the potential exists for permanently dewatering the aquifer or for inducing saltwater encroachment. The most efficient response to the problem of declining water levels in the basin is conversion from ground water sources to surface water sources, and employment of a conjunctive use management strategy.

4. Surface-water quality in the Boeuf-Tensas Basin has been degraded by nonpoint pollution from sources such as soil erosion, streambank erosion, urban runoff, and surface and subsurface disposal sites. One solution that is recommended to reduce the surface-water quality problems in the basin is the implementation of Best Management Practices (BMP's). It is also recommended that an intensive public education effort be initiated to inform water users of the economic benefits as well as environmental benefits that could be expected as a result of the implementation of BMP's.

5. Flooding problems due to excessive runoff from high intensity or long duration rainfall events occur throughout the Boeuf-Tensas Basin. Floodwaters cause agricultural damages in the basin by restricting land use, increasing production cost, decreasing product quality, and decreasing yield. Flooding and drainage problems in the basin can be reduced primarily by non-structural solutions related to land treatment measures and floodplain management. Farm owners and operators could improve surface drainage and irrigation effectiveness by installing adequate field drains and by practicing land forming techniques such as grading, smoothing, and leveling. Losses in flood-prone areas could also be curtailed by enforcement of floodplain management in conjunction with the National Flood Insurance Program.

6. Destruction of fish and wildlife in the Boeuf-Tensas Basin has primarily resulted from the extensive conversion of woodland and wetland areas to cropland. Suitable habitats for wildlife have been destroyed in the process and increased soil erosion and pesticide contamination from cropland areas have significantly impacted the fishery resource in the basin. One solution to the problem of fishery degradation in the basin has recently been implemented with the construction of a pumping plant upstream of Lake Chicot. The Lake Chicot project was designed to improve the water quality of the lake by diverting streamflow containing high concentrations of dissolved solids and suspended sediment to the Mississippi River which should contribute to the improvement of the sport fishery resource of the lake. The fishery resource in the Boeuf River and Bayou Macon could be improved by the proposed diversion of Arkansas River water to the basin.

The major surface water and ground water problems that currently exist in the Boeuf-Tensas Basin should be alleviated by implementation of the solutions that have been recommended. However, additional increases in the number of water users in the basin may intensify the water-resource problems that already exist. Therefore, it is imperative that the ground water and surface water supplies in the basin be managed and protected as that adequate water is available to satisfy all future water users in the Boeuf-Tensas Basin.

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ARKANSAS
FORESTRY
COMMISSION

P. O. Box 4523, Asher Station ■ Little Rock, Arkansas 72214

Edwin E. Waddell
State Forester

Ph. 501 664-2531

RECEIVED
AUG 8 1988
SOIL AND WATER
CONSERVATION COMMISSION

4 August 1988

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

Dear Mr. Young:

These comments are in response to the draft Supplement to the Boeuf-Tensas Basin segment of the Arkansas State Water Plan.

The draft report identifies the extensive conversion of woodlands and wetlands to cropland as a cause of the destruction of fish and wildlife in the area. This land use conversion destroys habitat and increases soil erosion and pesticide contamination of waters.

In addition to engineering solutions, the Water Plan should promote reforestation as a way to reverse this cause of the water quality problems. Marginal cropland can be restored to productive woodlands. These woodlands would require no irrigation, and pesticide application on woodlands would be far less than applications on cropland. Reforestation programs sponsored by the U.S. Department of Agriculture (FIP, ACP, CRP) provide a framework for voluntary water quality/quantity restoration work by private landowners.

Let me know if you need information regarding these USDA programs. Thank you for the opportunity to review the draft Water Plan.

Sincerely,

Edwin E. Waddell
State Forester

By: Garner Barnum
Assistant State Forester
Resource Management

JGB:dr

DEPARTMENT OF THE ARMY
VICKSBURG DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60
VICKSBURG, MISSISSIPPI 39180-0060

REPLY TO
ATTENTION OF:

September 21, 1988

RECEIVED
SEP 26 1988
SOIL AND WATER
CONSERVATION COMMISSION

Planning Division
Western Tributaries

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

Dear Mr. Young:

We have reviewed the draft Arkansas State Water Plan reports for the Boeuf-Tensas and Eastern Arkansas Basins and have the following comments.

The Grand Prairie and Bayou Meto Basin project was omitted from the discussion of authorized U.S. Army Corps of Engineers projects in the draft Eastern Arkansas Basin report. This project was authorized by the Flood Control Act of 1928, as amended by the Flood Control Acts of 1950 and 1965. The project provides for water supply for the Grand Prairie region and flood control for the Bayou Meto Basin. The flood control features include enlargement realignment and cleanout of approximately 165 miles of channels in Big Bayou Meto, Little Bayou Meto-Salt Bayou, Wabbaseka Bayou, Indian Bayou, and Bradley Slough. The water supply features included a pumping plant at DeValls Bluff and a system of canals to distribute water to 190,000 acres of agricultural lands in the Grand Prairie region.

As stated in my letter of January 13, 1988, this project was included on the list of projects to be deauthorized unless construction funds are provided by December 1989 as required by Public Law 99-662.

I trust this information meets your needs. If we can be of further assistance, please let us know.

Sincerely,

V. C. Ahrlich

V. C. Ahlrich, P.E.
Chief, Planning Division

Arkansas **DEPARTMENT OF HEALTH**

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

M. JOYCELYN ELDERS, M.D.
DIRECTOR

BILL CLINTON
GOVERNOR

August 31, 1988

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

Re: Draft Supplement to the
Boeuf-Tensas Basin Report

Dear Mr. Young:

A staff review has been made on the referenced report. We would suggest that extra care be taken when referencing secondary drinking water standards so that the public does not perceive them as primary (enforceable/health related) standards. There are also instances in the report where no reference is made to primary or secondary, leaving the impression of a primary standard rather than secondary.

Enclosed for your information is a copy of the current primary and secondary drinking water standards (with the exception of radionuclides). Please note that the secondary standards are not legally enforceable and are related to aesthetic values (i.e.; taste, odor, appearance), rather than public health values.

If you have any questions please advise. Thanks for the opportunity to review the report.

Yours truly,

Bob Makin

Bob Makin, P.E.
Assistant Director
Division of Engineering

BM:cd

RECEIVED
SEP 1 1988
SOIL AND WATER
CONSERVATION COMMISSION

Arkansas Department of Health
Division of Engineering
March 1, 1988

National Primary Drinking Water Standards

Microbiological Parameters	MCL*
1) Total Coliform	1 CFU (monthly average)
2) Turbidity (Surface Water Only)	1 NTU (monthly average)

Inorganic Contaminants	MCL (mg/l)
1) Arsenic	0.05
2) Barium	1.0
3) Cadmium	0.010
4) Chromium	0.05
5) Lead	0.05
6) Mercury	0.002
7) Nitrate (as N)	10.
8) Selenium	0.01
9) Silver	0.05
10) Fluoride	4.0

Organic Contaminants	MCL (mg/l)
1) Endrin	0.0002
2) 2,4-D	0.1
3) Lindane	0.004
4) Methoxychlor	0.1
5) 2,4,5-TP	0.01
6) Toxaphene	0.005
7) Trihalomethanes	0.10
**8) Benzene	0.005
9) Carbon Tetrachloride	0.005
10) 1,2 - Dichloroethane	0.005
11) Trichloroethylene	0.005
12) p-Dichlorobenzene	0.075
13) 1,1 - Dichloroethylene	0.007
14) 1,1,1 - Trichloroethane	0.2
15) Vinyl Chloride	0.002

*MCL = Maximum Contaminant Level
CFU = Colony Forming Unit
NTU = Nephelometric Turbidity Unit
mg/l = milligram per liter (parts per million)

**Nos. 8 through 15 are referred to as VOC's - Volatile Organic Chemicals

0612F

Steve N. Wilson
Director

Scott Henderson
Assistant Director

Arkansas Game & Fish Commission

September 7, 1988

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

Dear Randy:

The staff of the Arkansas Game and Fish Commission has reviewed the draft supplement to the Boeuf-Tensas Basin report of the Boeuf State Water Plan. The Commission has some major problems with the minimum stream flow section where maintenance flows as recommended by AGFC (Arkansas Method - see Filipek et al. in 1987 Arkansas Academy of Sciences) are viewed by your agency as "**desirable**" flows and not minimum flow levels. While our flow recommendations are higher than some daily flows during the low flow or summer months, it should be realized that low flow season is a critical time of year for aquatic biota and those terrestrial organisms dependent on streams for their survival. Since streams in this basin do not have reliable flow during the summer months when it is most needed by agriculture, a more realistic solution to the problem than pumping streams dry is to store surplus flood water in the winter and spring and use it during the low flow months. This would keep fish kills and impacts to our wildlife resources to a minimum while still providing a reliable source of water for agriculture.

Simply setting the minimum flow at a level that is exceeded 94-99% of the time (Table 11, page 49) without consideration of the effects on the fish and wildlife in the area appears to be reckless endangerment of a resource invaluable to the State of Arkansas. As the agency responsible for the wise management and conservation of the fish and wildlife resources of this great state, we cannot endorse a State Water Plan that allows diversion of stream flow for the benefit of one use to the detriment of several instream uses, such as fisheries and wildlife, water quality, recreation, aesthetics and others.

On an issue of such importance to the state, surely we can work out a plan that maintains our fish and wildlife at acceptable levels while still allowing for diversion of surplus surface water to offstream users. We remain ever willing to work on a State Water Plan that represents all the interests and needs of the citizens and resources of this state.

Thank you for the opportunity to review this draft proposal.

Cordially,

Steve N. Wilson
Director

SNW:SF:amcg

National Secondary Drinking Water Standards

Contaminant	SMCL* (mg/l)
1) Chloride	250
2) Color	15 (Color Units)
3) Copper	1
4) Corrosivity	- Non Corrosive
5) Fluoride	2.0
6) Foaming Agents	0.5
7) Iron	0.3
8) Manganese	0.05
9) Odor	3 (Threshold Odor Number)
10) pH	6.5 - 8.5 (pH Units)
11) Sulfate	250
12) Total Dissolved Solids (TDS)	500
13) Zinc	5

*SMCL = Secondary Maximum Contaminant Level

Unregulated Contaminants (URC's)**

(01) Chloroform
(02) Bromodichloromethane
(03) Chlorodibromomethane
(04) Bromoform
(05) trans-1,2-Dichloroethylene
(06) Chlorobenzene
(07) m-Dichlorobenzene
(08) Dichloromethane
(09) cis-1,2-Dichloroethylene
(10) o-Dichlorobenzene
(11) Dibromomethane
(12) 1,1-Dichloropropene
(13) Tetrachloroethylene
(14) Toluene
(15) p-Xylene
(16) o-Xylene
(17) m-Xylene
(18) 1,1-Dichloroethane
(19) 1,2-Dichloropropane
(20) 1,1,2,2,-Tetrachloroethane
(21) Ethylbenzene
(22) 1,3-Dichloropropane
(23) Styrene
(24) Chloromethane
(25) Bromomethane
(26) 1,2,3-Trichloropropane
(27) 1,1,1,2-Tetrachloroethane
(28) Chloroethane
(29) 1,1,2-Trichloroethane
(30) 2,2-Dichloropropane
(31) o-Chlorotoluene
(32) p-Chlorotoluene
(33) Bromobenzene
(34) 1,3-Dichloropropene
(35) Ethylene dibromide (EDB)
(36) 1,2-Dibromo-3-chloropropane(DBCP)
(37) 1,2,4-Trimethylbenzene
(38) 1,2,4-Trichlorobenzene
(39) 1,2,3-Trichlorobenzene
(40) n-Propylbenzene
(41) n-Butylbenzene
(42) Naphthalene
(43) Hexachlorobutadiene
(44) 1,3,5-Trimethylbenzene
(45) p-Isopropyltoluene
(46) Isopropylbenzene
(47) Tert-butylbenzene
(48) Sec-butylbenzene
(49) Fluorotrichloromethane
(50) Dichlorodifluoromethane
(51) Bromochloromethane

**These are monitored in conjunction with the VOC's. No enforceable standards have been developed for these compounds.

ARKANSAS SOIL AND WATER CONSERVATION COMMISSION

WATER RESOURCES PLANNING STAFF

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