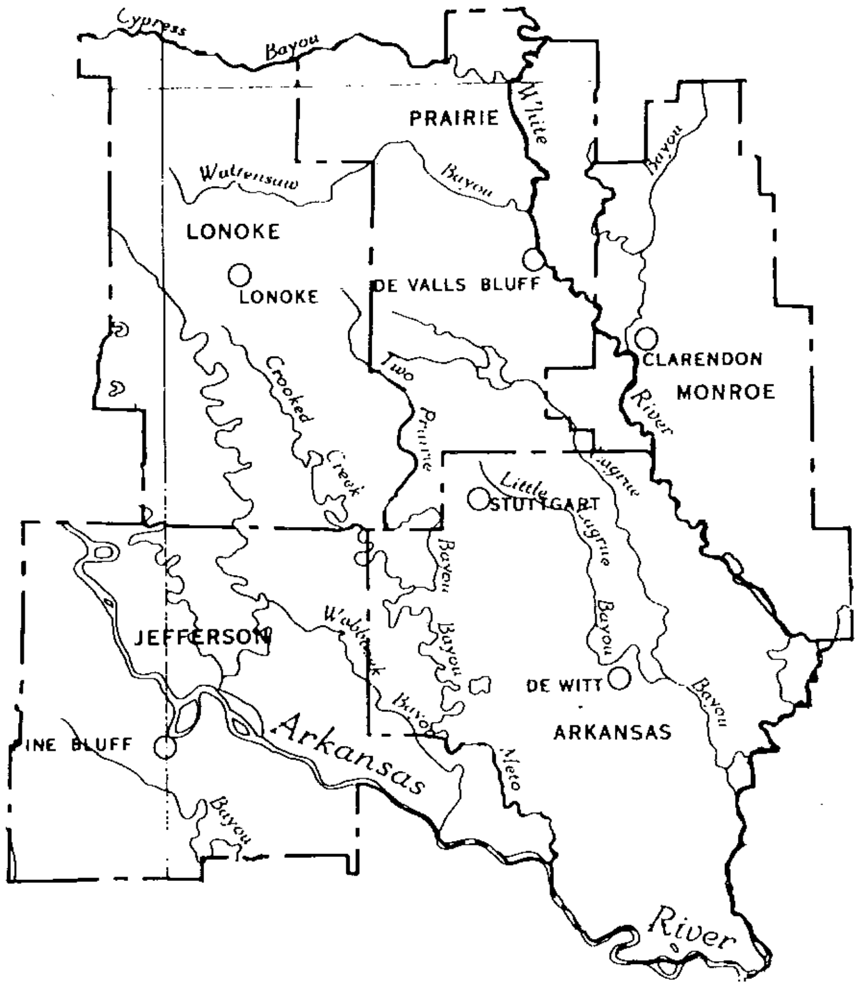
ARKANSAS STATE WATER PLAN

SPECIAL REPORT

POTENTIAL ARKANSAS AND WHITE RIVERS WATER AVAILABLE FOR DIVERSION TO THE GRAND PRAIRIE



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INTRODUCTION

1.1 Study Objective

At the present time, the rate of groundwater use in the Grand Prairie region of Arkansas exceeds natural replenishment of the underlying aquifer. Most of the groundwater is used for agricultural production. If current agricultural water needs of the region are to be satisfied under sustained yield conditions, supplemental surface water will be required. The objective of this study is to assess the viability of the Arkansas and White Rivers as sources of supplemental water for meeting water needs in excess of those which can be met with groundwater.

To accomplish this objective, instream water requirements were evaluated and the discharge available for diversion was estimated. Water quality is assumed to be adequate for use and therefore, this study is limited to quantitative assessment.

1.2 Background and Scope of Study

The study focuses upon the Grand Prairie region, the lower section of the Arkansas River below Murray Dam, and the White River downstream of De Valls Bluff, Arkansas. A gridded map of the Grand Prairie region is presented in Figure 1. Murray Dam, not shown in Figure 1, is located approximately 6.1 miles (9.8 km) upstream of Little Rock, Arkansas. De Valls Bluff is situated on the White River at a point approximately 52 miles due east of Murray Dam. Murray Dam and De Valls Bluff were selected based upon the availability of streamflow data and information

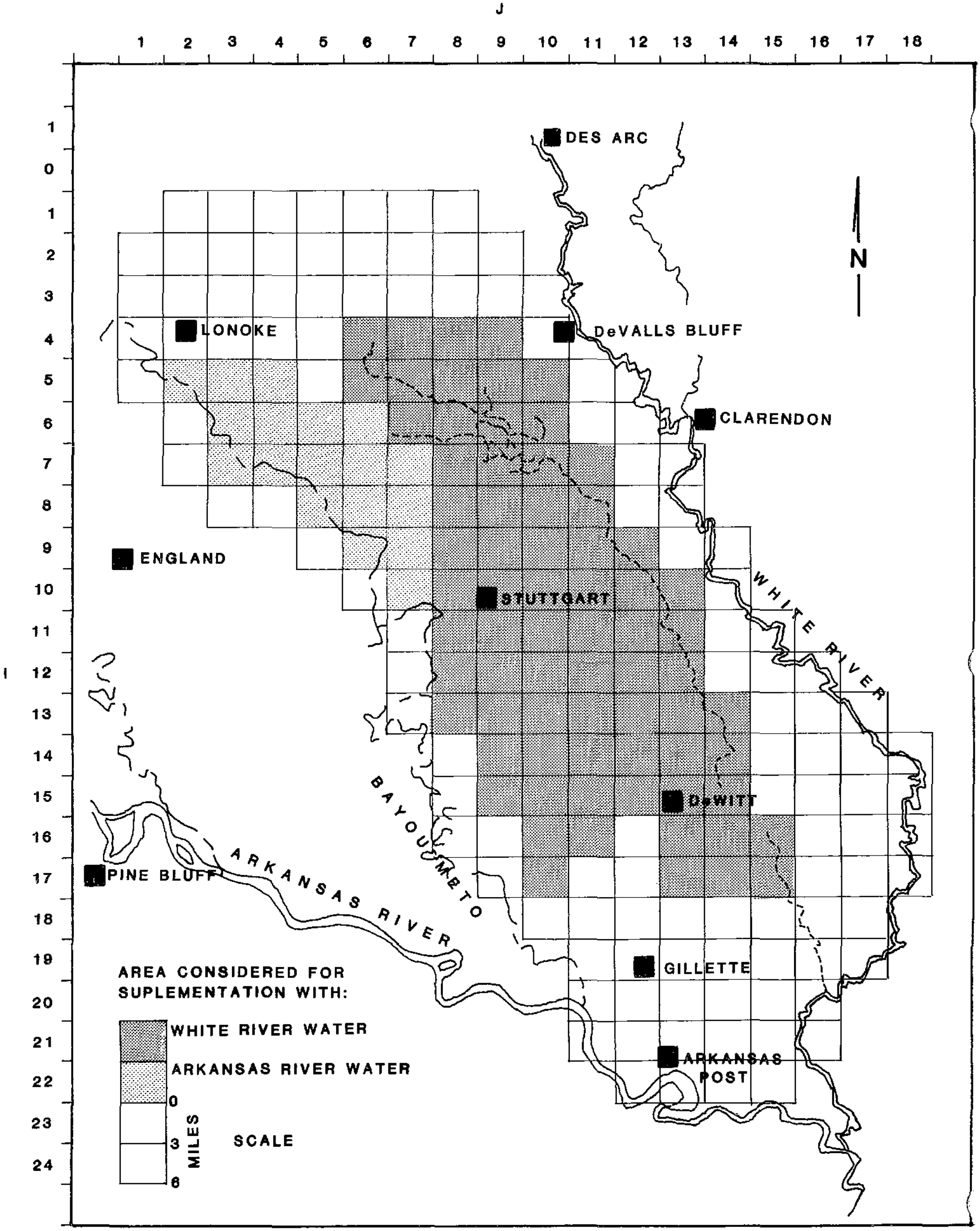

figure 1 : GRAND PRAIRIE REGION of ARKANSAS.

contained in previous reports which indicate that these locations are near feasible withdrawal sites for diversion of water to the Grand Prairie [1,15].

Constraints imposed upon the availability of surface water for transport to the Grand Prairie may result from water requirements necessary to carry out existing and potential river based activities and programs. Instream flow requirements often include provisions for navigation, water quality maintenance, fish and wildlife protection, and recreation. Interstate water supply agreements may also play an important role in determining availability of streamflow for diversion.

In addition to satisfying instream needs, Arkansas River and White River water is currently used by riparian owners for irrigation. Analysis of individual riparian rights is beyond the scope of this study. Therefore, quantities required for satisfying these rights are not included in determining availability of water for diversion to the region. Consideration of current and potential withdrawals by riparian landowners must be included in any future study attempting to rigourously determine availability of water for allocation.

Analysis of streamflow data for this study involves the use of monthly average flows for the Arkansas River and White River during the periods 1970-1982 and 1964-1970 respectively. Monthly averages should be used with caution since minimum flows, which can result in critical shortages, are not accounted for. Weekly averages or daily measurements provide greater accuracy for estimating surface water availability because of rapidly fluctuating flow rates. However, this study is of reconnaissance level and some degree of accuracy was sacrificed in an effort to provide timely information. To determine the legal availability of water for allocation a more detailed study should use weekly or daily flows.

For purposes of this report, assessment of available surface water is based upon flow rates in the Arkansas River and White River. Storage facilities or reservoirs, which provide means of capturing surface water for subsequent use, are not considered.

August exhibits the lowest average mean monthly flow of all complete months during the irrigation season [16]. The irrigation season normally runs from June through mid-September. During this period, water use increases significantly for production of rice and soybeans. Therefore, August was selected to represent the "critical" month for analysis. Streamflows and estimates of "available surface water" under both average and dry climatological conditions are presented in this report. Conditions during June-September of 1980, representing the driest growing season for soybeans or rice during the 1965-1980 period [7], were chosen to represent dry extremes.

2.1 Selection of Streamflow Data

The Little Rock District of the U.S. Army Corps of Engineers (COE) identified the pool above Terry Lock & Dam (Lock & Dam #6) as a workable withdrawal site on the Arkansas River [1]. Discharge records are not available for this location. Therefore, measurements at the Murray Lock & Dam gaging station (Lock & Dam #7) are used to assess water availability in the Arkansas River. Murray Dam is located approximately 17.3 navigation miles (27.7 km) upstream of David D. Terry Lock and Dam. There are no major tributaries between these two points and local consumptive use of Arkansas River water is assumed to be insignificant with regard to study objectives.

A series of locks, dams, and reservoirs, constructed prior to 1970, is located upstream of Murray Dam. The operation of these multipurpose facilities has resulted in continual regulation of flow along the Arkansas River over the last 15 years. Efforts to obtain a consistent record of streamflows for purposes of analysis required that hydrologic data for water years after 1970 be used. The average of August mean flows at Murray Dam during the period 1970 - 1982 is 12,978 cubic feet per second (cfs). Mean flow of August 1980, resulting from dry climatological conditions, is 5,545 cfs. (Caution should be used in evaluating on the basis of mean flow data since flows were near zero at times during August 1980.) These numbers are presented as estimates of discharge under alternative "streamflow conditions" in Table 1.

TABLE 1

ESTIMATED "AVAILABLE SURFACE WATER" OF THE ARKANSAS RIVER IN AUGUST AT MURRAY DAM / TERRY LOCK AND DAM

	Streamflow Conditions				
	Average Conds., August Average Flow: 12,978	Average Conds., August Average Flow Reduced By Legal Obligs.: 8,176	Dry Conds., 1980 August Mean Flow: 5,545	Min. Flows Provided By Hydraulic Operation Of Navig. Sys., Mean Mthly. Flow: 4,600	Min. Flows Provided By Hydraulic Operation Of Navig. Sys., Mean Daily Flow: 3,600
Constraints On Water Availability					
Water Quality Standards, 7Q10: 891	12,087	7,285	4,654	3,709	2,709
Navigational Requirement: 1,510	11,468	6,666	4,035	3,090	2,090
Maintenance Of Water Quality: 3,400	9,578	4,776	2,145	1,200	200
Present And Potential Needs Of Basin: 10,000	2,978	-	-	-	-
Protection Of Fish & Wildlife: 12,978	-	-	-	-	-

Figures are cfs.

Table 1 is designed to show estimates of "available surface water" or quantities available for diversion subject to maintenance of instream requirements. Potential discharge under various "streamflow conditions" is shown at the top of the columns. Headings of the two right-hand columns show estimates of minimum flow based upon hydraulic operation of Arkansas River navigation facilities. According to estimates by the COE, system operation should provide minimum mean monthly flow of 4,600 cfs and minimum mean daily flow of 3,600 cfs in the Arkansas River at Little Rock [4] under normal conditions.

Instream flow requirements are presented in the left-hand column as "constraints on water availability". The figures in the interior of the matrix are derived by subtracting a chosen constraint from the discharge representing a selected streamflow condition. The difference may be regarded as the flow of surface water available for withdrawal in the absence of conflict with riparian rights. The following example shows how the table may be used to obtain an estimate of available surface water.

Example: Navigational requirement is chosen as the predominant instream flow requirement. Selected streamflow is that which reflects discharge under dry conditions. Therefore, estimated available surface water is calculated as follows: 5,545 cfs - 1,510 cfs = 4,035 cfs.

2.2 Legal Obligations

The Arkansas Soil and Water Conservation Commission represents the State of Arkansas in matters pertaining to the Arkansas River Basin Compact. The Compact provides for apportionment of specific surface water supplies between the states of Arkansas and Oklahoma. Apportionment is based upon percentages of "annual yield" of specific subbasins located on the border of the two states. Reports prepared by the Little Rock office of the United States Geological Survey reveal that during water years 1974-1980 and 1982, Oklahoma's annual usage ranged from 1% to 71% of its allotment. The highest percentage used (71%) occurred during 1980 under exceptionally dry conditions [17].

A study of existing and projected water use in Arkansas shows that flows at Little Rock may experience a 37% decline in the event Oklahoma uses its entire allotment during average climatological conditions [3]. An estimate of available surface water under average conditions is exhibited in Table 1. August average flow, reduced by 37 %, is presented as discharge after fulfillment of potential legal obligations. Flow under dry climatological conditions (August 1980) was not reduced accordingly, since recorded flows of 1980 reflect withdrawals by Oklahoma equal to 71 % of its allocation.

The Commission is also responsible for allocation of surface water supplies during periods of shortage [2]. However, the Commission has not adopted a specific policy with regard to flow maintenance in the Arkansas River [12].

2.3 Water Quality Standards

Water quality control is a primary responsibility of the Arkansas Department of Pollution Control and Ecology. The Department conducts studies and makes recommendations regarding flow requirements for maintenance of water quality and protection of stream life. Minimum flow requirements have not been established for the Arkansas River by the Department. Alternatively, the current "7Q10" or the seven day low flow corresponding to a recurrence interval of ten years is used as an estimate of expected low flow for pollution control studies and establishment of water quality standards [11]. Based upon recorded flows of the period 1972-1981, the 7Q10 at Murray Dam is 891 cfs [5]. This figure is presented in Table 1 as a constraint on surface water availability due to instream need for meeting water quality standards.

In addition, 3,400 cfs is cited by an independant consultant as the "flow requirement to maintain water quality" in the Arkansas River at Murray Dam [13]. Therefore, this figure is presented in Table 1 as an alternative flow requirement for purposes of maintaining water quality.

2.4 Navigational Water Requirements

The Little Rock District of the COE is responsible for operation and maintenance of navigation facilities along the Arkansas River. In addition to Murray Dam and Terry Lock and Dam, facilities include (a) Lock and Dam #5 near Jefferson, (b) Lock and Dam #4 near Pine Bluff, (c) Lock and Dam #3 near Swan Lake, (d) Arkansas Post Canal which connects the lower Arkansas River with the White River, and (e) Dam #2 on the Arkansas River just downstream of the mouth of the canal. Lock #2 and Lock and Dam #1 are located on the canal. A diagram representing the lower Arkansas River navigational system is presented as Figure 2.

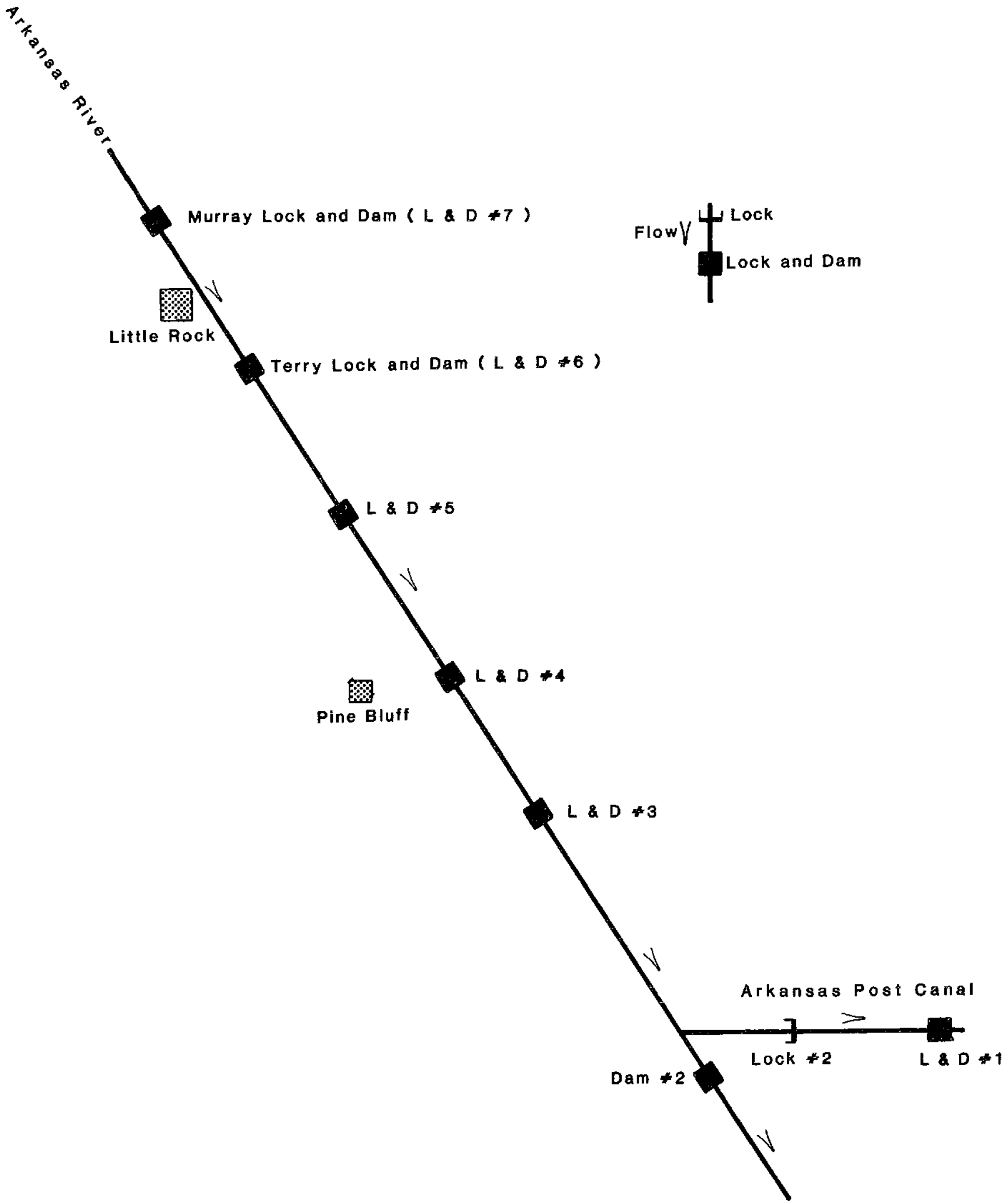

figure 2 : LOWER ARKANSAS RIVER NAVIGATIONAL SYSTEM

The COE established a minimum flow requirement of 870 cfs for the maintenance of stream life in the channel below Dam #2 [8]. As shown in Table 2, flow requirements for upstream reaches include provisions for release of this quantity and evaporation losses from pools at the various dams. Figures in the third column of Table 2 represent estimates of flows passed at each facility due to lockage and leakage through the lock and dam. Leakage is approximated to be 30 cfs at Dams #2-#9. The flow required for lockage represents that amount which is necessary for passage of vessels through the lock.

With the exception of Dam #2, flow requirements "at site" represent the sum of lockage, leakage, and evaporation. The "accumulated" flow requirements at Dams #3-#9, shown in the right-hand column of Table 2, equal pool evaporation at the selected dam plus accumulated requirement at the dam immediately downstream. For example, the flow requirement at Terry Lock and Dam (L&D #6) is 1,510 cfs as shown in Table 2. It represents the sum of (a) 70 cfs, evaporation loss from Terry Lake, and (b) 1440 cfs, accumulated flow requirement at L&D #5. This figure is presented in Table 1 as the constraint on water availability resulting from navigational requirements.

2.5 Base Flow Recommendations For Basin Needs And Fish & Wildlife Protection

The U.S. Army Corps of Engineers' Southwestern Division and the U.S. Fish and Wildlife Service issued base flow recommendations in conjunction with a reconnaissance level investigation into the feasibility of transporting water from

TABLE 2

NAVIGATIONAL WATER REQUIREMENTS AT
ARKANSAS RIVER LOCK & DAM NOS. 1 THROUGH 9

	Minimum Flow In Downstream Channel (cfs)	Lockage And Leakage (cfs)	Evapo-ration (cfs)	Total Requirement	
				At site (cfs)	Accumu-lated (cfs)
L&D #1		310	0	310	310
Lock #2		310	0	310	310
Dam #2	870	30	70	940	1250
L&D #3		340	50	390	1300
L&D #4		340	70	410	1370
L&D #5		340	70	410	1440
L&D #6		340	70	410	1510
L&D #7		340	70	410	1580
L&D #8		340	50	390	1630
L&D #9		340	60	400	1690

Adapted from table provided by U.S. Army Corps of Engineers, Little Rock District.

Minimum experienced flow. Considered to be necessary to maintain downstream channel.

Leakage only. Contributory to downstream requirement, thus not additive.

Eastern Arkansas to the High Plains region of Texas and Oklahoma [14]. Some of the preliminary plans presented in the High Plains study included provisions for withdrawal of water from the Arkansas River and White River.

Preliminary plans presented in the COE's High Plains report include a figure of 10,000 cfs as the estimated base flow at Pine Bluff, Arkansas [14]. As shown in Figure 2, Pine Bluff is located downstream of Murray Dam. Base flow is defined as "the amount of water sufficient to meet all of the upstream and downstream existing and future water needs within each [the] basin." According to the report, diversion of water for transport to the High Plains is to take place only when natural flows exceed the estimated base flow amount.

Minimum flow requirements for protection of fish and wildlife in the Arkansas River have not been established by the Arkansas Game and Fish Commission. According to the Commission, adequate protection requires seasonally variable base flows as opposed to a single base flow figure. However, further studies are required before seasonal minimum flows can be suggested [9].

The U.S. Fish and Wildlife Service recommends that the minimum or target level of flow for a particular month approximate the monthly mean flow of that month [14]. This recommendation resulted from lack of available data and limited funds for carrying out a more detailed study of instream needs [14]. A seasonally variable base flow, as suggested by the Arkansas Game and Fish Commission, may vary significantly from the mean monthly flow of 12,978 cfs. Nevertheless, in accordance with the recommendation, the August average mean flow during the period 1970-1982 was adopted in this analysis for protection of fish and wildlife.

WHITE RIVER

3.1 Selection of Streamflow Data

The period 1964-1970 was chosen for analysis of water availability in the White River because (a) the most recent of several reservoirs upstream of De Valls Bluff was completed in December 1963, and (b) streamflow records from the De Valls Bluff gaging station are not available for water years after 1970. The average of August mean monthly flows at De Valls Bluff during the period 1964-1970 is 14,080 cfs. This figure is presented in Table 3 as an estimate of discharge under average conditions. The format adopted in Table 3 is the same as that found in Table 1.

Since data is not available for 1980 at the De Valls Bluff station, an approximation of water availability under dry conditions was based upon mean discharge for August 1980 at the Clarendon gaging station. The Clarendon station is located approximately 25.2 miles (40.6 km) downstream of De Valls Bluff. August mean flows for water years 1966-1970 at each gaging station were totaled. The sum for De Valls Bluff represents 89% of the Clarendon total. Therefore, mean August 1980 discharge of 10,000 cfs at Clarendon was multiplied by .89 to derive an approximation (8,900 cfs) of flow under dry conditions at De Valls Bluff.

TABLE 3

ESTIMATED "AVAILABLE SURFACE WATER" OF THE WHITE RIVER IN AUGUST AT DE VALLS BLUFF / CLARENDON

	Streamflow Conditions		
	Average. Conds., August Average Flow: 14,080	Average Conds., August Average Flow Reduced By Potential Legal Obligs.: 10,842	Dry Conds., 1980 August Mean Flow: 8,900
Constraints On Water Availability			
Water Quality Standards, 7Q10: 5,860	8,220	4,982	3,040
Navigation Requirement: 8,850	5,230	1,992	50
Protection Of Fish & Wildlife: 14,080	-	-	-
Present And Potential Needs Of Basin: 20,000	-	-	-

Figures are cfs.

A similar estimate results from calculations based upon relative size of drainage area. The drainage areas for the De Valls Bluff and Clarendon gaging stations are 23,483 mi (60,821 km) and 25,555 mi (66,187 km) respectively [6]. Ratio of the size of the De Valls Bluff drainage area to that of the Clarendon gaging station is approximately 92%, a figure comparable to the ratio of August mean flows.

3.2 Potential Legal Obligations

Development of a compact has been considered as a means of allocating surface water supplies between the states of Arkansas and Missouri. If a compact is established, flows in the White River at Clarendon may be reduced by 23% in the event Missouri uses its entire hypothetical allotment under average climatological conditions [3]. Estimates of available surface water under conditions reflecting reductions due to potential legal obligations are exhibited in Table 3. Existing and potential riparian rights should be investigated before such quantities are considered available for withdrawal.

3.3 Water Quality Standards

The Arkansas Department of Pollution Control and Ecology has not issued recommendations pertaining to minimum flows required for acceptable water quality in the White River [9]. Therefore, the 7Q10 was adopted in this analysis to reflect instream needs for meeting water quality standards. A 7Q10 of 5,860 cfs was calculated using measured streamflows at De Valls

Bluff for the period 1956-1970 [5]. This figure is listed as a constraint in Table 3.

3.4 Navigational Water Requirements

The Memphis District of the COE is responsible for maintaining channel conditions adequate for navigation in the White River. Desirable conditions for navigational activity occur when flows are sufficient to provide 9 feet of channel depth and 200 feet of channel width at Clarendon. Such conditions occur when flow levels reach 8,850 cfs at De Valls Bluff and 9,650 cfs at Clarendon [10]. Therefore, 8,850 cfs was adopted as the instream flow requirement for navigation presented in Table 3.

3.5 Base Flow Recommendations For Basin Needs And Fish & Wildlife Protection

Base flow of 20,000 cfs at Clarendon was assumed by COE for purposes of meeting present and potential needs of the lower White River basin [14]. As previously mentioned, the U.S. Fish and Wildlife Service recommendation for minimum flow is based upon the average mean monthly flow. Therefore, 14,080 cfs was adopted as the target flow at De Valls Bluff for maintenance of fish and wildlife habitat in the lower White River. These flow recommendations are listed in Table 3 as constraints on water availability.

CONCLUDING REMARKS

Conjunctive use of groundwater and surface water in the Grand Prairie may involve scheduling of groundwater pumping based upon temporal and spatial distribution of demand, economic criteria, aquifer characteristics, and surface water availability. In an area where storage facilities are not available, management strategies should be designed for maximum use of available surface water during high flow periods. Objectives of such a strategy would include the reservation of adequate groundwater supplies as a means of providing drought protection. This "reserve" would then be available for use during those periods in which large water demand and below normal precipitation result in insufficient supplemental surface water to meet total needs.

Navigation holds the priority of water use for those rivers developed by the Federal government for navigation. Analysis shows that if navigation requirements are selected as the predominant instream needs, surface water is available for diversion from the Arkansas River and White River under average conditions. Under these criteria, potentially divertable flows are 11,468 cfs and 5,230 cfs respectively. It is noted that these values are estimated assuming average monthly flows and without considering diversion by riparian landowners. A rigorous effort to determine legally and physically permissible allocation rates should be based on daily or weekly flows and should include actual and potential diversion to riparian lands.

No comparison is made between the values mentioned above and the flow needed to satisfy irrigation needs in the specified service areas. However, it is unlikely that the White River can provide much divertable surface water during a period as dry or more dry than August 1980. It is also unlikely that much divertable surface water would be available from the Arkansas River under such conditions since the flow was near zero at times during August 1980. More severe droughts can reasonably be expected to occur in the future. Thus, it may be necessary to emphasize the use of surface water during high flow periods in an effort to avert the risk of dangerously low water supplies resulting from drought.

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