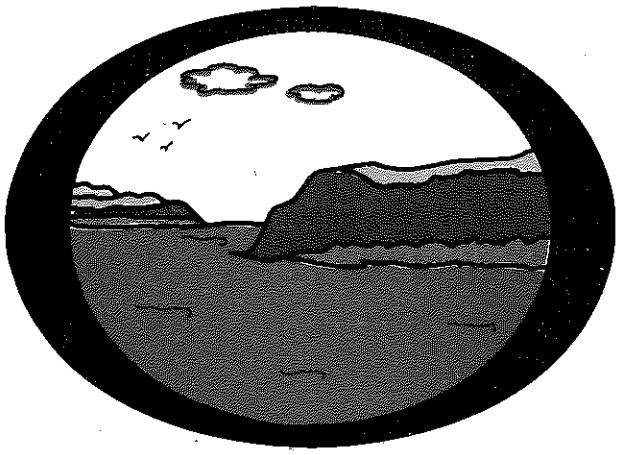
ARKANSAS
STATE WATER PLAN

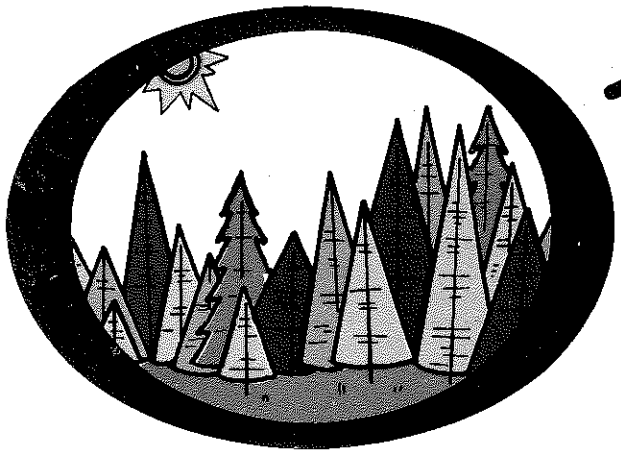
WATER AND RELATED LAND RESOURCES



APPENDIX "B"

EXISTING AND PROJECTED WATER USE IN ARKANSAS

SUPPLEMENT "1" - PROJECTED WATER REQUIREMENTS AND SURFACE WATER AVAILABILITY (1978)



ARKANSAS SOIL & WATER CONSERVATION COMMISSION

in cooperation with

ARKANSAS WATER RESOURCES RESEARCH CENTER

and

AGRICULTURAL EXPERIMENT STATION

Division of Agriculture
University of Arkansas, Fayetteville

APR

SPECIAL REPORT No. 61

PROJECTED WATER REQUIREMENTS AND SURFACE WATER AVAILABILITY FOR ARKANSAS

by

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PROJECTED WATER REQUIREMENTS AND SURFACE WATER AVAILABILITY FOR ARKANSAS

I. SUMMARY, IMPLICATIONS, AND LIMITATIONS

Arkansas is being considered as a potential source of water for the drier states of the South and Southwest. However, little is known about the efficient use and allocation of water in Arkansas.

The state was divided into five Arkansas Water Resource Planning Areas for this study. They were: (1) Mississippi-St. Francis and Crittenden County area, (2) Ouachita and Mississippi-Tensas area, (3) White River Area, (4) Lower Arkansas River and Benton County area, and (5) Lower Red River area.

The mean annual discharge of Arkansas' streams was estimated to be 78,687 million gallons per day (MGD) for 1975. However, for estimating surplus and deficit water areas within Arkansas, only mean firm discharges were considered. Mean firm discharge is defined as mean annual discharge as reported by the U.S. Geological Survey minus any legal obligations to allow water to flow to border states. Arkansas presently is a partner with Oklahoma in the Arkansas River Compact of 1970 and negotiations are underway with Texas and Louisiana.

Given this political atmosphere, two alternative assumptions were developed regarding potential obligations of Arkansas stream flows to border states.

Mean firm discharge #1 assumes that compacts will be developed for all water flowing directly between Arkansas and the states of Missouri, Oklahoma, Texas and Louisiana. These are standardized compacts allocating 60 percent

of the annual yield to the upstream state and 40 percent to the downstream state. If the assumed compacts became law, the mean firm discharge of state streams would equal 48,278 MGD, a decrease of 38.6 percent.

Mean firm discharge #2 assumes that compacts would be developed for all waters flowing into and out of Arkansas. This would include those streams flowing into the Mississippi River. Mean firm discharge would be reduced to 25,319 MGD, a decrease of 67.8 percent from present annual discharge.

Water allowed to flow downstream to meet legal obligations to border states may also be used to meet navigation and water quality flow requirements. In some areas, however, these legally obligated flows are not adequate and additional water is necessary to assure navigation and desired water quality levels. These additional requirements were subtracted from mean firm discharge to estimate present levels of available water. This available water may be used for expanding water uses within Arkansas or sold to neighboring states.

Water requirements for each of the five Water Resource Planning Areas were developed for the following primary user groups: manufacturing, domestic, livestock, irrigation, power generation, and fish farms and wildlife impoundments. State-wide water requirements are projected to increase by 2,051 MGD between 1975 and 2020. This represents a 54.5 percent increase over Arkansas' 1975 withdrawal rate or 2.6 percent of the state's annual discharge. Irrigation use is projected to increase by 1,129 MGD, or 55.1 percent of the total projected increase in Arkansas water use.

A comparison of available surface water within Arkansas under the assumptions of firm discharge #1 and #2, with projected increases in water requirements from 1975 to 2020 is given in the table. The difference is excess surface water availability, and the estimates for #1 and #2 appear in the last two columns of the table.

Comparison of Surface Water Availability in Arkansas and Increased Water Requirements by 2020

Region[1]	Available surface water in 1975, assuming Firm #1	Available surface water in 1975, assuming Firm #2	Projected increase in water requirements, from 1975 to 2020	Excess surface water available In 2020, under Firm #1	Excess surface water available In 2020, under Firm #2
	Million gallions per day				
1	2,266	1,183	729	1,537	454
2	3,216	3,216	800	2,416	2,416
3	4,171	5,197	48	4,123	5,149
4	23,972	10,835	437	23,535	10,398
5	3,166	3,166	36	3,130	3,130
State Total	36,791	23,597	2,051	34,741	21,547

[1]See text for description of regions.

All regions projected to have excess available surface water in 2020. The projected excess of only 454 MGD in the Mississippi-St. Francis and Crittenden County area is very small, however, indicating the greatest potential for water shortages.

The Texas Water Board presently is considering a plan to transport six million acre-feet of water per year from Arkansas to Texas. Stephen's Consultant Services, Inc. of Little Rock has proposed a tentative transportation route that would withdraw 1,500 MGD from the White River, 2,571 MGD from the Arkansas River, and 643 MGD from both the Ouachita River and the Millwood Reservoir.

The withdrawal point on the White River is just above DeValls Bluff and within the Mississippi-St. Francis and Crittenden County area. In our research we projected excess surface water of 1,537 MGD assuming standard compacts with Missouri, Oklahoma, Texas, and Louisiana, which would leave only 37 MGD uncommitted under conditions of normal stream flow. In years of below-normal stream flow all commitments could not be met. If compacts existed for all incoming and outgoing water, as assumed under firm discharge #2, withdrawals would exceed the available supply by 1,046 MGD even in a normal year. Other regions would have little difficulty in providing the proposed export levels.

This study compared projected water requirements with surface water availability for various water basins in Arkansas. As such it represents a first approximation of Arkansas' potential as a water exporter.

The mean annual estimates of water use and availability presented in this initial study are not adequate to assure the absence of temporary deficit periods, however they are sufficient to rule out potential exporting regions. If use estimates approach availability on an annual basis all water will be required within the region. Water may need to be stored or

transferred within the region to effectively match availability with use during the year, but water will definitely not be available for export unless replaced by imported water.

Although Arkansas presently enjoys a water surplus, it will not be in a position to provide water to all the potential claimants outside the state and still have adequate flows for expanded uses within the state.

In order to determine the economic feasibility and desirability of transfering water, several additional steps must be taken.

First, estimates must be made of present and future demand for each of the major users. The present study used the water requirements approach to project future use. This approach does not explicitly consider the effect of price on the use of water nor does it usually consider the effect of various economic policies. It generally assumes that the trends which influenced water use in the past are stable and can be expanded into the future. However, the quantities of water used are highly dependent on the prevailing objectives of society and upon the methods and purposes of water use (e.g., whether for industry or irrigation), upon economic policy (whether fully priced or subsidized), and other variables that can be influenced by public policy.

An alternative approach which incorporates the determinants of water use is necessary to evaluate the transfer of water. Such an approach would estimate a water demand schedule along with the determinants of demand for each of the principle users of water. It would enable a projection of future water use under different assumptions of policies, including price. In addition, when used with estimates of an economic water supply schedule it can provide information as to the value of that additional water to the principle users relative to the cost of providing it. When used in this way the water demand approach helps to determine both the optimal price to

charge water users and the efficiency of allocating resources for specific water resource projects, e.g., inter-basin transfers.

Second, estimates must be made as to the time of year when the water is likely to be withdrawn and then compared to the likely availability at those time. The present study includes only annual estimates of water use and average availability, but both use and stream flow are likely to vary during the course of a year. It is possible for an area to show a surplus for the year but yet have a water shortage in months in which use is high but stream flow low. Morever, variations in stream flow and water use during the year are also likely to affect the quality characteristics of the water. Obviously, it is necessary to know when surplus water is likely to be available as well as its quality in evaluating interbasin transfers.

Third, estimates of available ground water should be made. The present study was based on the assumption that any increases in future water requirements would be met by increases in surface water use. This assumption was used because of the general lack of information on Arkansas groundwater. Reliable estimates should be developed to get a better overall picture of water supply.

Fourth, estimates should be made of the primary and secondary economic impacts of transporting water between basins. These might include, but are not limited to, the effects on the labor force, income levels, income distribution, and production of both the exporting and importing areas. The transfer of water will involve large expenditures which will generate both benefits and costs to the various water basins. These must be estimated to evaluate the transfers.

Finally, the economic supply schedule of water should be estimated. The present study estimated supply in a physical sense without serious

consideration of the cost of making that supply available to potential users. In essence, this approach assumes that water can be supplied at zero price to the user. In actuality, of course, the available water supply depends on some positive price. A paper plant, for example, which is located along a stream will incurr a cost to extract the water from that stream. The amount of water used will depend partially on the cost of its use. To look at the physical quantity of water and say the state has a surplus is comparable to looking at the vast quantities of coal, oil shale, and the sun which the United States has and stating that we have a vast surplus of energy. In a physical sense, these statements are true; in a economic sense, not necessarily. The amount of these resources which are available for use depends, in part, on price. The amount of water available for surplus depends, in part, on the cost of providing it.

Research is currently underway to estimate the value of water for irrigation within Arkansas and the relative changes in domestic use which could result from changes in the price of water. This and other information will be necessary to more fully evaluate the feasibility for exportation of water

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II. INTRODUCTION

This report completes Phase I of a more broadly designed project entitled "Estimating Future Water Demand and Supply in Arkansas" which is aimed at evaluating the economic feasability and desirability of interbasin water transfers. The specific objective of this phase of the study is to identify the geographical areas of present and potential surplus and deficit water availability within the state of Arkansas considering both quantity and quality characteristics of the water.

The data contained in this report were developed from existing sources of published information such as the U.S.G.S., AWRMIS, as well as preliminary reports of the regional committees for the 1975 National Water Assessment and unpublished data developed within the Department of Agricultural Economics and Rural Sociology, University of Arkansas. These sources were examined for information on the quantity, quality, and location of surface waters within the state and the uses of these waters. Estimates of presently available water and water use by major water users were made for the state as well as the Water Resource Planning Area basins.

Future uses of water were projected through the year 2020 by basin and by user considering both quantity and quality characteristics of the water and holding price constant. This procedure is equivalent to projecting future requirements where water use coefficients are applied to projected growth in population, per capita personal

income, earnings, and other user characteristics. The technique ignores any impact which future price changes might have on consumption but can generally be expected to identify the maximum quantities of water that may be necessary.

In evaluating surplus water only "firm" discharges will be considered. "Firm" discharges are those discharges remaining after legal obligations to border states are considered. Thus mean surface water discharges will be adjusted to take account of Arkansas' potential legal obligation to other states as well as our navigation and water quality requirements. Future surface water availability will be assumed to equal present availability adjusted for these legal obligations, navigation, and water quality requirements.

Surface waters will be defined as surplus only if all increases in water requirements can be met. Data on ground water availability within Arkansas is extremely limited. Given the uncertainty of available ground water, no increases in ground water use is projected and all increases in water needs will be met with surface waters. In those area of the state experiencing a decrease in ground water availability, a partial shift from ground water to surface water must also be assumed.

The remainder of this report details the methodology used to estimate present and future water use (Sections I through VI). It also discusses the current legal relationships between Arkansas and Oklahoma and potential compacts with downstream states (Sections VII-IX). Finally, it compares by region projected water use to surface water availability (Section X).

The methodology employed in the OBRA forecasts is based on the assumption that manufacturing water demands are related directly to the output of manufacturing products, and have no direct relationship to employment or population. A common measure of manufacturing output is gross product originating (GPO) which is a constant dollar measure of the output of an industry which can be derived from the OBERS constant dollar earnings figures. Since there is a relatively fixed relationship between GPO and gross water demand, the OBERS projections of gross product originating can be used to project gross industrial water demands. The technical files can be used to estimate water intake, consumption, and discharge. Because it is anticipated that manufacturers will practice recycling to an increasingly greater extent, withdrawal demands may be expected to decrease in most cases over the next 25 years even though gross water demands increase. After that time, however, it is expected that the rates of change in withdrawals will parallel the rates of change in gross demand as the limits to the degree of recycling due to consumptive losses and build-up of dissolved solids most likely will be approached.

The purpose of this section is to obtain estimates by region for five Arkansas Water Resource Planning Areas (AWRPA), which represent portions of Aggregated Sub-Areas (ASA), of manufacturing water withdrawals and consumption for the years 1975, 1985, 2000 and 2020. The AWRPAs and associated ASAs are: (1) Mississippi-St. Francis and Crittenden County (ASA 801), (2) Ouachita and Mississippi-Tensas (ASA 802), (3) White (ASA 1101), (4) Lower Arkansas and Benton County (ASA 1104), and (5) Lower Red (ASA 1107). The AWRPAs are defined by county boundaries which are indicated in Figure 1.

1975 OBRA estimates are adjusted downward utilizing actual real earnings figures. These adjusted figures are more in line with the U.S.G.S. estimates. The projected estimates, however, are based on the assumption that the economy will move toward full employment, which is consistent with the OBERS baseline projections.* These projections would be affected, of course, if the economy failed to attain full employment.

The 1975 estimates, presented in Table I, indicate that most of the state's industrial water use is concentrated in the Lower Arkansas and Ouachita regions. Total intake or withdrawal in these areas accounts for 235 million gallons per day or 85 percent of the state total. The largest water users in these regions are the chemical industry in the Lower Arkansas area and the paper industry in the Ouachita area. The projected estimates indicate the continued dominance of these two regions and industries as water users. The projections show that these regions will account for 88 percent of the state's industrial water withdrawals in the year 2020, and these industries will account for 70 percent of the state total.

* Full employment is defined as a situation where the unemployment rate is equal to 4 percent.

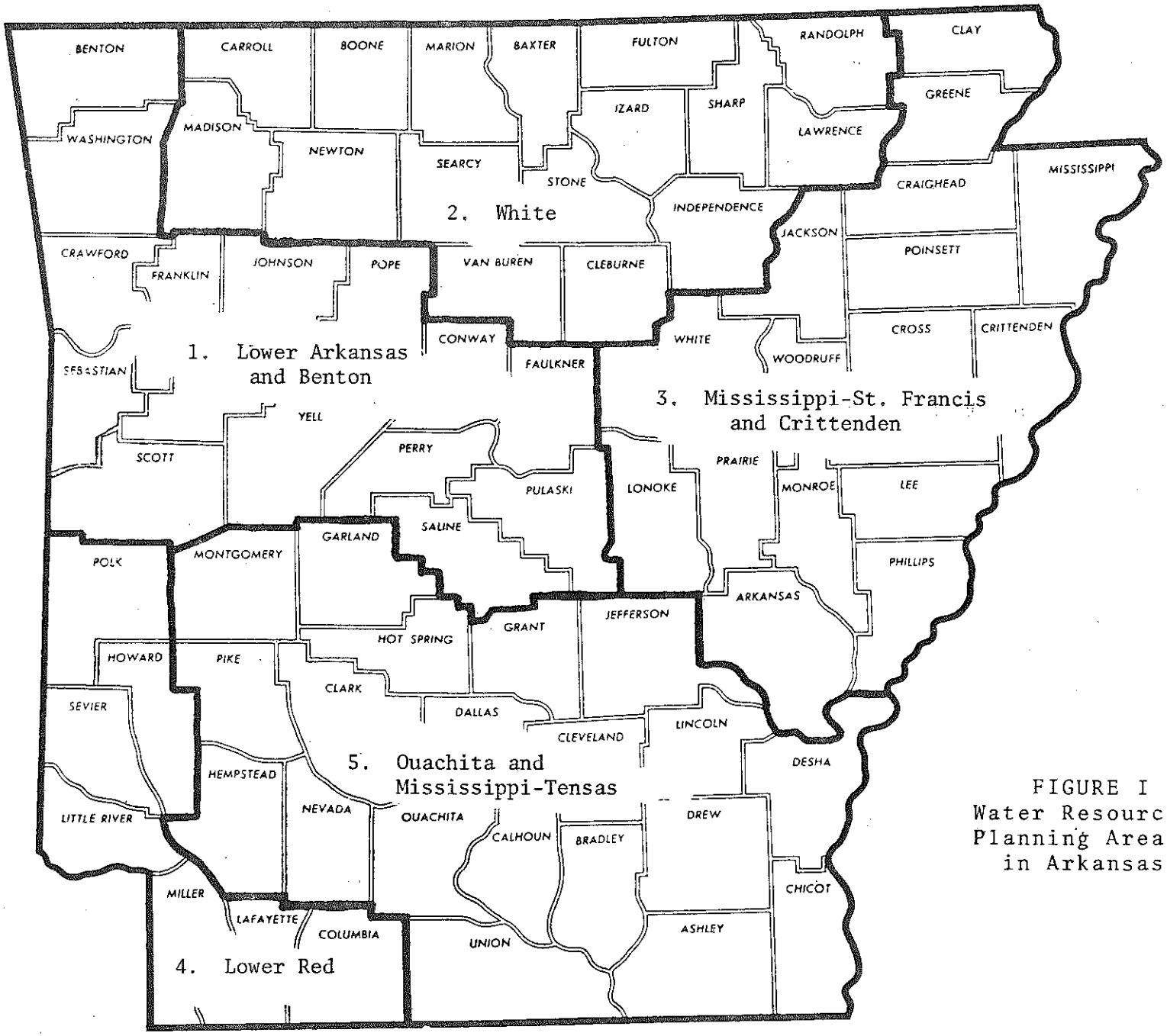

FIGURE I
Water Resource
Planning Areas
in Arkansas

III. MANUFACTURING WATER REQUIREMENTS

The manufacturing water requirements are developed from information provided by the Office of Business Research and Analysis (OBRA) which constructed a water forecasting model.[1] The model is based on three data banks which contain the OBRA file of 9300 large manufacturing plants, the OBERS file of regional economic activity, and several files of technical coefficients such as recirculation rates and consumption rates.

The OBRA file of large plants is the result of a survey made in 1971 of the manufacturing plants which use over 10 million gallons per year. These plants accounted for about 98 percent of the water used by the United States manufacturing sector. The OBERS file contains historical data on population and economic activity as well as Series E projections for the nation and various economic and water resource regions.

The technical coefficient files contain engineering and economic factors which were estimated by OBRA specialists based on their knowledge of industrial water use. These coefficients are calculated for each industry, based on that industry's particular characteristics. One of the files contains estimates of the average recirculation rates that each 4-digit industry should obtain at various points in time. Another file contains estimates of the average consumption rates which correspond to the recirculation rates just mentioned. Other files contain coefficients for estimating water requirements of the smaller manufacturing plants, estimates of the ratio of gross product to earnings at various times, and the estimated number of operating days in the year for each industry.

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[1] The description of the OBRA files and methodology which follows is extracted in large part from a memorandum provided by the Bureau of Domestic Commerce.

The methodology employed in the OBRA forecasts is based on the assumption that manufacturing water demands are related directly to the output of manufacturing products, and have no direct relationship to employment of population. A common measure of manufacturing output is gross product originating (GPO) which is a constant dollar measure of the output of an industry which can be derived from the OBERS constant dollar earnings figures. Since there is a relatively fixed relationship between GPO and gross water demand, the OBERS projections of gross product originating can be used to project gross industrial water demands. The technical files can be used to estimate water intake, consumption, and discharge. Because it is anticipated that manufacturers will practice recycling to an increasingly greater extent, withdrawal demands may be expected to decrease in most cases over the next 25 years even though gross water demands increase. After that time, however, it is expected that the rates of change in withdrawals will parallel the rates of change in gross demand as the limits to the degree of recycling due to consumptive losses and build-up of dissolved solids most likely will be approached.

The purpose of this section is to obtain estimates by region for five Arkansas Water Resource Planning Areas (AWRPA), which represent portions of Aggregated Sub-Areas (ASA), of manufacturing water withdrawals and consumption for the years 1975, 1985, 2000 and 2020. The AWRPAs and associated ASAs are: (1) Mississippi-St.Francis and Crittenden County (ASA 801), (2) Ouachita and Mississippi-Tensas (ASA 802), (3) White (ASA 1101), (4) Lower Arkansas and Benton County (ASA 1104), and (5) Lower Red (ASA 1107). The AWRPAs are defined by county boundaries which are indicated in Figure 1.

Manufacturing water requirements estimates for the years mentioned are available for the entire state by two digit SIC groups in the form of the Department of Commerce's OBRA projections but aren't available by AWRPA. To convert these to regional estimates, the ratio of AWRPA earnings projections to Arkansas earnings for each SIC group is used. The earnings figures were obtained from OBERs Series E projections. To obtain estimates by SIC group of withdrawals and consumption for the years 1985, 2000 and 2020, the OBRA estimates of these figures, stated in millions of gallons per year, are multiplied by the ratio of regional to state earnings for each SIC group in 1980 and divided by 365 to reduce them to millions of gallons per day. The OBRA estimates are in terms of millions of gallons per operating day rather than a 365 day year (e.g., SIC 20 uses a 250 day year but SIC 26 uses a 330 day year to estimate daily water use). In order to permit comparability among the industries, the OBRA figures are converted to a 365 day year. The final step in obtaining the 1985, 2000, and 2020 estimates is to sum the industry totals for each AWRPA.

The above procedure was used originally to obtain 1975 estimates, but the results varied considerably from actual figures published in a U.S.G.S. report for the State of Arkansas.[2] The OBRA estimate is made on the basis of OBERS Series E projections which implicitly assume a full employment economy. Since the economy has been at less than full employment for the past several years, the actual constant dollar earnings are less than the projected. To account for this discrepancy, the original

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[2] H. N. Halberg, Use of Water in Arkansas, 1975, U. S. Geological Survey, 1977. The U.S.G.S. report estimates water use for "self-supplied industry" of 196 MGD for the state in 1975 while the OBRA report estimates 318 MGD for "self-supplied intake."

1975 OBRA estimates are adjusted downward utilizing actual real earnings figures. These adjusted figures are more in line with the U.S.G.S. estimates. Since it is expected the economy will move toward full employment, no such adjustments are made for the projected estimates.

The 1975 estimates, presented in Table I, indicate that most of the state's industrial water use is concentrated in the Lower Arkansas and Ouachita regions. Total intake or withdrawal in these areas accounts for 235 million gallons per day or 85 percent of the state total. The largest water users in these regions are the chemical industry in the Lower Arkansas area and the paper industry in the Ouachita area. The projected estimates indicate the continued dominance of these two regions and industries as water users. The projections show that these regions will account for 88 percent of the state's industrial water withdrawals in the year 2020, and these industries will account for 70 percent of the state total.

TABLE I. MANUFACTURING WATER REQUIREMENTS
FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
	-in million gallons per day-							
Mississippi-St.Francis and Crittenden	20.691	3.665	20.602	9.558	20.833	14.937	28.138	21.733
Ouachita and Mississippi-Tensas	134.667	14.905	172.043	52.096	175.591	138.494	303.890	234.717
White	5.075	0.886	4.459	2.132	4.428	3.045	5.628	4.347
Lower Arkansas and Benton	110.289	18.922	105.522	48.253	105.223	79.882	191.338	147.785
Lower Red	16.413	1.389	22.261	6.475	22.629	17.525	33.766	26.080
STATE TOTAL	287.135	39.767	324.887	118.514	328.704	253.883	562.760	434.662

IV. DOMESTIC WATER REQUIREMENTS

The domestic water requirements are developed from information provided by the United States Department of Agriculture in conjunction with the 1975 National Water Assessment.[3] Domestic water use derives either from central systems or self-supplied systems and is a function of the number of people served by each system and the per capita use of those people. The 1970 Census of Housing is used to determine the number of people on self-supplied systems. A 2.25 percent annual rate of decline in the number of these people is assumed to continue throughout the projection period. Daily per capita use figures (withdrawal and consumption) are determined for self-supplied systems by information gathered from the E.P.A., U.S.G.S. circulars, completed river basin and other studies, Farmers Home Administration, and other sources. The per capita use figures are expected to increase for self-supplied systems with water under pressure but remain the same for those without running water.

The number of people on central systems is determined as the difference between the OBERS Series E projections and the number of people on self-supplied systems determined above. Per capita withdrawal use in Arkansas is determined to be 86.3 gallons per day on the basis of 1970 U.S.G.S. data (Circular 676). Consumptive use is determined to be 0.212 of withdrawal use on the basis of the ratio of total public supplied consumption to total public supplied withdrawal in the Geological Survey data. Domestic central system water requirements are the product of the estimated

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[3] The description of the methodology which follows is extracted from a memorandum form the Special Projects Division of the United States Department of Agriculture.

population served and the per capita use figure which is assumed to remain constant throughout the projection period. This assumption is based on the recent expert opinion that the environmental need for conservation would counteract any additional expansion of usage.

The 1975 National Water Assessment provides data by ASA. The Arkansas' Water Resource Planning Areas, however, represent only a portion of the ASAs with which they are associated. To obtain Arkansas figures, the ration of the population of each AWRPA (estimated from OBERS Series E projections) to that ASA of which it is a part is multiplied by the ASA figure. This procedure is consistent with the U.S.D.A. methodology to determine domestic water requirements.

The results of this procedure are shown in Table II. The 1975 estimates indicate that most of the state's domestic water use is concentrated in the Mississippi-St. Francis and Lower Arkansas regions which account for 105 million gallons per day or 65 percent of the state's total withdrawals. By the year 2020 the largest domestic water user will be the Lower Arkansas area with a daily withdrawal of 103 million gallons, an increase of almost 63 percent from 1975. By comparison the entire state will withdraw 222 million gallons per day or an increase of about 39 percent over the same time period.

TABLE II. DOMESTIC WATER REQUIREMENTS
FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
	in million gallons per day							
Mississippi-St. Francis and Crittenden								
Total:	38.563	10.987	41.255	10.907	44.019	11.252	45.590	11.110
Central	33.461	7.730	35.930	7.617	39.115	8.292	41.786	8.859
Self-supply	5.102	3.257	5.325	3.290	4.904	2.960	3.804	2.251
Ouachita and Mississippi-Twnsas								
Total:	33.775	9.633	36.961	10.348	40.607	10.915	42.168	10.353
Central	28.119	5.961	30.846	6.539	34.747	7.366	38.490	8.160
Self-supply	5.656	3.672	6.115	3.809	5.860	3.549	3.678	2.193
White								
Total:	12.512	4.575	14.384	4.925	16.321	5.121	17.523	4.933
Central	7.897	1.674	9.706	2.058	12.057	2.556	14.222	2.973
Self-supply	4.615	2.901	4.678	2.867	4.264	2.565	3.301	1.960
Lower Arkansas and Benton								
Total:	63.617	16.621	73.489	18.879	88.981	22.125	103.448	24.685
Central	56.021	11.876	65.214	13.825	80.581	17.083	96.216	20.398
Self-supply	7.596	4.745	8.275	5.054	8.400	5.042	7.232	4.287
Lower Red								
Total:	9.443	2.661	10.357	2.853	11.485	3.031	13.979	3.425
Central	7.875	1.670	8.726	1.850	9.958	2.111	12.772	2.708
Self-supply	1.568	0.991	1.631	1.003	1.527	0.920	1.207	0.717
STATE TOTAL								
Total:	160.910	44.477	176.446	47.916	201.413	52.092	222.708	54.506
Central	136.373	28.911	150.442	31.893	176.458	37.056	203.486	43.098
Self-supply	24.537	15.566	26.024	16.023	24.955	15.036	19.222	11.408

V. LIVESTOCK WATER REQUIREMENTS

The livestock water requirements are developed from information provided by the United States Department of Agriculture in conjunction with the 1975 National Water assessment, the United States Geological Survey, the Lower Mississippi Region Comprehensive Study Coordinating Committee and the Statistical Reporting Service of the U.S.D.A.

County water use data reported by the U.S.G.S. was aggregated to form the 1975 estimates of livestock water use for each of the five Arkansas Water Resource Planning Areas.

Growth rates for agricultural livestock water use for the Mississippi-St. Francis and Crittenden and the Ouachita and Mississippi-Tensas areas were developed from projections of the Lower Mississippi Region Comprehensive Study[4] for years 1985, 2000, and 2020. The growth rates of the national WRPA, of which the Arkansas WRPA is a part, was assumed to be representative of the Arkansas situation. Growth factors for the agricultural livestock water use developed by the U.S.D.A. for the Water Resources Council 1975 National Water Assessment were used to project water requirements for the years 1985 and 2000 for the Lower Arkansas and Benton, the White and Red River AWRPAs.[5]

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[4] Lower Mississippi Region Comprehensive Study, Appendix H, pp. 29, 32, 65, 77 and 80, 1974.

[5] Memorandum from Regional Study Director, Paul Willmore of the United States Water Resources Council 1975 Water Assessment to Work Group Chairmen, Ad Hoc Assessment Committee, AWRBIAC, May 13, 1976. Annual Water Requirements Printout dated February 20, 1976 for ASA's 1101, 1104 and 1107.

Growth factors to project 2020 use were not available for the Lower Arkansas and Benton, the White, and the Lower Red AWRPAs. To make this projection, it was assumed that the same ratio of growth rates would exist between each of these regions and the Ouachita-Mississippi-Tensas region over the period 2000 to 2020 as is projected to exist over the period 1985 to 2000.

Growth factors for projected livestock water requirements are a function of (1) drinking water and other water use rates, and (2) livestock production.[6] Drinking water use rates were based on published reports, particularly on J. F. Sykes' "Animals and Fowl and Water" and were based on pasture, range conditions and temperature zones. Non-drinking water use rates were estimated based upon published reports, uses reported in special area studies and on completed river basin studies. Evaporation losses allotted to livestock were assumed to be a proportion of range animal drinking water scaled by net evaporation to precipatation ratios. Watering losses were assumed at 10% and 15% of animal and poultry drinking water, respectively.

Agricultural statistical reports provided data on 1970 livestock numbers. Conversion factors that gave daily quantities of water used for each class of livestock were developed by dividing the daily water requirements by the number of the class of livestock actually produced. Conversion factors were assigned to ASAs by visual interpolation of the completed state factors.

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[6] The description of the methodology which follows is extracted in large part from a memorandum entitled "Methodology and Assumptions for Livestock Water Use Projections," Feb. 1975 provided by the Water Resource Council as a part of the Nationwide Analysis Work Statement Document.

The livestock water requirement for consumption is considered to be equal to withdrawal. Monthly variations were estimated based upon temperatures, seasonal rations, composition of the herd or flock, evaporation from stockwater ponds, and cooling.

Livestock water requirements for Arkansas by AWRPA are presented in Table III.

TABLE III. LIVESTOCK WATER REQUIREMENT FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumptio
	in million gallons per day							
Mississippi-St. Francis and Crittenden	5.95	5.95	6.80	6.80	8.75	8.75	11.76	11.76
Ouachita and Mississippi-Tensas	7.93	7.93	9.45	9.45	12.38	12.38	16.46	16.46
White	11.78	11.78	12.63	12.63	13.95	13.95	15.11	15.11
Lower Arkansas and Benton	16.80	16.80	18.45	18.45	21.28	21.28	24.33	24.33
Lower Red	5.38	5.38	5.98	5.98	7.00	7.00	7.91	7.91
STATE TOTAL	47.84	47.84	53.31	53.31	63.36	63.36	75.57	75.57

VI. IRRIGATION WATER REQUIREMENTS

Estimates of annual water requirements for crop irrigation were developed for each Aggregated Sub-Area (ASA) as part of the 1975 National Water Assessment. However, these estimates did not anticipate the removal of rice acreage allotment restrictions or the large increases in rice acreage that accompanied the removal of acreage restrictions in 1973. Thus, new estimates were required.

Intensive study of the potential for rice acreage expansion has been underway in the Department of Agricultural Economics and Rural Sociology at the University of Arkansas in cooperation with the Economic Research Service of the U.S.D.A. Estimates of irrigated rice acreage presented in this report are based on the findings of these studies.[7]

Potential rice acreages are dependent upon three primary factors; the physical characteristics of the land, i.e. soil type and slope, the availability of water for irrigation, and the relative profitability of rice to alternative crops.

There are presently 2,167,000 acres of land within the primary rice growing areas of Arkansas; Northeast Arkansas, the Grand Prairie, and the Mississippi Delta, which are cleared and highly capable of rice production. An additional 601,250 acres within this region are presently forested but would be prime rice acreage if cleared.

Present rice technology requires rotation of rice with other crops (primarily soybeans) in order to control red rice and noxious weed problems. Thus sustained annual rice production within eastern Arkansas would be limited to 1,083,500 acres assuming a 1 to 1 rotation of cleared land.

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[7] "An Economic Evaluation of the Potential Rice Acreage Expansion in East Arkansas with an Indifference Price Analysis for Rice and Soybeans", MS Thesis by Randall E. Pope, June 1977, University of Arkansas.

In any given year, however, rice acreages may exceed the sustained annual acreage if producers feel higher prices may offset any yield losses due to disease or weed problems.

Rice acreages have doubled from 1970 to 1975. The expansion in rice acreages by both old and new growers was prompted by unprecedented rice prices in 1973, the removal of allotment restrictions and the concurrent shift to irrigated soybeans in response to increasing soybean prices. In rotation, rice and soybeans complement each other in many respects and should a program of unrestricted planting of rice remain in effect, rice will become a regular enterprise (in rotation with soybeans, as well as wheat and grain sorghum) on most farms in eastern Arkansas having significant acreages of clay and mixed soils.

Projected rice acreages were originally developed for both favorable and unfavorable price situations for years through 1985 and for normal and abnormal weather situations for later years. Favorable prices refer to a price-cost situation similar to that which existed in 1973 while unfavorable prices imply a price-cost situation similar to 1975-76. The weather situation refers to weather conditions in Asia. Abnormal weather assumes a five percent reduction in world production from normal weather situations. The total five percent is taken from the Asian region.

Rice acreages for each AWRPA for 1975 were taken from the 1975 Arkansas Irrigation Survey. Expected growth rates for rice acreages were developed from unpublished data within the Department of Agricultural Economics and Rural Sociology, University of Arkansas. These growth rates were applied to the 1975 base acreage to produce projections for 1985, 2000 and 2020. Projected rice acreages reported in Table IV-A represent the midpoint between the various price or weather situations

and assume that an unrestricted planting policy will continue.

Projections of irrigated soybean and irrigated cotton acreages were developed using 1975 figures reported in the 1975 Arkansas Irrigation Survey as a base.[8]

Growth rates for the Mississippi-St. Francis and Crittenden Basin and the Ouachita and Mississippi-Tensas Basin were developed from projected data on pgs. 28,31,63,67,75, and 79 of the Lower Mississippi Region Comprehensive Study, Appendix H. This assumed that the rate of growth for the AWRPA's is identical to the rate projected for the national WRPA of which it is a part.

Growth rates for the White, Lower Arkansas and Benton and Lower Red Basins were taken directly from the Water Resources Council memorandum as developed by the U.S.D.A. as part of the 1975 Water Assessment. Again the AWRPA growth rate was assumed to equal the growth rate for the ASA of which it is a part.

Projections of irrigated soybean and irrigated cotton acreages appear in Table IV-A.

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[8] 1975 Arkansas Irrigation Survey. Arkansas Cooperative Extension Service. University of Arkansas, Division of Agriculture USDA Cooperating.

TABLE IV-A. IRRIGATED ACREAGES FOR RICE, SOYBEANS, AND COTTON FOR ARKANSAS BY AWRPA

Region	1975	1985	2000	2020
	- - - - - - - - - - acres - - - - - - - - - -			
Mississippi-St. Francis and Crittenden				
Soybeans	386,875	464,033	520,579	572,640
Cotton	27,400	26,258	29,150	31,190
Rice	710,198	737,241	817,600	817,600
TOTAL	1,124,473	1,227,532	1,367,329	1,421,430
Ouachita and Mississippi-Tensas				
Soybeans	23,900	27,769	41,690	49,200
Cotton	34,248	33,829	34,930	35,630
Rice	158,457	200,217	222,041	222,041
TOTAL	216,605	261,815	298,661	306,871
White				
Soybeans	406	646	630	630
Cotton	100	156	150	150
Rice	42,500	41,862	46,425	46,425
TOTAL	43,006	42,664	47,205	47,205
Lower Arkansas and Benton				
Soybeans	13,310	14,541	16,880	16,880
Cotton	3,400	2,674	2,870	2,870
Rice	11,147	10,504	11,649	11,649
TOTAL	27,857	27,719	31,399	31,399
Lower Red				
Soybeans	650	688	350	350
Cotton	-	-	-	-
Rice	9,325	10,546	11,695	11,695
TOTAL	9,975	11,234	12,045	12,045
STATE TOTAL	1,421,916	1,570,964	1,756,989	1,818,950
Soybeans	425,141	507,677	580,479	639,700
Cotton	65,148	62,917	67,100	69,840
Rice	931,627	1,000,370	1,109,410	1,109,410

Water withdrawal and consumption factors for each crop were available from the U.S.G.S. report, Use of Water in Arkansas, 1975, Water Resources Summary Number 9. Projected water use for irrigation by AWRPA is reported in Table IV-B.

Water use estimates assume continued use of flood irrigation in rice production and seven percent conveyance losses for irrigation of soybeans and cotton. It is highly probable that center-pivot sprinkler irrigation of rice may replace flooding at some time during the projection period. If this takes place, reductions in irrigation water of 50 to 60 percent for rice could be achieved according to work by Ferguson and Gilmore.[9]

All increases in irrigation projected in Table IV-B will be assumed to be withdrawn from surface water.

Declining ground water tables within the Mississippi-St. Grancis and Crittenden area and the Ouachita and Mississippi-Tensas area will also cause increasing use of surface waters in these regions. A 25 percent shift from ground water to surface water is projected for land which is irrigated in 1975.

Thus surface water will be relied upon to provide an additional 366.101 and 94.478 MGD respectively for the Mississippi-St. Grancis and Crittenden area and the Ouachita and Mississippi-Tensas area. These quantities will be in addition to the increase in withdrawals shown in Table X-B, and are included in the last column of Table X-A.

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[9] Ferguson, James A. and John T. Gilmore, "Center-Pivot Sprinkler Irrigation of Rice", Arkansas Farm Research, Vol. XXVI, NO. 2, March-April, 1977, p. 12, University of Arkansas Agricultural Experiment Station, Fayetteville.

TABLE IV-B. IRRIGATED CROP WATER REQUIREMENTS FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumpt
	in million gallons per day							
ssissippi-St. Francis and Crittenden								
Soybeans	184.800	123.816	222.750	149.240	248.670	166.610	273.340	183.270
Cotton	17.540	11.752	16.890	11.320	18.660	12.500	19.980	13.390
Rice	1,566.480	1,174.860	1,626.400	1,219.800	1,803.600	1,352.700	1,803.600	1,352.700
TOTAL	1,768.820	1,310.428	1,866.040	1,380.360	2,070.930	1,531.810	2,096.920	1,549.360
uachita and Mississippi-Tensas								
Soybeans	11.420	7.650	13.330	8.930	19.910	13.340	23.500	15.745
Cotton	21.900	14.670	21.760	14.580	22.400	15.010	22.800	15.276
Rice	481.760	361.320	715.980	536.985	794.000	595.500	794.000	595.500
TOTAL	515.080	383.640	751.070	560.495	836.310	623.850	840.300	626.521
hite								
Soybeans	.190	.130	.310	.210	.300	.200	.300	.200
Cotton	.060	.040	.100	.070	.100	.070	.100	.070
Rice	98.480	73.860	96.990	72.740	107.600	80.700	107.600	80.700
TOTAL	98.730	74.030	97.400	73.020	108.000	80.970	108.000	80.970
ower Arkansas and Benton								
Soybeans	6.360	4.260	6.980	4.680	8.060	5.400	8.060	5.400
Cotton	2.170	1.450	1.720	1.150	1.840	1.230	1.840	1.230
Rice	23.950	17.960	22.570	16.930	25.030	18.770	25.030	18.770
TOTAL	32.480	23.670	31.270	22.760	34.930	25.400	34.930	25.400
ower Red								
Soybeans	.310	.210	.330	.220	.170	.110	.170	.110
Cotton	-	-	-	-	-	-	-	-
Rice	15.230	11.420	17.220	12.920	19.100	14.325	19.100	14.325
TOTAL	15.540	11.630	17.550	13.140	19.270	14.435	19.270	14.435
STATE TOTAL	2,403.650	1,803.398	2,763.330	2,049.775	3,069.440	2,276.465	3,099.420	2,296.686

VII. POWER GENERATION WATER REQUIREMENTS

The water requirements for power generation were developed directly from information provided by the Federal Power Commission which participated in the 1975 National Water Assessment. The F.P.C. developed estimates of present water use for both steam-electric and hydroelectric plants and also projected future requirements based in part on the OBERS Series E projections.

Both the 1975 estimates and future projections include only those plants with at least 25 megawatts of installed capacity. In general, smaller plants operate for limited periods of the year and do not utilize significant quantities of water.

The F.P.C. water withdrawal estimates for 1975 differ substantially with USGS estimates. For example, the F.P.C. estimated total withdrawals of 427 MGD for the state while the U.S.G.S. estimated 1,717 MGD. The major reason for the discrepancy is the different ways these agencies defined "withdrawal". U.S.G.S. considered as withdrawals all water which was used to cool the condensor regardless of the type of cooling system used, i.e., wet tower, cooling pond, or once-through. The first two systems recirculate the water and to count the entire condensor flow as a withdrawal would overstate withdrawals as the term has been used in this report.

The F.P.C., on the other hand, defines withdrawal for once-through cooling plants as the entire daily condensor flow--but for wet tower and cooling pond plants as the sum of consumptive (evaporation) and water quality (blowdown) uses.

This definition of withdrawals for once-through plants is consistent with the definition used in other parts of this report. The flow of a river will be continually decreased between the point of withdrawal and the point of discharge for a once-through cooling plant. In the case of the wet towers and cooling pond plants, the flow of a river will be only temporarily decreased as the wet tower or cooling pond is filled. Once this filling process is completed, only evaporation losses and blowdown losses will be incurred on a continual basis. The amount of water used by steam-electric plants is thus determined by a combination of factors involving the size and design characteristics of each plant.

The water use estimates for 1975 were based on actual generation data reported to the F.P.C. by the utilities. The estimated cooling water requirements were based on the type of plant (fossil or nuclear), the type of cooling plant, and the generation data supplied by the utilities.

The estimates for 1985 were based on OBERS Series E projections of population and economic activity, along with the expected effects of energy conservation, oil and gas shortages, higher electricity rates, and pollution abatement requirements. They were developed for each plant expected to be in operation in 1985 and then aggregated to the sub-area.

Projections for the other years were made on an assumed growth rate based on the OBERS projection and economic projections as well as the expected increase in the use of electricity in the total energy picture as gas and oil assume significantly smaller roles by that

date. In addition, the estimates reflect increased recirculation rates in steam-electric plants due to more stringent standards on the temperature of the water when discharged.

Table V. shows the estimated water requirements for power generation in various AWRPAs in Arkansas. In 1975 most of the water withdrawals were concentrated in the Mississippi-St. Francis region which accounted for 80 percent of the state total. The projections show that this region will account for an estimated 47 percent of the state's withdrawals in 2020. This dramatic decrease in relative water use is a direct result of the equally dramatic increase in water use in the Lower Arkansas region as well as increased recirculation rates for new plants. All of the estimated withdrawals reflect water use by steam-electric plants. Hydroelectric plants require large amounts of water for turbine flow but do not divert any appreciable amounts.

TABLE V. POWER GENERATION WATER REQUIREMENTS FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption:	Withdrawal	Consumption:	Withdrawal	Consumption:	Withdrawal	Consumption
	- in million gallons per day -							
Mississippi-St. Francis and Crittenden	340.000	0.000	576.000	4.000	238.000	1.000	321.000	2.000
Ouachita and Mississippi-Tensas	55.000	2.000	69.000	4.000	39.000	9.000	68.000	16.000
White	0.000	0.000	0.000	0.000	21.000	14.000	27.000	23.000
Lower Arkansas	30.000	7.000	129.000	37.000	148.000	31.000	269.000	57.000
Lower Red	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
STATE TOTAL	427.000	9.000	774.000	45.000	446.000	55.000	685.000	98.000

VIII. COMMERCIAL FISH FARM, FISH HATCHERY AND WILDLIFE IMPOUNDMENT WATER REQUIREMENTS

COMMERCIAL FISH FARM

The aquaculture industry of Arkansas has experienced considerable fluctuation over time as producers enter and leave the industry. However, most knowledgable people feel production has leveled off. Expert opinion from the National Marine Fisheries Service, U.S. Dept. of Commerce and the Arkansas Game and Fish Commission indicate expected future growth should be in the range of zero to 2.4 percent per year.

Mr. Bill Bailey, Special Projects Coordinator and Supervisor of Hatcheries for the Arkansas Game and Fish Commission expects little change in fish farming acreages in the near future.[10] While some producers are expanding their acreages, others are leaving the business resulting in zero net gain or loss. There are an estimated 41,000 acres of surface water devoted to fish farming at the present time; 21,200 acres devoted to bait fish, minnows and goldfish; 18,000 acres of food fish, primarily catfish, and approximately 1,000 acres of fingerling and miscellaneous fish. Of the total 41,000 acres, approximately 30,000 acres are farmed intensively with annual stocking and harvesting, while 11,000 acres are non-intensive.

Fish Hatcheries, Nursery Ponds and Fishing Lakes

A federal fish hatchery is planned for the White River below the dam on Beaver Reservoir. This hatchery will utilize a raceway system and will have roughly the same water requirements as the Greers Ferry National Fish Hatchery, 11.32 MGD.

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10 Phone communication, June 7, 1977.

Expansion of state owned nursery ponds and fishing lakes are planned, according to Mr. James L. Collins, Assistant Chief of Fisheries Division of the Arkansas Game and Fish Commission. Three new nursery ponds will be constructed in the state. These will be constructed above the power pool level at Beaver Reservoir, Lake Dardanelle, and at Lake Maumelle and will require average withdrawals of .357, .714, and .446 MGD respectively. These withdrawals are required to fill the nursery ponds which are drained and refilled at least once each year.

Six public fishing lakes are also being planned at this time. These lakes will normally be given a fifty percent draw down and refill every four years. Average withdrawals will amount to 5.348 MGD.

Wildlife Impoundments

In 1975, 68.54 MGD was withdrawn from wells or diverted from streams to fill impoundments for migrating ducks and geese. By 1985, two additional state impoundments should be constructed, 1,100 acres at White Oak in Ouachita County, and approximately 900 acres in Sebastian County. These areas will require .982 and .804 MGD respectively.[11]

The federal government is also developing the Felsenthal complex which will include the 65,000 acre Felsenthal National Wildlife Refuge in Union, Ashley, and Bradley Counties. The navigation pool requires 30,000 acre feet of water while an additional 140,000 acre feet of water is required to develop the recreational pool. This represents 125 MGD.[12]

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[11] Communication with Mr. John Sutherland, Assistant Chief, Wildlife Management Division, Arkansas Fish and Game Commision, June 10, 1977.

[12] Hydrological Information from the U.S. Army Corps of Engineers, Vicksburg District.

TABLE VI. COMMERCIAL FISH FARMS, FISH HATCHERIES & WILDLIFE IMPOUNDMENTS
WATER REQUIREMENTS FOR ARKANSAS BY AWRPA

Region	1975		1985		2000		2020	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
Mississippi-St. Francis and Crittenden								
Fish and Minnow Farms	211.65	126.99	213.862	128.317	213.862	128.317	213.862	128.317
Wildlife Impoundments	62.13	-	62.130	-	62.130	-	62.130	-
Total	273.78	126.99	275.992	128.317	275.992	128.317	275.992	128.317
Ouachita and Mississippi-Tensas								
Fish and Minnow Farms	64.06	38.436	66.359	39.815	66.359	39.815	66.359	39.815
Wildlife Impoundments	3.57	-	130.356	-	130.356	-	130.359	-
Total	67.63	38.436	196.715	39.815	196.715	39.815	196.715	39.815
White								
Fish and Minnow Farms	41.71	25.036	42.067	25.24	42.067	25.24	42.067	25.24
Wildlife Impoundments	0.00	-	0.000	-	0.000	-	0.000	-
Total	41.71	25.036	42.067	25.24	42.067	25.24	42.067	25.24
Lower Arkansas and Benton								
Fish and Minnow Farms	21.53	12.919	22.690	13.614	22.690	13.614	22.690	13.614
Wildlife Impoundment	2.84	-	10.876	-	10.876	-	10.876	-
Total	24.37	12.919	43.566	13.614	43.566	13.614	43.566	13.614
Lower Red								
Fish and Minnow Farms	3.65	2.19	4.487	2.692	4.487	2.692	4.487	2.692
Wildlife Impoundments	00.0	-	0.000	-	0.000	-	0.000	-
Total	3.65	2.19	4.487	2.692	4.487	2.692	4.487	2.692
STATE TOTAL	411.14	205.561	562.827	209.678	562.827	209.678	562.827	209.678
Fish and Minnow Farms	342.60	205.561	359.465	209.678	359.465	209.678	562.827	209.678
Wildlife Impoundments	68.54	-	203.362	-	203.362	-	203.362	-

IX. LEGAL OBLIGATIONS TO BORDERING STATES

The Arkansas River Basin Compact of 1970 apportioned up to 60 percent of the annual yield of the Arkansas River Sub-basin to the state of Oklahoma. Annual yield is defined as the computed annual gross runoff that would have passed any certain point on a stream and would have originated within the specified sub-basin under natural conditions, without any man-made depletion or accretion during the water year.

Annual yield figures were developed by T.E. Lamb of the U.S. Geological Survey[13] for both 1974 and 1975. In 1974, the Arkansas River Sub-basin had an annual yield equivalent to 56,834.69 MGD. If Oklahoma retained 60 percent of this as allowed in the compact, Arkansas would have received 22,733.875 MGD. Actual run-off figures as measured at Dam 13 near Van Buren, Arkansas show that Arkansas actually received 41,642.857 MGD or 83 percent more than the compact apportionment.

Annual yield for 1975 was estimated to equal 56,882.14 MGD of which Arkansas had a right to 22,752.857 MGD. Actual runoff measured at Dam 13 showed 41,848.214 MGD which is 84 percent more than the compact apportionment. Oklahoma used only 17 percent of the water allotted to them by the compact in 1974 and 16 percent of their allotment in 1975.

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[13] Report of the Annual Yield of the Arkansas River Basin for the Arkansas River Basin Compact, Arkansas-Oklahoma, 1974 water year: 1975 water year.

If Oklahoma were to withdraw all of its Arkansas River allotment, the flow of the Arkansas at Dam No. 13 would be decreased by 45.5 percent. The discharge of the Arkansas at Murray Dam at Little Rock would be decreased by 37.0 percent.

Legally required flows at Van Buren represents 40 percent of the annual yield of the Arkansas River Sub-basin in Oklahoma. The legally restricted flow at Little Rock represents that flow which would exist if Oklahoma were to increase its use from present levels to maximum allowable levels and normal accretion and depletion of Arkansas River waters ixisted between Van Buren and Little Rock.

Actual flow and legally required flow for water years 1971 through 1975 for the Arkansas River at Dam No. 13 near Van Buren, Arkansas and actual flow and legally restricted flow for the Arkansas River at Murray Dam, Little Rock, Arkansas are shown in Table VII.

The period from water year 1970 through water year 1975 was selected as the basis for computing normal discharge for the Arkansas River as this period follows the completion of the McClellan-Kerr Arkansas River Navigation System in November, 1970.[14]

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[14] Conversation with Mr. David Buroughs, Planning Division, U.S. Army Corps of Engineers, Little Rock, May 24, 1977.

TABLE VII. ACTUAL FLOW AND LEGALLY REQUIRED FLOW OF THE ARKANSAS RIVER, 1971 THROUGH 1975

Water Year	Actual Flow	Legally Required Flow
	Arkansas River at Dam No. 13 Near Van Buren	
	- - - -in million gallons per day- - - - - - -	
1971	12,910.714	7,036.339
1972	12,794.643	6,973.080
1973	45,669.643	24,889.955
1974	41,642.857	22,733.875
1975	41,848.214	22,752.857
Average 1971-75	30,973.219	16,877.221
	Arkansas River at Murray Dam at Little Rock	
1971	17,321.429	11,447.054
1972	15,794.643	9,973.080
1973	57,482.143	36,702.455
1974	49,732.143	30,823.161
1975	50,008.929	30,913.571
Average 1971-75	38,067.857	23,971.864

X. ESTIMATES OF "FIRM DISCHARGES FOR MAJOR RIVER BASINS

In evaluating surplus water only "firm" discharges should be considered. "Firm" discharges are those discharges remaining after legal obligations to border states are considered. At the present time, Arkansas' only agreement with a border state is the Arkansas River Basin Compact of 1970. However, other such compacts are in the mill and similar agreements may be expected.

The mean discharge of the Arkansas' major river basins are presented in Table VIII. These figures were obtained from Water Resources Data for Arkansas[15] and with the exception of the Arkansas River, represent the average discharge for the stream for the periof of record as reported for the most recent year for which data is available. The Arkansas River discharge is the average discharge for water years 1971 through 1975; years following the completion of the Mc Clellan-Kerr Navigation Project.

Arkansas presently has an average discharge of 78,686.608 MGD. This figure would be reduced to 64,590.610 MGD if Oklahoma were to remove its entire allotment of Arkansas River Basin water.

Arkansas' "firm discharge #1" is developed assuming compacts will be developed with Missouri, Oklahoma, Texas, and Louisiana on all waters which flow directly between the states. These compacts would apportion 60

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15 Water Resources Data for Arkansas. U.S. Geological Survey. Water Resource Data for Arkansas, water year 1975, Water Data Report AR-75-1. Reported with the cooperation of the Arkansas Soil and Water Conservation Commission and other state and federal agencies. Also water years; 1974, AR-74-1&2 and 1973 AR-73-1.

percent of the annual yield of streams to the state where the water originated. The remaining 40 percent must be allowed to flow to the downstream state.

Under these conditions Arkansas would receive 40 percent of the annual yield of streams entering the state and in turn would be required to allow 40 percent of the annual yield of Arkansas streams to flow to the downstream states of Louisiana and Missouri.

Firm discharge #1 assumes that no compacts will be developed for waters flowing into the Mississippi River. While this is the most likely situation, it would be unreasonable to ignore the possibility of legal obligations on these waters. "Firm Discharge #2" is developed assuming a legal obligation to allow 40 percent of the annual yield of all Arkansas streams to flow out of the state. This includes not only those with which flow directly into Louisiana and Missouri, covered under "firm Discharge#1", but also those waters which flow into the Mississippi River.

Since annual yield figures have been computed for only the Arkansas River Sub-basin, it is assumed that the relationship between the annual yield and discharge on all other streams will be proportional to the relationship between annual yield and discharge for the Arkansas River Sub-basin as reported for the Arkansas River Basin Compact. There, discharge represented 73 percent of annual yield or conversly annual yield equalled 137 percent of discharge. Based on this relationship, the "firm" discharge of Arkansas' major river basins was computed. "Firm Discharge #1" and "Firm Discharge #2" figures for the major river basins and the state are presented in Table VIII.

TABLE VIII. PRESENT DISCHARGES AND PROJECTED "FIRM" DISCHARGES FOR ARKANSAS MAJOR RIVER BASINS

Region	Mean[2] Discharge	Firm[3] Discharge #1[4]	Firm Discharge #2[5]
Mississippi-St.Francis & Crittenden			
White River between Newport and Clarendon	4,450.509	4,450.509	2,011.630
St. Francis at Parkin, AR	1,829.464	1,212.406	548.008
L'Anguille River at Plaestine, AR	763.929	763.929	345.296
	7,043.902	6,426.844	2,904.934
Ouachita & Mississippi-Tensas			
Ouachita River at Camden, AR	4,825.000	2,181.164	2,181.164
Bayou Bartholomew near McGehee, AR	445.089	201.205	201.205
Saline River near Rye, AR	1,696.429	766.880	766.880
Moro Creek near Fordyce, AR	148.125	66.960	66.960
	7,114.643	3,216.209	3,216.209
White			
White River at Clarendon, AR	14,870.920	11,497.694	5,196.958
Lower Arkansas & Benton			
Arkansas River at Little Rock, AR	38,067.857	23,971.864	10,835.282
Lower Red			
Red River at Fulton, AR	11,589.286	3,165.665	3,165.665

[1]Mean discharge for period of record as most recently reported by U.S.G.S in Water Resources Data for Arkansas.

[2]Mean discharge for period 1971 to 1975.

[3]"Firm" discharges are those discharges remaining after projected legal obligations to border states are considered.

[4]Assume compacts with Oklahoma, Missouri, Texas, and Louisiana on all waters which flow directly between the states.

[5]Assume compacts on all incoming and outgoing waters.

XI. LEGAL OBLIGATIONS, NAVIGATION, AND WATER QUALITY REQUIREMENTS

Additional water may not be required to meet future navigation and water quality requirements. The same water which is available to downstream border states is also available to Arkansas for navigation and dilution and assimilation of waste discharges. Only in cases where navigation or water quality requirements exceed the amount of water which Arkansas may be legally obligated to provide to downstream states, will additional water be required.

Navigation requirements were determined through communication with the U.S. Army Corps of Engineers at Little Rock, Arkansas[16] and Memphis, Tennessee[17] and generally represents the flow necessary to maintain a nine foot channel ninety five percent of the time.

Water quality flow requirements are assumed to equal the seven day, ten year low flow of each river as reported by the U.S. Geological Survey.[18] Stream flow water quality standards as established and enforced by the Arkansas Department of Pollution Control and Ecology assume a river flow equivalent to the seven day, ten year low flow.

Table IX presents the potential legal obligations to border states, as well as navigation requirements, water quality requirements and additional water required for navigation or water quality maintenance above and beyond legal obligations.

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16 Conversation with Mr. David Burrough, Planning Division, Little Rock District, U.S. Army Corps of Engineers, Little Rock, Arkansas, January 26, 1977.

17 Conversation with Mr. Mike White, Planning Division, Memphis District, U.S.Army Corps of Engineers, Memphis Tennessee, January 27, 1977.

18 Flow Duration and Low-Flow Frequency Determinations of Selected Arkansas Streams by Marion S. Hines, J.S. Geological Survey Water Resources Circular NO. 12, 1975.

This additional water must be subtracted from the firm discharge of the basin to determine the water use expansion potential of the basin.

Navigations and water quality repuirements can be met by the legal obligations to other states for all streams except the White River. In the White River Basin, navigation requirements exceed legal obligations by 7,326.467 MGD under the assumptions of Firm Discharge #1.

As the White River flows into the Mississippi-St. Francis and Crittenden Region an additional 4,160.991 MGD must be provided for navigation before reaching De Valls Bluff. These amounts must be taken from the basins firm discharge.

Under the assumptions of "Firm Discharge #2", legal obligations on all outgoing waters will allow an adequate flow to cover navigation and water quality requirements on all streams except for the White River between Newport and Clarendon. Here an additional 1,722.112 MGD must be available.

TABLE IX. LEGAL OBLIGATIONS, NAVIGATIONS REQUIREMENTS, AND WATER QUALITY REQUIREMENTS FOR ARKANSAS BY AWRPA

Region	Legal Obligations to Border States Firm 1	Legal Obligations to Border States Firm 2	Navigation Requirements[1]	Water Quality Requirements	Navigation or Water Requirements in Excess of Legal Obligations to Border State: Firm 1	Navigation or Water Requirements in Excess of Legal Obligations to Border State: Firm 2
Mississippi-St. Francis and Crittenden						
White River between Newport and Clarendon	0000.000	2,438.879	4,160.991[2]	3,196.936[4]	4,160.991	1,722.112
St. Francis River at Parkin, AR	617.058	1,281.456		439.629	0.000	0.000
L'Anguille River at Palestine, AR	0000.000	418.633		.555	0.000	0.000
Basin Total	617.058	4,138.968		439.784	4,160.991	1,722.112
Ouachita and Mississippi-Tensas						
Ouachita River at Camden, AR	2,643.836	2,643.836	1,934.984[3]	270.898	0.000	0.000
Bayou Bartholomew near McGehee, AR	243.884	243.884		7.430	0.000	0.000
Saline River near Rye, AR	929.550	929.550		17.028	0.000	0.000
Moro Creek near Fordyce	81.125	81.125		0.000	0.000	0.000
Basin Total	3,898.395	3,898.395		295.356	0.000	0.000
White						
White River at Newport, AR	3,373.223	12,112.840	10,699.690[2]	2,267.460	7,326.467	0.000
Lower Arkansas and Benton						
Arkansas River at Little Rock, AR	14,095.993	27,232.575	4,643.963	2,492.260	0.000	0.000
Lower Red						
Red River at Fulton, AR	8,423.641	8,423.641		834.365	0.000	0.000
STATE TOTAL	30,408.310	55,806.419				

(footnotes continued-next pag

[1]10 year, seven day low flow figures taken from most recent U.S.G.S. Water Resource Data for Arkansas.

[2]14,860.681 MGD is required for navigation at DeValls Bluff, this has been divided between the White Region and the Mississippi-St. Francis-Crittenden region in proportion to firm discharge availability.

[3]Present navigation requirement. Future requirement is 406.4 MGD.

[4]Total water quality requirements at Clarendon is 5,464.396 MGD, however 2,267.460 MGD is required at Newport; assuming this remains in the stream only 3,196.936 MGD additional will be needed at Clarendon.

XII. FUTURE WATER USE AND SURFACE WATER AVAILABILITY

This section of the report summarizes the present and projected water uses developed in previous sections and compares the projected increases in water requirements from 1975 to the year 2020 with firm discharges adjusted for navigation and water quality requirements.

Total water withdrawals for Arkansas by AWRPA for 1975 and 2020 are presented in Table X-A. The Mississippi-St. Francis and Crittenden area used the greatest amount of water in 1975 representing 65 percent of the state's total use. The majority of this water was ground water used for irrigation. While this region will continue to expand its use, its proportion of the total state withdrawal is projected to decrease to 53 percent by 2020.

The projected increase in water withdrawal within the AWRPAs range from 13.56 percent in the Mississippi-St. Francis and Crittenden area to 140.17 percent in the Lower Arkansas and Benton area. Statewide total withdrawals are projected to increase by 1,907.189 MGD by 2020.

Increased withdrawals are not the only source of decreasing water availability in Arkansas. Measurements of the mean discharge for each basin as reported by the U.S.G.S. have been recorded as close as possible to the basin's discharge point within the state. Thus, the major water withdrawals within the state have already been made and in most cases user discharges have re-entered the rivers as return flows. If major water users within a basin were to increase their consumption of water while decreasing, maintaining, or increasing to a lesser degree their withdrawal, the impact would be to decrease mean discharges through the decrease in return flows.

Thus, evaluation of the use of Arkansas waters must include not only changes in withdrawals but also changes in consumption. In some cases, increases in consumption may exceed increases in withdrawals. This situation will likely be the case in manufacturing and power where increased recirculation and land disposal is required to meet environmental regulations. Table X-B presents total water consumption for Arkansas by AWRPA and user group for 1975 and 2020.

Table X-C presents a comparison of increased water requirements and surface water availability for Arkansas by AWRPA. Increased water requirements are equal to the increase in consumption or withdrawals for each user group, whichever is larger. These are then aggregated to equal the increased water requirements of the AWRPA. Surface water availability is equal to firm discharges minus the excess of navigation and water quality requirements over potential legal obligations to bordering states. With the exception of the Mississippi-St. Francis and Crittenden and the White River region, surface water availability was equal to firm discharges. In the White River region, navigation and water quality requirements exceeded anticipated legal obligations by 7,326.467 MGD under the assumptions of "firm discharge #1". This amount was subtracted from firm discharges to arrive at the figure shown in Table X-C. Likewise, 4,160.991 MGD and 1,722.112 MGD had to be subtracted from firm discharge in the Mississippi-St. Francis and Crittenden Region under assumptions of "firm discharge #1" and "firm discharge #2" respectively.

The figure in Table X-C indicate that Arkansas will have surface water available in excess of projected requirements. This excess is equal

to 34,740.449 MGD assuming legal obligations on all waters flowing directly between Missouri, Oklahoma, Texas, Louisiana and Arkansas. This is 44 percent of the present mean discharge of Arkansas' streams.

If all incoming and outgoing waters were under compact, Arkansas excess will equal 21,546.569 MGD or approximately 27 percent of the present mean discharge of Arkansas' streams.

The state of Arkansas is projected to require the use of up to 73 percent of its surface water flows under the assumptions of this study. The most dramatic impacts of these projections result from the potential legal obligations to down stream border states and the expected partial shift from ground water to surface water for irrigation.

All regions of the state are expected to have water surpluses in 2020. The Mississippi-St. Francis and Crittenden region has the greatest potential to experience a water shortage. This potential may be decreased through effective water management within the region and a shift from flood irrigation to center-pivot irrigation.

Each of the AWRPAs is a relatively large area and, consequently, parts of a region may face serious water problems even though the region as a whole may have more than enough water to satisfy its users. Present water law in Arkansas does not permit the transfer of water from one basin to another.

The estimated surpluses are based on the expected physical amount of water available without consideration of the cost of making that amount available to potential users. Explicit consideration of prices and costs could conceivably alter the major findings of this study, but these are topics of another study.

TABLE X-A. TOTAL WATER WITHDRAWAL FOR ARKANSAS BY AWRPA. 1975-2020

Region	1975	2020	Increased Water Withdrawal 1975-2020
	- - in million gallons per day- - - - -		
Mississippi-St. Francis & Crittenden			
Manufacturing	20.691	28.138	7.447
Domestic	38.563	45.590	7.027
Livestock	5.950	11.760	5.810
Irrigation	1,768.820	2,096.920	694.201[1]
Power	340.000	321.000	-19.000
Fish Farm	273.780	275.992	2.212
Total	2,447.804	2,779.400	697.697
Ouachita & Mississippi-Tensas			
Manufacturing	134.667	303.890	169.223
Domestic	33.775	42.168	8.393
Livestock	7.930	16.460	8.530
Irrigation	515.080	840.300	419.698[2]
Power	55.000	68.000	13.000
Fish Farm	67.630	196.715	129.085
Total	814.082	1,467.533	747.929
White			
Manufacturing	5.075	5.628	.553
Domestic	12.512	17.523	5.011
Livestock	11.780	15.110	3.330
Irrigation	98.730	108.000	9.270
Power	0.000	27.000	27.000
Fish Farm	41.710	42.067	.357
Total	169.807	215.328	45.521
Lower Arkansas & Benton			
Manufacturing	110.289	191.338	81.049
Domestic	63.617	103.448	39.831
Livestock	16.800	24.330	7.530
Irrigation	32.480	34.930	2.450
Power	30.000	269.000	239.000
Fish Farm	24.370	43.566	19.196
Total	277.556	666.612	389.056
Lower Red			
Manufacturing	16.413	33.766	17.353
Domestic	9.443	13.979	4.536
Livestock	5.380	7.910	2.530
Irrigation	15.540	19.270	3.730
Power	2.000	0.000	-2.000
Fish Farm	3.650	4.487	0.837
Total	52.426	79.412	26.986
STATE TOTAL	3,761.675	5,208.285	1,907.189

[1] 366.101 MGD has been added to increased withdrawals to reflect a 25 percent shift from ground water to surface water.

[2] 94.478 MGD has been added to increased withdrawals to reflect a 25 percent shift from ground water to surface water.

TABLE X-B. TOTAL WATER CONSUMPTION FOR ARKANSAS BY AWRPA
1975-2020

Region	1975	2020	Increased Water Consumption 1975-2020
	- - -in million gallons per day- - -		
Mississippi-St. Francis& Crittenden			
Manufacturing	3.665	21.733	18.068
Domestic	10.987	11.110	0.123
Livestock	5.950	11.760	5.810
Irrigation	1,310.428	1,549.360	238.932
Power	0.000	2.000	2.000
Fish Farm	126.990	128.317	1.327
Total	1,458.020	1,924.778	266.260
Ouachita & Mississippi-Tensas			
Manufacturing	14.905	234.717	219.812
Domestic	9.633	10.353	0.720
Livestock	7.930	16.460	8.530
Irrigation	383.640	626.521	242.881
Power	2.000	16.000	14.000
Fish Farm	38.436	39.815	1.379
Total	456.544	943.866	487.322
White			
Manufacturing	0.886	4.347	3.461
Domestic	4.575	4.933	0.358
Livestock	11.780	15.110	3.330
Irrigation	74.030	80.970	6.940
Power	0.000	23.000	23.000
Fish Farm	25.026	25.240	0.214
Total	116.297	153.600	37.303
Lower Arkansas & Benton			
Manufacturing	18.922	147.785	128.863
Domestic	16.621	24.685	8.064
Livestock	16.800	24.330	7.530
Irrigation	23.670	25.400	1.730
Power	7.000	57.000	50.000
Fish Farm	12.919	13.614	0.695
	95.932	292.814	196.882
Lower Red			
Manufacturing	1.389	26.080	24.691
Domestic	2.661	3.425	0.764
Livestock	5.380	7.910	2.530
Irrigation	11.630	14.435	2.805
Power	0.000	0.000	0.000
Fish Farm	2.190	2.692	0.502
Total	23.250	54.542	31.292
STATE TOTAL	2,150.043	3,369.600	1,019.059

TABLE X-C. COMPARISON OF INCREASED WATER REQUIREMENTS AND SURFACE WATER AVAILABILITY FOR ARKANSAS BY AWRPA 2020

Region	Projected Increase In Water Requirements From 1975 to 2020	Available Surface Water Assuming		Excess Surface Water Availability	
		Firm #1	Firm #2	Firm #1	Firm #2
	in million gallons per day				
Mississippi-St. Francis and Crittenden	729.227	2,265.853	1,182.822	1,536.626	453.596
Ouachita and Mississippi-Tensas	799.518	3,216.209	3,216.209	2,416.691	2,416.691
White	48.429	4,171.226	5,196.958	4,122.797	5,148.529
Lower Arkansas and Benton	436.870	23,971.864	10,835.282	23,534.994	10,398.412
Lower Red	36.324	3,165.665	3,165.665	3,129.341	3,129.341
STATE TOTAL	2,050.368	36,790.817	23,596.936	34,740.449	21,546.569

[1]Increase in water requirement is equal to the increase in consumption or withdrawals for each user group, which ever is larger. User groups were then aggregated to form region estimates.

[2]Available surface water is equal to firm discharges minus any navigation and water quality requirements in excess of legal obligations to border states.