THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Arkansas-White-Red Region

Second National Water Assessment by the U.S. Water Resources Council

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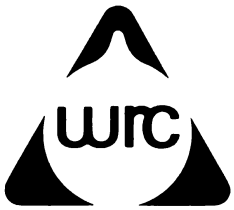

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Foreword

The Water Resources Planning Act of 1965 (Public Law 89-80) directs the U.S. Water Resources Council to maintain a continuing study of the Nation's water and related land resources and to prepare periodic assessments to determine the adequacy of these resources to meet present and future water requirements. In 1968, the Water Resources Council reported the results of its initial assessment. The Second National Water Assessment, a decade later, provides a comprehensive nationally consistent data base for the water resources of the United States. The results of the Second National Water Assessment were obtained by extensive coordination and collaboration in three phases.

Phase I: Nationwide Analysis

The Council member agencies researched, analyzed, and prepared estimates of current and projected water requirements and problems and the implications of the estimates for the future.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed State and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting State and regional objectives, and (3) problems and conflicts needing resolution.

Phase III: National Problem Analysis

The Council conducted this final phase in three steps: (1) An evaluation of phases I and II, (2) an analysis that identified and evaluated the Nation's most serious water resources problems, and (3) the preparation of a final report entitled "The Nation's Water Resources--1975-2000."

The final report of the Second National Water Assessment consists of four separate volumes as described below. These volumes can assist Federal, State, local, and other program managers, the Administration, and the Congress in establishing and implementing water resources policies and programs.

Volume 1, Summary, gives an overview of the Nation's water supply, water use, and critical water problems for "1975," 1985, and 2000 and summarizes significant concerns.

Volume 2, Water Quantity, Quality, and Related Land Considerations, consists of one publication with five parts:

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the numerous documents that are part of the assessment, and ident-

ifies the individuals and agencies that contributed to the assessment.

II, "Water-Management Problem Profiles," identifies ten general water problem issues and their implications and potential consequences.

Part III, "Water Uses," focuses on the national perspectives regarding existing ("1975") and projected (1985 and 2000) requirements for water to meet offstream, instream, and flow-management needs. State-regional and Federal perspectives are compared.

Part IV, "Water Supply and Water Quality Considerations," analyzes the adequacy of fresh-water supplies (ground and surface) to meet existing and future requirements. It contains a national water budget; quantifies surface- and ground-water supplies, reservoir storage, and transfers of water within and between subregions; describes regional requirements and compares them to supplies; evaluates water quality conditions; and discusses the legal and institutional aspects of water allocation.

Part V, "Synopses of the Water Resources Regions," covers existing conditions and future requirements for each of the 21 water resources regions. Within each regional synopsis is a discussion of functional and location-specific water-related problems; regional recommendations regarding planning, research, data, and institutional aspects of solving regional water-related problems; a problem-issue matrix; and a comparative-analysis table.

Volume 3, Analytical Data, describes the methods and procedures used to collect, analyze, and describe the data used in the assessment. National summary data are included with explanatory notes. Volume 3 is supplemented by five separately published appendixes that contain data for the regions and subregions:

Appendix I, Social, Economic, and Environmental Data, contains the socioeconomic baseline ("1975") and growth projections (1985 and 2000) on which the water-supply and water-use projections are based. This appendix presents two sets of data. One set, the National Future, represents the Federal viewpoint; the other set, the State-Regional Future, represents the regional sponsor and/or State viewpoint.

Appendix II, Annual Water Supply and Use Analysis, contains baseline water-supply data and baseline and projected water withdrawal and water-consumption data used for the assessment. Also included are a water adequacy analysis, a natural flow analysis, and a critical-month analysis.

Appendix III, Monthly Water Supply and Use Analysis, contains monthly details of the water-supply, water-withdawal, and water-

consumption data contained in Appendix II and includes an analysis of monthly water adequacy.

Appendix IV, Dry-Year Conditions Water Supply and Use Analysis, contains both annual and monthly baseline and projected water-withdrawal and water-consumption data for dry conditions. Also, a dry conditions water-adequacy analysis is included.

Appendix V, Streamflow Conditions, contains detailed background information on the derivation of the baseline streamflow information. A description of streamflow gages used, correction factors applied, periods of record, and extreme flows of record, are given for each subregion. Also included is the State-Regional Future estimate of average streamflow conditions.

Volume 4, Water Resources Regional Reports, consists of separately published reports for each of the 21 regions. Synopses of these reports are given in Volume 2, Part V.

For compiling and analyzing water resources data, the Nation has been divided into 21 major water resources regions and further subdivided into 106 subregions. Eighteen of the regions are within the conterminous United States; the other three are Alaska, Hawaii, and the Caribbean area.

The 21 water resources regions are hydrologic areas that have either the drainage area of a major river, such as the Missouri Region, or the combined drainage areas of a series of rivers, such as the South Atlantic-Gulf Region, which includes a number of southeastern States that have rivers draining directly into the Atlantic Ocean and the Gulf of Mexico.

The 106 subregions, which are smaller drainage areas, were used exclusively in the Second National Water Assessment as basic data-collection units. Subregion data point up problems that are primarily basinwide in nature. Data aggregated from the subregions portray both regional and national conditions, and also show the wide contrasts in both regional and national water sources and uses.

The Second National Water Assessment and its data base constitute a major step in the identification and definition of water resources problems by the many State, regional, and Federal institutions involved. However, much of the information in this assessment is general and broad in scope; thus, its application should be viewed in that context, particularly in the area of water quality. Further, the information reflects areas of deficiencies in availability and reliability of data. For these reasons, State, regional, and Federal planners should view the information as indicative, and not the only source to be considered. When policy decisions are to be made, the effects at State, regional, and local levels should be carefully considered.

In a national study it is difficult to reflect completely the regional variations within the national aggregation. For example, several regional

reviewers did not agree with the national projections made for their regions. These disagreements can be largely attributed either to different assumptions by the regional reviewers or to lack of representation of the national data at the regional level. Therefore, any regional or State resources-management planning effort should consider the State-regional reports developed during phase II and summarized in Volume 4 as well as the nationally consistent data base and the other information presented in this assessment.

Additional years of information and experience show that considerable change has occurred since the first assessment was prepared in 1968. The population has not grown at the rate anticipated, and the projections of future water requirements for this second assessment are considerably lower than those made for the first assessment. Also, greater awareness of environmental values, water quality, ground-water overdraft, limitations of available water supplies, and energy concerns are having a dramatic effect on water-resources management. Conservation, reuse, recycling, and weather modification are considerations toward making better use of, or expanding, available supplies.

CONTENTS

Illustrations

Physiography

Description

The Arkansas-White-Red Region embraces about 244,000 square miles[1] (7 percent of the Nation) in the south-central portion of the United States between the Continental Divide and the Mississippi River. The three major rivers, the Arkansas, White, and Red, drain the region which includes all of Oklahoma and parts of Colorado, New Mexico, Kansas, Missouri, Arkansas, Texas, and Louisiana (Figure 11-1).

With the exception of the White River, which drains a part of the Ozark Plateau in the northeast corner of the region, the rivers originate on the eastern slopes of the southern Rocky Mountains and in the High Plains that are the western extreme of the region. Elevations range from a few feet above sea level in Louisiana to over 14,000 feet above sea level in Colorado. Between the mountains and the rich alluvial farmlands of the Mississippi Valley, the rivers flow through the High Plains of Colorado, Kansas, New Mexico, Oklahoma, and Texas, where the land is devoted primarily to livestock and grain production and to the production of oil, gas, and metallic and nonmetallic minerals (Figure 11-2). Some of the major cities include Colorado Springs, and Pueblo, Colorado; Wichita, Kansas; Oklahoma City, and Tulsa, Oklahoma; Amarillo, Texas; Springfield, Missouri; Little Rock, Arkansas; and Shreveport, Louisiana.

In the headwaters of the Arkansas, Red, and Canadian Rivers, waterflow and quality are satisfactory for most needs except in drought periods. However, as the rivers enter the plains, their flows decrease and become highly saline. Low flows in the plains portions of the basins result from scanty rainfall and withdrawals for agriculture and other needs. Salinity increases are induced by irrigation return flows, inflows from natural brine springs and seeps, and the entrance of oil field brines. In the eastern portion of the region, only the White River has water quality and flows which have been satisfactory for most needs.

Geology

Surface and subsurface geologic formations vary widely throughout the region. The oldest rocks of geologic history (Cryptozoic and Precambrian Eras) outcrop in the Rocky Mountains of Colorado and New Mexico and in Oklahoma. Precambrian rocks underlie a series of geologic formations of the region in Colorado, Kansas, Missouri, Arkansas, Oklahoma, and Texas. Frequently these formations are important sources of metallic minerals in Colorado, New Mexico, southeastern Kansas, Missouri, Arkansas, Oklahoma, and Texas. They yield some ground water and provide aggregate and stone in outcrop areas.

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[1] This is the sum of the areas of counties used to approximate the hydrologic area of the region. Land use and other socioeconomic data are related to this area. The drainage area within the hydrologic boundary is 247,540 square miles.

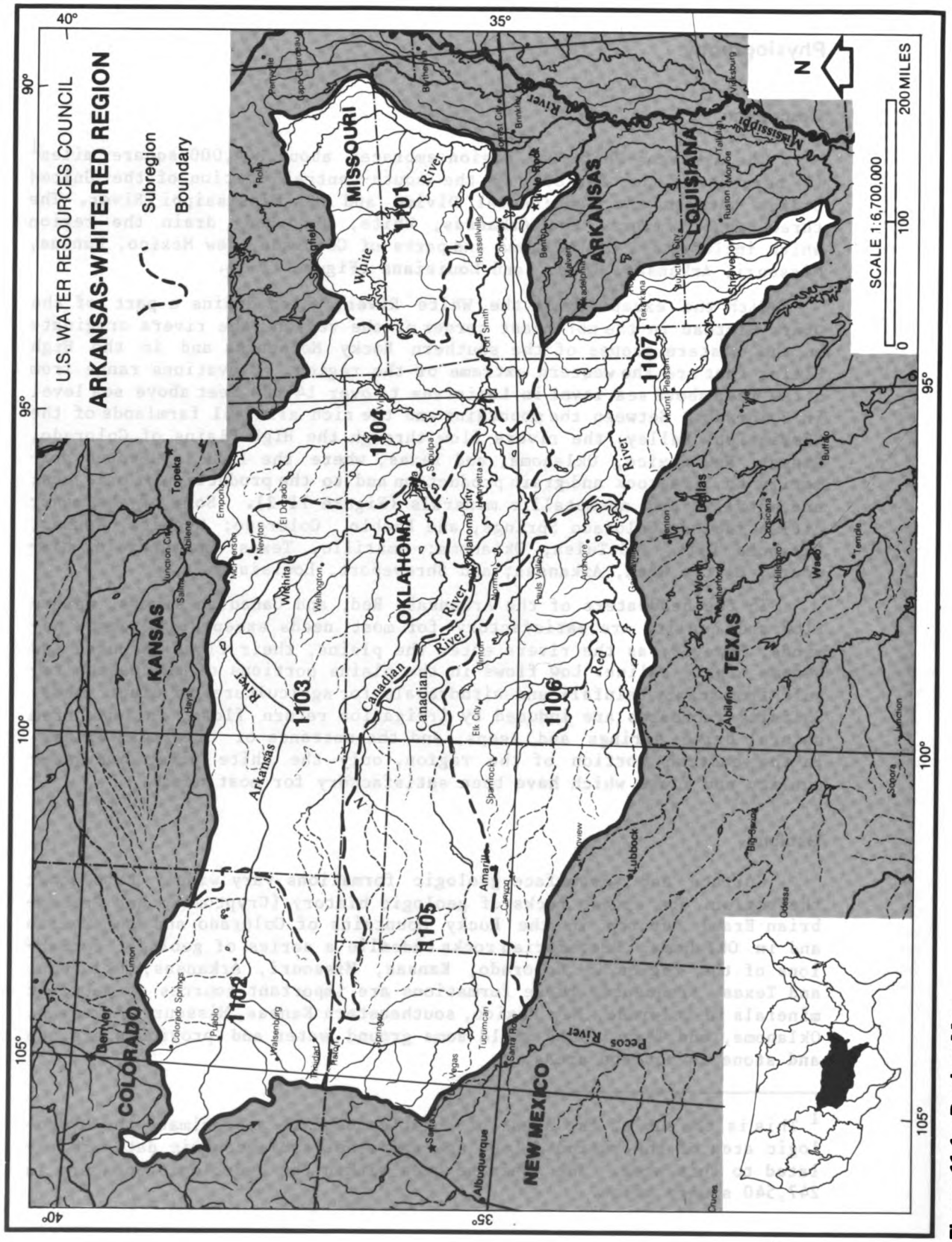


Figure 11-1. Region Map

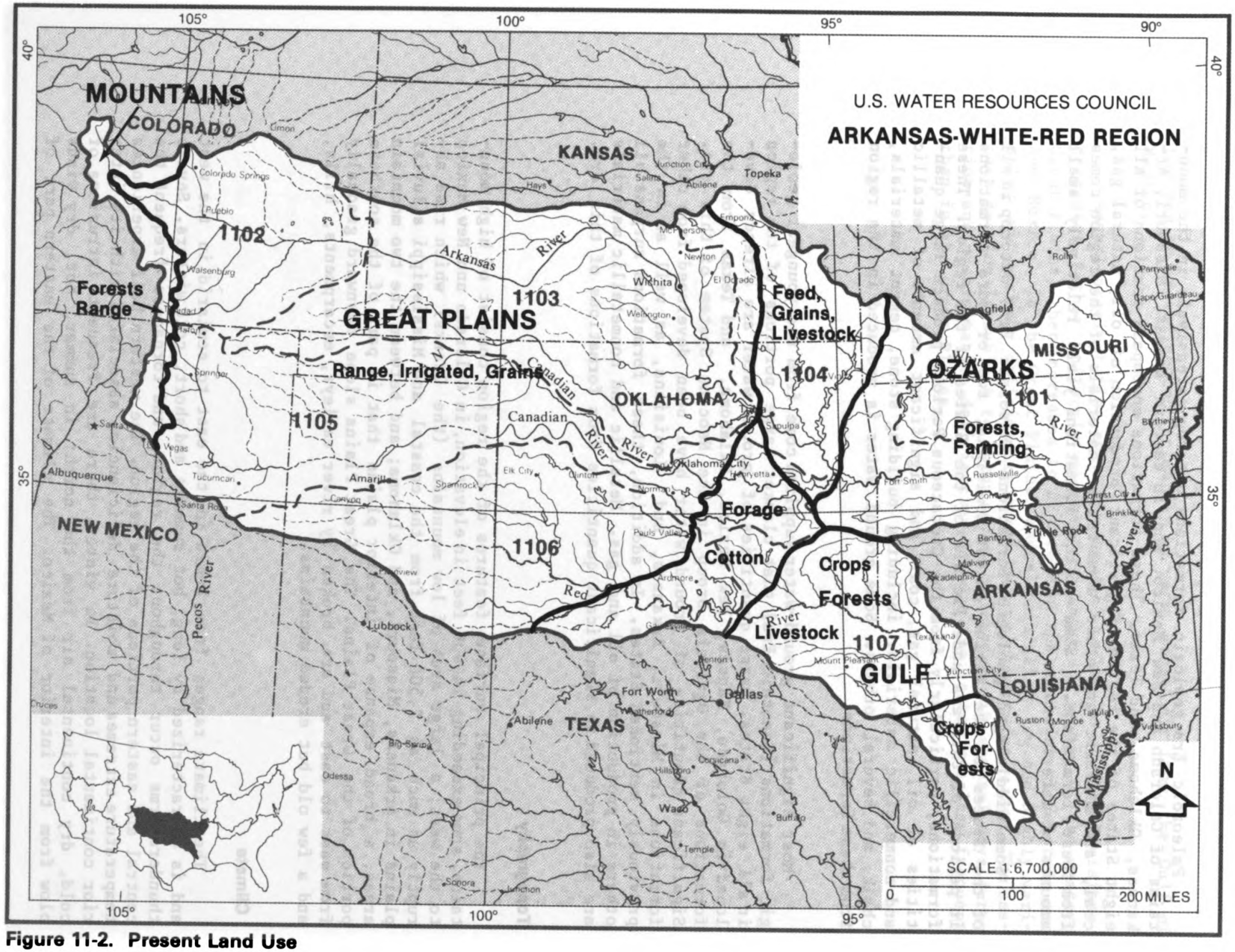


Figure 11-2. Present Land Use

Paleozoic Era geologic formations outcrop extensively in the mountains of Colorado and New Mexico, and in eastern Kansas, Missouri, Arkansas, Oklahoma, and Texas. These formations encompass portions of all eight States of the region. Significant production of oil, natural gas, coal, and metallic and other nonmetallic materials of the region comes from these formations. Some of the formations yield relatively small amounts of water.

Some middle-aged geologic formations (Mesozoic Era) outcrop in all of the States of the region except Louisiana; two or more formations in periods of this era underlie all of the States of the region. These formations, particularly from the Cretaceous Period, produce large quantities of oil, natural gas, coal, and significant amounts of metallic and nonmetallic materials, including building stone, cement materials, chalk, and several others. Some ground water is produced in the region from these formations.

Most significant ground-water supplies come from the youngest geologic formations (Cenozoic Era) that blanket large portions of the region in all eight States. Large quantities of ground water are already developed in Colorado, Kansas, New Mexico, Oklahoma, and Texas from the formations of the Ogallala Group in the Neocene System of this era. Significant quantities of ground water have been developed from other formations in Missouri, Arkansas, and Louisiana, as well as in the previously mentioned States. In addition, these formations surpass all others in production of oil and gas. Metallic and nonmetallic materials are also produced in significant quantities from formations of this era.

Topography

The principal surface features of the region consist of high mountains, some exceeding 14,000 feet in elevation, in Colorado and New Mexico to the west; a large area of low mountains (the Ozarks) which rise abruptly as much as 2,500 feet from the coastal and Mississippi alluvial plains in Arkansas, Missouri, and Oklahoma; and between the two mountain areas, a broad expanse of interior plains that is part of the southern portion of the Great Plains. The Great Plains slope downward gradually from west to east and are broken by river valleys, escarpments, hills, and a few old but eroded mountains.

Climate

The climate ranges from humid in the east to semiarid in the west and is characterized by long, hot summers and short, cold winters. Severe thunderstorms occur throughout the region, and tornadoes frequent the central and eastern portions of the region. The western half experiences temperature extremes and moisture deficiencies associated with its interior continental location. In winter, there are frequent intrusions of cold, dry continental air from the north; in summer, hot, dry winds blow from the interior of Mexico. The climate of the eastern part of

the region is influenced primarily by warm, moist air from the Gulf of Mexico.

Annual precipitation averages about 60 inches in eastern Louisiana, decreases rather uniformly westward to about 12 inches in the western Great Plains, then increases to 32 inches in the mountains of Colorado and New Mexico. In the Great Plains, annual rainfall is low and highly variable, and serious deficiencies occur during the growing season. The eastern section is subject to both severe rainstorms of several days duration and precipitation deficiencies, though the latter are less frequent than in the Great Plains.

People and the Resources

People in both rural and urban areas have problems related to water and land resources. Current and future activities relating to these resources are important in identifying those problems. Estimates and projections of the population, economy, land and water resources, and other parameters have been made by the Water Resources Council and cooperating Federal and State agencies. The estimates for the Nation, regions, and aggregated subregions prepared by the Federal agencies are referred to as the National Future (NF) data, which are used in this chapter on the region. Some pertinent differences in the NF data and the State-regional data (SRF) are mentioned where appropriate.

Population

Historically most of the people of the region have rural backgrounds. The trend for a few decades has been a gradual movement of people from the farm to the cities and their suburbs.

Economy

The estimated population in the Arkansas-White-Red Region in 1975 was 6.8 million, or 3.2 percent of the total population of the Nation. About one-half of these people live in cities, such as Little Rock, Arkansas; Tulsa and Oklahoma City, Oklahoma; Wichita, Kansas; Colorado Springs and Pueblo, Colorado; and smaller urban areas. Those not residing in urban areas live in small towns and on scattered large farms and ranches.

By 2000 the population of the region is projected to increase by about 14 percent to 7.8 million with the growth occurring mainly in urban areas.

About 2.7 million people were employed in 1975. The 1975 total personal income, measured in 1975 dollars, was $35.8 billion with a per capita income of $5,237 per person in the region. Major earnings in the individual categories were from manufacturing, about 20 percent, and from agriculture, 7.2 percent. A small part was in mining, but the "other" shown in Table 11-1 includes more than two-thirds of the total earnings, which cover wholesale and retail trades, government, services, transportation, public utilities, etc.

Total per capita income is projected to increase to $10,904 per annum by 2000, at which time it will still be about 13 percent below the national average.

Table 11-1.--Arkansas-White-Red Region earnings--1975, 1985, 2000
(million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing	5,425	8,057	13,334
Agriculture	1,937	1,868	2,139
Mining	801	828	879
Other	18,802	27,512	46,807
Total	26,965	38,265	63,159

Natural Resources

There are vast resources of agricultural land, oil, natural gas, and other minerals in the region. Nonurban lands, including total cropland, forests, woodland, and other lands, including pasture, make up about 99 percent of the region. Cropland and pasture, both irrigated and nonirrigated, account for 71 percent. Irrigated land, particularly in Colorado, western Kansas, Oklahoma, Texas, and eastern New Mexico, totals about 3 percent of the region. Urban development, although of great economic significance, accounts only for about 1 percent of the region. (See Table 11-2.) Oil, natural gas, and other minerals occur in a large part of the region.

Table 11-2.--Arkansas-White-Red Region surface area and 1975 land use

Surface area or land use type	1,000 acres	Percentage of total surface area
Surface area		
Total	156,163	100.0
Water	1,855	1.2
Land	154,308	98.8
Land use		
Cropland	44,480	28.5
Pasture & rangeland	66,559	42.6
Forest & woodland	33,545	21.5
Other agriculture	2,244	1.4
Urban	1,636	1.1
Other	5,844	3.7

Agriculture

Between 1975 and 2000 the cropland acreage is expected to increase from 44,480,000 acres to 45,051,000 acres, and the cropland harvested will similarly increase from 27,793,000 acres to 37,364,000 acres. Only 62 percent of the cropland was harvested in 1975. Irrigated farmland included 4,765,000 acres in 1975 and is expected to increase to 5,545,000 acres by 2000. By 2000, about 8 million acres of marginal lands will be removed from crop production. Some 191,000 acres of forestlands and 787,000 acres of pasturelands are expected to be converted to cropland by drainage between 1975 and 2000. The remainder to be converted to cropland can be converted without drainage (Table 11-3, Projected changes in land use).

Table 11-3.--Projected changes in cropland and irrigated farmland in the Arkansas-White-Red Region--1975, 1985, 2000

Land category	1975	1985	2000
Total cropland	44,480	44,642	45,051
Cropland harvested	27,793	34,340	37,364
Irrigated farmland	4,765	5,380	5,545

Energy

In 1975, a total of 72,816 gWh of electric energy was produced, of which 84 percent was produced by fossil fuel steam electric plants and the remainder by hydroelectric generating plants and one nuclear plant. By 2000, eight new nuclear plants are projected to be in operation, plus 46 fossil fuel steam electric plants. With the existing hydroelectric generating stations, this will bring the combined energy output to 404,432 gWh. The relative energy production from fossil fuels and from nuclear plants in 1975 and 2000 is shown in Table 11-4. Water consumption in the steam electric plants, currently 89 mgd, will increase by 513 percent to 457 mgd. Because of the large amount of water required for cooling, steam condensers are commonly employed in the evaporative cooling towers or ponds in the thermal generating stations to allow the cooling water to be recirculated.

All new steam electric generating stations in the region will utilize evaporative cooling towers or ponds to cool and recycle their cooling waters. As a consequence, discharge of heat to surface waters from these generating stations is only 13 trillion Btu per year and will decrease to 12 trillion Btu per year by 2000.

The use of cooling towers or ponds by manufacturers is projected to decrease their thermal discharges to surface waters from the present 21 trillion Btu per year to 2.8 trillion by 2000.

Table 11-4.--Arkansas-White-Red Region electric power generation--1975, 1985, 2000

(gigawatt-hours)

Fuel source	1975	1985	2000
Fossil	60,877	115,400	101,570
Nuclear	4,878	43,810	296,900
Conventional hydropower	7,061	5,829	5,962
Total generation	72,816	165,039	404,432

Navigation

The McClellan-Kerr Arkansas River program, involving navigation, recreation, flood control, power developments, and the construction of 17 dams and locks in Arkansas and Oklahoma was completed in 1971 as far as Catoosa, Oklahoma, near Tulsa. This program has opened the lower Arkansas River to commercial navigation as part of the Nation's inland waterway system in the Mississippi Valley. Other navigation in the region occurs on the lower White River in Arkansas and on the Red River in Louisiana, Texas, and Oklahoma. In 1975 waterborne commerce was 5.2 million tons on the Arkansas River, 1.5 million tons on the Red River, and 0.7 million tons on the White River. The Red River also connects with the Mississippi River navigation system. Improvement of these systems, particularly on the lower Red River, is expected to help economic growth along the waterways (see Figure 11-3).

Environment

This region is an enormous storehouse of historic and archeological sites. Many facilities are provided for fishing, hunting, and recreation,

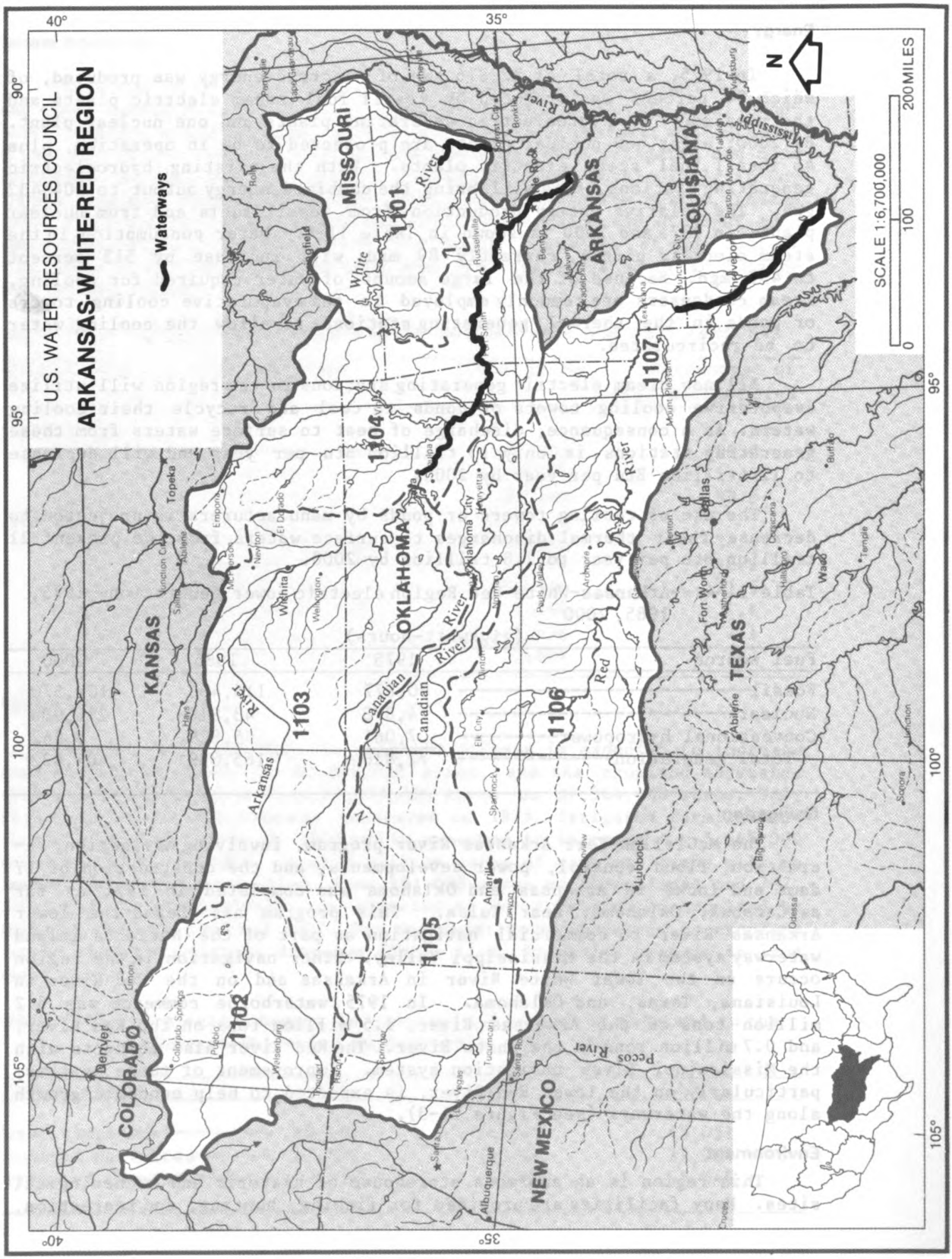


Figure 11-3. Navigation System

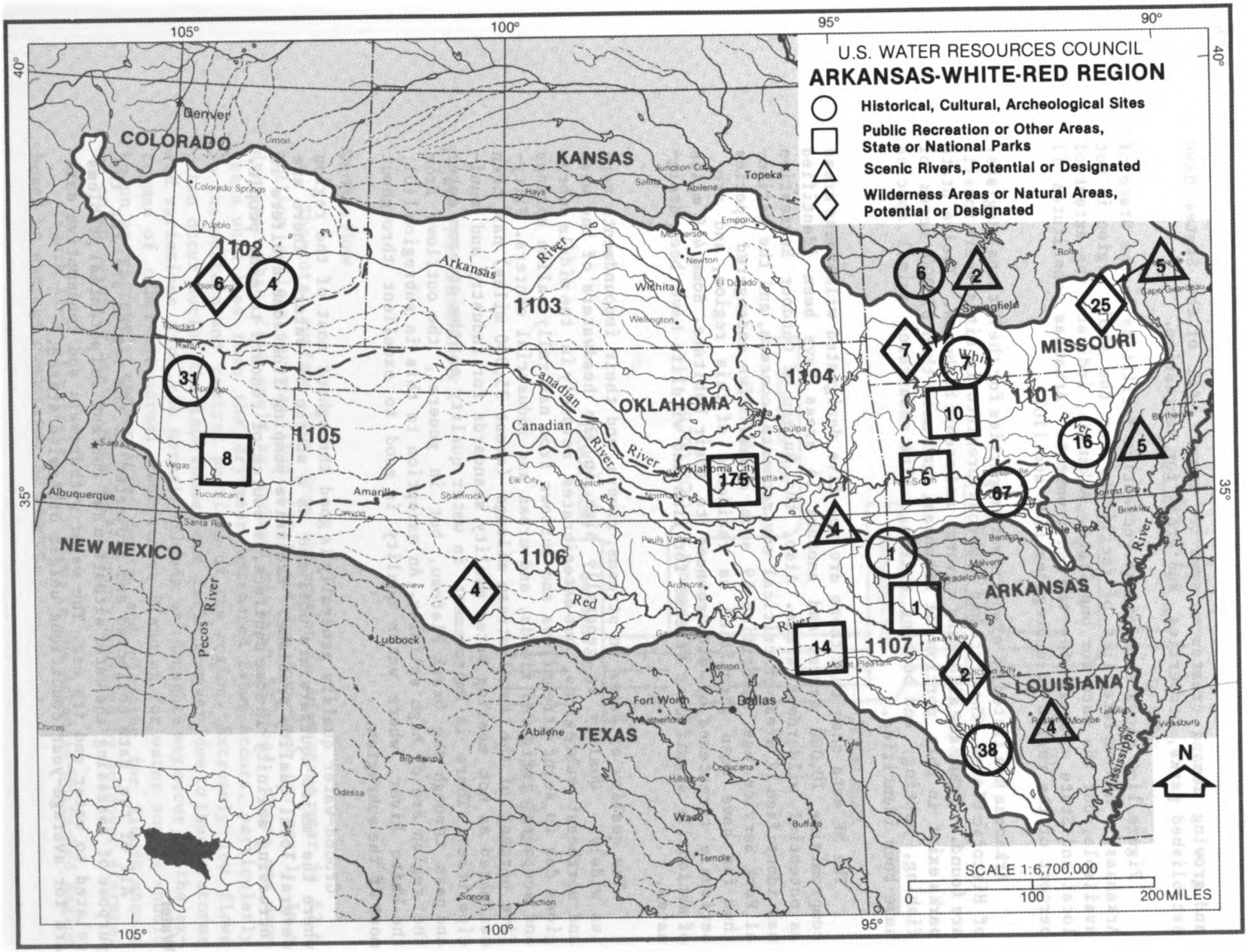


Figure 11-4. Environmental Resources

and growing demand creates a need for more. All of the States have established parks, properties, and areas for recreation.

Figure 11-4 shows some of the recreation facilities in the State of Arkansas. A complete list of facilities for the whole region is not available, but the data for one State, Arkansas, indicate the extent of local and State concern for the environment. Arkansas constitutes 11 percent of the region in subregions 1101 and 1107.

Arkansas has listed 86 significant properties for the National Register of Historic Places. The State has numerous prehistoric sites where fossils are found. There are also many caverns and scenic highways. Twelve State parks exist in this portion of Arkansas, and more than 67,000 acres of fishing, hunting, and boating waters. Nine endangered animal species have been identified.

The NF data show that there are now five designated wilderness areas compromising 70,000 acres, and another 14 areas have been identified as potential wilderness areas. Also, the Bureau of Outdoor Recreation has identified 12 areas of critical environmental concern, and the National Park Service has identified 59 such areas. Five endangered species thus far have been identified as residents of this region, and are seriously threatened by disturbances to their habitats. Some 440 miles of nationally significant streams for fish and wildlife have been designated.

The quality of water in streams, rivers, and their impoundments varies widely. Quality is generally high in the headwaters of the west and northeast subregions, but deteriorates severely in the middle subregions due to scant streamflows and inflows from naturally saline springs and seepages, irrigated fields, and urban and industrial centers. Fifty-five percent of the total stream mileage (about 35,000 miles) has been estimated as not meeting water quality standards for industry and municipalities. There is improvement in water quality as the streams enter and pass through the Ozark Plateau, but in general, the outflows from the region are of high salinity. An exception to this is subregion 1101, the White River, where water quality is good to excellent throughout most of the subregion.

Ground-water quality generally is good throughout most of the region where the major aquifers are utilized as a source of water. There are several local quality problems. Excessive pumping from some aquifers is increasing salinity in some aquifers, a source of concern to many people.

Water

All of the data collected and projected in the region are for the purpose of assessing the water situation and current and potential problems related to water and its use. The water withdrawals and consumptive data are for average-year conditions unless otherwise stated.

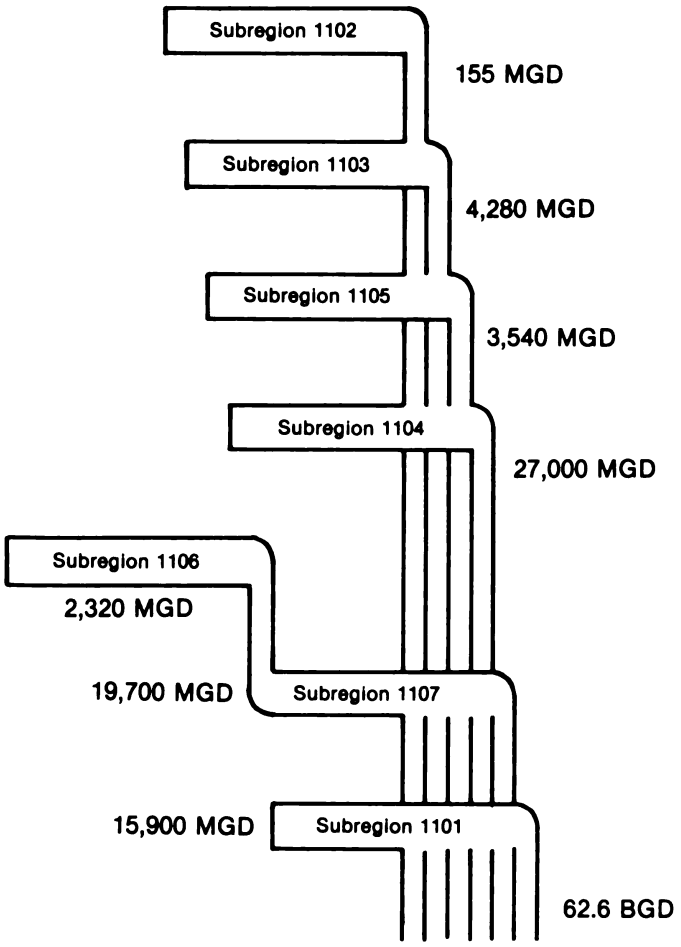


Figure 11-5. Streamflow

Surface Flow

The total surface flow from the region in an average year is 62.6 billion gallons per day (bgd) (70.1 million acre-feet per year). In a dry year this flow would be reduced to about 37.4 bgd. There are many years when less than the dry-year estimated flows occurs, particularly in the western and central portions of the region. Extremely low flows often occur during the late summer and fall. However, due to thunderstorms and variations from the normal, floods or droughts may occur at the extremes of otherwise normal conditions. Planning for water supply should be on an extremely conservative basis, and planning for floods should be on an opposite basis, with water supply modified by holdover storage.

Figure 11-5 illustrates 1975 flows in the Arkansas-White-Red Region based on average conditions of record.

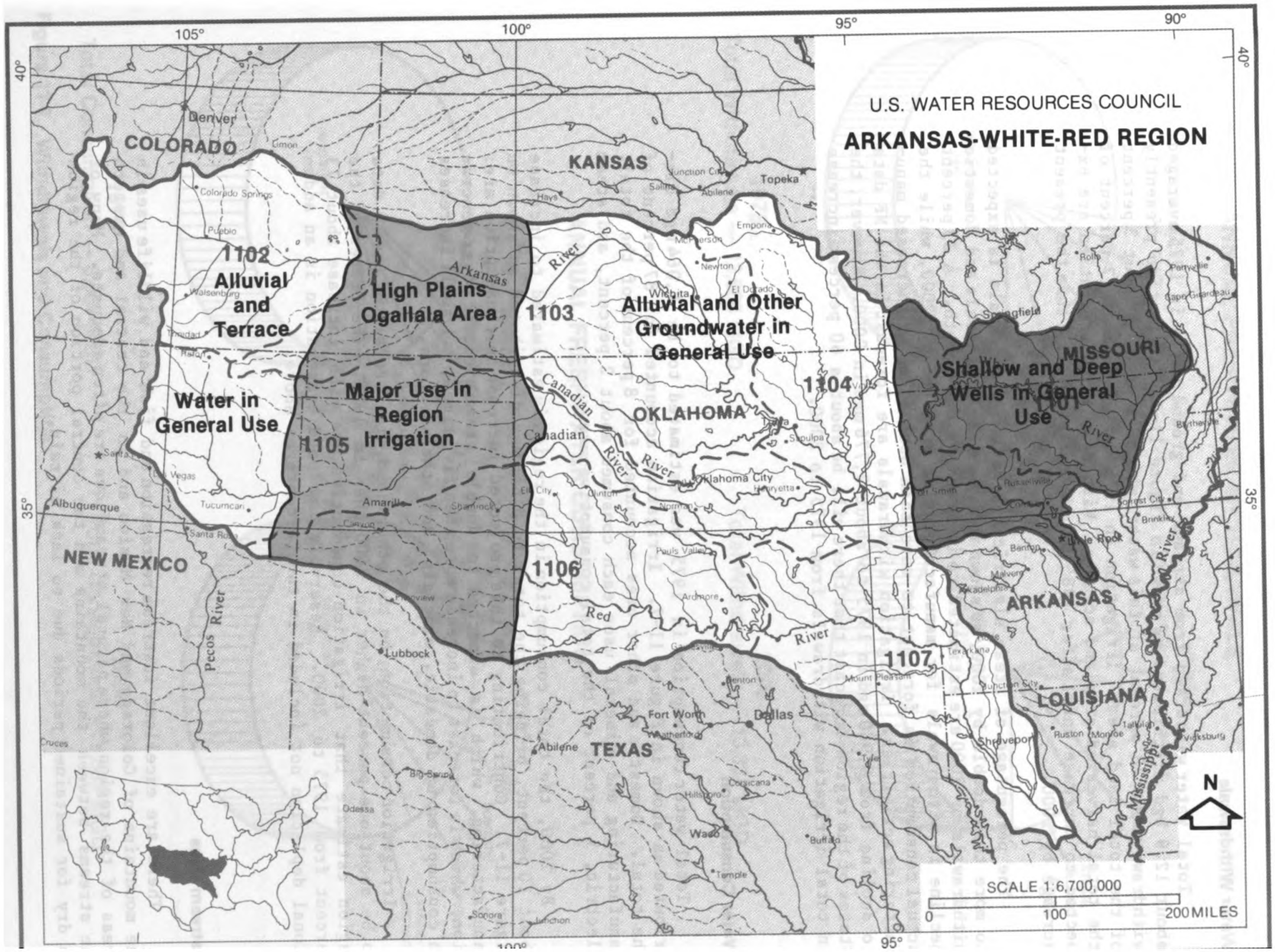
While the outflow from the region as displayed in Figure 11-5 provides an impression of a relatively water-abundant region, the quantity of surface water available in the west and central portions and the surface water quality over much of the region are inadequate for satisfying many requirements. This is particularly true for the Colorado plains and in the High Plains area from Kansas through Oklahoma, New Mexico, and Texas. An average 158 mgd are imported to the Arkansas River in Colorado from the Upper Colorado River. Streamflows are scant in the western parts of the region due to diversions for irrigation, and quality is impaired by high salinity introduced by naturally alkaline soils, irrigation return flows, natural brine inflows, and occasional inflows of oil field brines.

Water is a major input to most of the manufacturing sector's operations, and it is estimated that the gross in-plant water use of the sector in 1975 is equivalent to withdrawals of 4,027 mgd. But manufacturers in the region are among the most efficient water users in the Nation. Through reuse and recycling of water and treated effluents, the region's manufacturing sector in 1975 managed to meet their water needs by withdrawing only 713 mgd. This success is due mainly to the extremely efficient use of water by the region's petroleum refiners, who, on the average, reused or recycled their withdrawals nearly 28 times before discharge.

In the lower Arkansas and Red Rivers, the flows are ample in quantity, but the high salinity of their waters, particularly during periods of low flows, limits their uses. In those areas, domestic water systems and industrial users generally obtain water from wells rather than from the rivers. There are, however, tributary streams of the Arkansas and Red Rivers that have reliable flows of good quality water, some of which is withdrawn for local uses. The State of Oklahoma proposes to develop several of the tributary streams to transfer water to the Oklahoma City and Tulsa metropolitan areas for domestic and industrial uses.

Ground Water

Ground-water resources in the High Plains area of Colorado, Kansas, Oklahoma, New Mexico, and Texas are highly developed for irrigation and municipal uses. Ground water from the alluvial valleys of the Arkansas, Red, and White Rivers are also fairly well developed, partly for irrigation and for municipal and industrial purposes. Withdrawals of ground water from the High Plains, or Ogallala Formation, exceed the recharge from precipitation in some of the areas, resulting in serious declines in water levels. This portends very serious problems to the irrigation economy in portions of the highly-developed areas, with the problems increasing as pumping continues to exceed recharge (see Figure 11-6).



Water Withdrawals

Total water withdrawn from streams and ground water in 1975 averaged about 12.9 bgd distributed as shown in Figure 11-7. Irrigation presently withdraws about 78 percent of this water, which is used on about 3 percent of the total land area. Irrigation in 1975 included about 17 percent of the total harvested cropland acreage. Withdrawals for irrigation are expected to increase until after 1985 but decrease to less than the present acreage by 2000.

The percentage of steam electric generation withdrawals is expected to more than double by 2000, as shown in Figure 11-7. Minerals and domestic withdrawals by 2000 are estimated to increase by one-fourth. A 33 percent decline in withdrawals for manufacturing is expected by 2000, while the actual consumption is forecast to more than double due to increased manufacturing activities. Irrigation withdrawals are forecast in the NF data to decline from 9,980 mgd in 1975 to about 9,776 mgd in 2000. However, the States of the region forecast that there will be about a 60 percent increase in total irrigation withdrawals from 1975 to 2000.

Water Consumption

Total water consumption in 1975 was estimated to be 8,064 mgd distributed as shown in Figure 11-7. Irrigation accounted for 87 percent of the total. Domestic and other uses accounted for 8 percent of the total. Manufacturing and mineral uses each consumed about 2 percent, and steam electric, 1 percent of the total consumptive use.

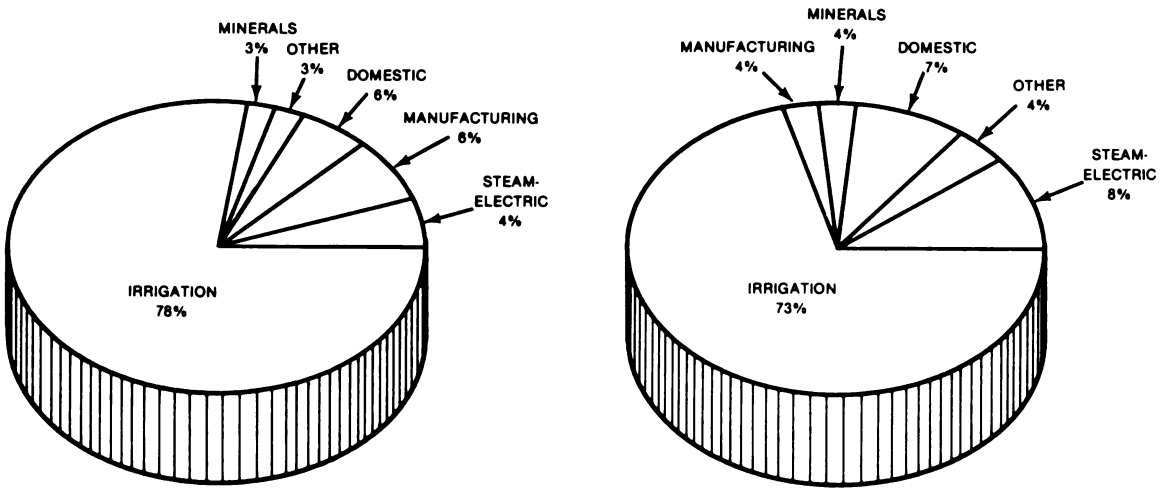
By 2000, the total consumption in the region is estimated to increase about 10 percent, bringing the total to 8,886 mgd distributed as shown on Figure 11-7. Contributing to this projected increase in consumption are: manufacturing, which is expected to double; steam electric power generation, which is forecast to increase more than five times; and small increases in consumption by domestic, minerals, and other sectors.

Irrigation consumption, on the other hand, is forecast in the NF data to be about one percent higher in 2000 than in 1975. The States of the region estimate that irrigation consumptive use will increase about 73 percent from 1975 to 2000. Reservoir and pond evaporation is an additional depletion not included in the percentages above.

Instream Uses

There are excellent instream recreation and fish and wildlife uses in the mountains of Colorado and New Mexico and in the central and eastern areas of the region where natural streamflows are often adequate. Many of the streams between the mountains and the central portion of the region go dry for sustained periods due to lack of rain.

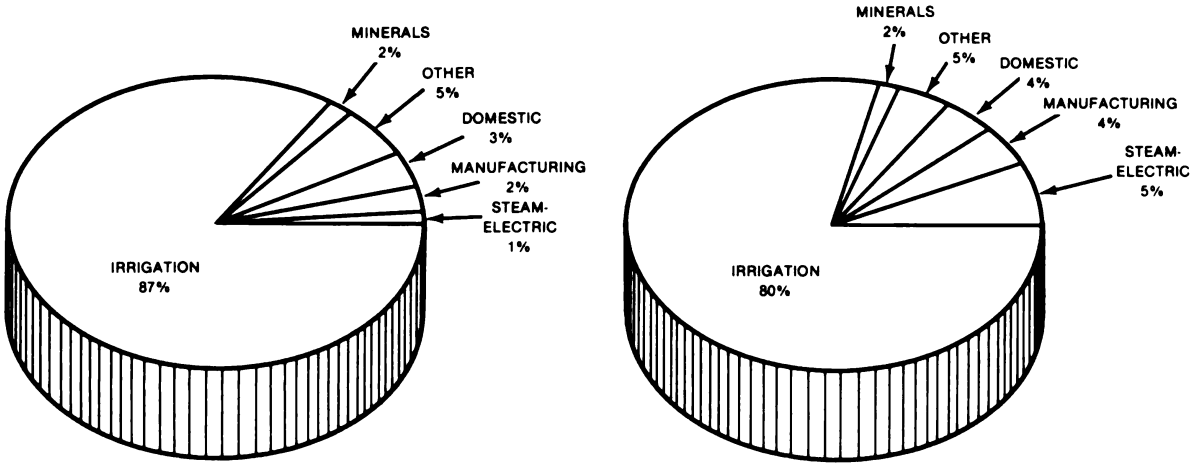
ANNUAL FRESHWATER WITHDRAWALS



1975
Total Withdrawals — 12,868 MGD

2000
Total Withdrawals — 13,337 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 8,064 MGD

2000
Total Consumption — 8,887 MGD

Figure 11-7. Withdrawals and Consumption

Eastern streams of the region, particularly in the Ozark Plateau portion of the Arkansas and White Rivers and in the lower Red River, generally have sustained flows supporting instream recreation and fish and wildlife uses as well as boating, navigation, hydroelectric power generation, and waste disposal.

Storage reservoirs created throughout the region primarily for flood control, irrigation, power, navigation, and other uses provide much needed recreation areas, and fish and wildlife habitats. They also provide some streamflow regulation that enhances the instream flow needs of the region.

Water Supply and Demand

Outflow from the Arkansas, White, and Red Rivers is fairly substantial on the average, giving the impression that the region has an adequate supply of water. This is true in normal water periods in the eastern parts of Kansas, Oklahoma, and Texas, and in all of Missouri, Arkansas, and Louisiana. However, even in these areas, general or local droughts and cyclical changes in streamflow may cause water shortages that are usually of short duration. The upper Arkansas River in Colorado, New Mexico, western Kansas, and western Oklahoma usually has water shortages every year, as does the upper Red River in eastern New Mexico and western Texas.

Water supply is adversely affected by the quality of surface water, particularly in the west and central portions of the region where it is inadequate for satisfying many requirements. Streamflows are scant due to diversions for irrigation, and quality is impaired by high salinity introduced by naturally alkaline soils, irrigation return flow, natural brine inflows, and occasionally by inflows of oil field brines.

Imports of about 177,000 acre-feet annually (158 mgd) into the upper Arkansas River in Colorado from the Colorado River Region partly alleviate the water supply problem in Colorado.

Ground water is pumped from the alluvial channels and from the High Plains of Colorado, Kansas, Oklahoma, New Mexico, and Texas to meet about one-half of the withdrawal requirements of the region. Since present withdrawals of ground water exceed the recharge rates in portions of the High Plains, it is evident that water supply problems in the western portions of the region will become more severe in the near future.

Comparative Analysis (SRF/NF)

Table 11-5 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water needs in the Arkansas-White-Red Region. SRF data was developed and adopted by consensus of the membership of the Arkansas-White-Red Interagency Committee.

Table 11-5--Socioeconomic and volumetric data summary: the Arkansas-White-Red Region

Category	"1975" NF	"1975" SRF	1985 NF	1985 SRF	2000 NF	2000 SRF
SOCIOECONOMIC DATA (1000)						
Total population	6,846	7,350	7,268	8,321	7,815	9,819
Total employment	2,670	1,565[a]	2,987	1,966[a]	3,369	2,530[a]
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	65,207	NE	65,207	NE	65,207	NE
Streamflow at outflow point(s)	62,600	62,605	56,192	NE	55,896	NE
Fresh-water withdrawals	12,868	13,551	13,799	16,434	13,337	22,622
Agriculture	10,195	9,827	10,721	11,737	10,055	16,056
Steam electric	498	1,297	1,026	2,032	1,012	3,233
Manufacturing	713	956	476	989	480	1,268
Domestic	735	1,060[b]	807	1,321[b]	894	1,645[b]
Commercial	210		221		238	
Minerals	448	200	469	142	571	206
Public lands	26	30	33	32	39	36
Fish hatcheries	43	NE	46	NE	48	NE
Other	0	180	0	177	0	178
Fresh-water consumption	8,064	9,433	8,769	11,611	8,887	16,405
Agriculture	7,263	8,379	7,706	10,221	7,404	14,422
Steam electric	89	126	237	285	457	577
Manufacturing	165	347	232	407	360	562
Domestic	179	466[b]	305	591[b]	331	710[b]
Commercial	69		72		78	
Minerals	173	70	184	67	218	90
Public lands	26	27	33	30	39	34
Fish hatcheries	0	NE	0	NE	0	NE
Other	0	17	0	10	0	10
Ground-Water withdrawals	8,846	6,968	NE	NE	NE	NE
Evaporation	2,615	10,179[c]	2,910	11,330[c]	3,111	12,388[c]
Instream approximation						
Fish and wildlife	46,169	NE	46,169	NE	46,169	NE

NE-Not estimated.

[a] Total includes only subregions 1101, 1102, 1105, 1106, and 1107. Data were not available for subregions 1103 and 1104.
[b] SRF domestic water use includes commercial and institutional requirements.
[c] Total does not include subregion 1102 for which data were not available.

The SRF data have been developed to reflect records and estimates of the eight States of the region. The records from Colorado, Kansas, Oklahoma, New Mexcio, and Texas are pertinent to the administration of water rights under the Doctrine of Prior Appropriation. Accordingly, the SRF data on withdrawals and consumptive use in these five States must be considered. In a number of cases, SRF data on irrigation consumptive use and withdrawals differ substantially from NF data. Although the region's problems are, for the most part, identified in both data sources, the severity of some problems appears greater in the SRF estimates.

SRF estimates of manufacturing and steam electric water withdrawals and consumption are consistently larger than the corresponding NF figures. The NF data show a greater proportion of water use in the minerals category than do those of regional sources.

Problems

The total water supply versus water use in the region on a whole during average years appears to be balanced, but, even under average conditions, this is not the case for portions of the region. Accordingly, there are water supply and water quality problems in about one-half of the region in practically every year. These problems affect the economic well-being of the people and environment of the region. The problems have been identified by representatives of the eight States and by Federal participants in this assessment.

High Plains Ground-Water Irrigation

One large and severe problem covering portions of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas and the three assessment regions--Missouri, Arkansas-White-Red, and Texas-Gulf--emerges on the High Plains. This is known as the High Plains or Ogallala ground-water irrigation problem in which private irrigation withdrawals in portions of the area exceed recharge rates.

The use of large aquifers has created one of the world's large irrigated areas during the past few decades. Each year some of the wells must be deepened and pumps set lower to reach the water. The costs of pumping rise accordingly. In addition, the cost of energy to operate the pumps is increasing, which escalates the water costs. Also, the quality of the ground water declines as the aquifer becomes dewatered, and, in some portions of the region, the water has become unsuitable for domestic use. This may eventually have a serious negative impact on the economy of the area.

Water Quality

Water quality is good in the headwaters of the Arkansas, Canadian, and Red Rivers and their major tributaries, but the quality deteriorates rapidly when the streams enter the high western plains of the region. There the rivers flow through highly erodible and frequently alkaline soils, and inflows from natural salt springs, irrigation return flows, runoff from urban areas and farmlands, and from municipal and industrial discharges degrade the quality of water, making it unsuitable for many uses. For example, the Arkansas River, fed by melting snows from the Rocky Mountains, enters the plains of eastern Colorado below Pueblo with about 400 mg/l of dissolved solids. By the time it has passed through the irrigated Colorado farmlands to enter Kansas, the dissolved solids are frequently as high as 3,500 mg/l, and its use for irrigation is limited to salt-tolerant crops. Additional inflows from fields irrigated by ground water used to supplement or replace the waters of the river system enter the mainstream. Dissolved solids are concentrated by evaporation in the river and reservoirs, and natural salt springs discharge into the river and its tributaries. During very low flow periods, concentrations

of dissolved solids have been recorded for short times as high as 60,000 mg/l, nearly twice the 35,000 mg/l of dissolved solids in sea water.

Water is being completely utilized, and quantity of usable water is the limiting factor in the central portion of the region. The generally poor quality of water in these rivers during low flow periods and the sparsity of streams in the prime agricultural lands in the west and central portion of the region have resulted in dependence on the ground-water aquifers from which, in the High Plains (Ogallala Formation), water is being withdrawn at rates well in excess of natural recharge.

The quality of the mainstream flows in the lower reaches improves through inflows of good quality water from tributaries. In the lower reaches, surface water from the tributaries and ground water provide opportunities for development of good quality water for areas in critical need.

Erosion and Sedimentation

Erosion and sediment loads are excessive in all of the rivers particularly during spring snowmelt, after heavy rains, and during the irrigation season. Most of the sediment results from sheet erosion from grazing lands, farmlands, and urban areas and from the steep slopes of the Ozark Plateau. Sediment clogs channels and induces flooding, destroys wildlife habitats, reduces storage capacity of reservoirs, interferes with navigation and other instream uses, increases costs of treatment for offstream uses, and presents problems in disposal once it is diverted from the stream.

Soil erosion is most severe in subregions 1101, 1104, and 1107, where average erosion rates are 21, 9, and 12 tons per cropland acre per year. For the region as a whole, however, erosion rates will average 6 tons per acre per year in 1985, and 2 tons per acre per year in 2000 when subregional average losses will range from a low of 1 ton to a high of 5 tons per acre per year. The reductions in soil losses are projected to result from improved water and land management and from the removal of nearly 8 million acres of marginal lands from crop production.

While present rates of erosion are high in many parts of the region, better management of the lands under cultivation and the water applied to them can reduce the losses of soils to the rivers. Data in the NF projections indicate that this will occur, but these projections will be achieved only with rigorous practice of soil conservation management techniques.

Flooding

Flood damages occur in the region at a current average annual rate of about $234 million and are projected to increase about 29 percent by 2000. Damages to agriculture account for $146 million, distributed re-

latively evenly throughout the subregions. Urban area flood damages now average slightly more than $39 million annually, with most occurring in Colorado, eastern Kansas, eastern Oklahoma, Missouri, and Arkansas. Flood damages to urban areas are projected to increase 69 percent by 2000 as a consequence of growth in population and investment values in the flood-prone zones.

Urban damages occur principally along the mainstreams. The U.S. Army Corps of Engineers has underway, or proposed, urban area studies of which flood control is an integral part at Tulsa, Wichita, Pine Bluff, Fort Smith, and Little Rock. The recommendations that develop from those studies for reducing losses will undoubtedly emphasize nonstructural methods, such as flood-plain zoning and management. Structural solutions in the west-central parts of the region, if reservoirs are included, can help to reduce losses without aggravating the salinity problems. Under appropriate design and operating conditions, evaporation in a flood control reservoir can be insignificant if the retention time of flood flows is limited. Channelization of the rivers is likely to provoke serious environmental objections because of destruction of critical water and land habitats for wildlife.

Water Quantity

The larger cities and metropolitan areas of the region face increasing difficulties and rising costs in obtaining reliable supplies of water to deliver to their residential, commercial, and industrial service areas. High salinity in the mainstream flows of the Arkansas, Cimarron, Canadian, and Red Rivers and many of their tributaries precludes their use as sources of potable water. Ground-water supplies, although generally suitable as the source for smaller cities and towns, are difficult and costly to develop for supplying larger population centers, whose very large requirements would necessitate the development and operation of numerous wells and well fields at scattered locations. Because of the excessive use of ground water and the threat of depletion of the major aquifers in some areas of the region, ground water is considered to be unreliable by some of the larger cities. Subsequent discussion of Problem Area 1 provides additional insight into ground-water problems.

While mainstream flows of the Arkansas and Red Rivers remain generally unsuitable for domestic use throughout their lengths, as they approach their eastern watershed areas a number of tributary streams with good quality water are encountered. Several of the States and municipalities have developed or proposed for development those streams as water sources to supply the eastern and central portions of the region. Most of the State plans are linked with the planning of Federal agencies--for example, the U.S. Army Corps of Engineers, whose river development planning and construction programs include reservoirs that intercept and store large volumes of good quality tributary flows.

In the Red River area of eastern Oklahoma, Boggy Creek and Kiamichi River have good-quality water and excellent reservoir sites, where several reservoirs are completed or under construction. Atoka Lake, on Boggy Creek, is now the major source of supply for Oklahoma City, some 70 miles to the north, and an additional reservoir, McGee, is proposed to be constructed on the same creek. The Lake Hugo project has been constructed on the Kiamichi River and is proposed for use to supply additional water to Oklahoma City; the Clayton Lake project on the same river is under construction. Two additional reservoir projects, Boswell Lake and Tuskahoma, are proposed for the Kiamichi. Ultimately, the State of Oklahoma proposes to obtain from those rivers approximately 1.5 million acre-feet of water annually, of which 800,000 acre-feet would be delivered to agricultural areas in western Oklahoma. Six other reservoirs have been proposed for development on tributaries downstream from Lake Texoma on the Red River. When developed, those reservoirs would provide additional sources of good quality water for both Texas and Oklahoma.

Problems of poor-quality water exist in the mainstream flow of the Arkansas River and its western tributary system east of Colorado, and few municipal water systems utilize them as sources of water. In western and central parts of the Arkansas River Basin, the ground-water aquifers are pumped excessively for irrigation, thus accelerating the decline of ground-water levels and increasing salinity. There, too, the cities look eastward for assurance of adequate supplies by development of tributary streams to the Arkansas River and possibly by transfers of water from the White River Basin.

A number of reservoir projects have been constructed on tributaries that drain southeastern Kansas, southwestern Missouri, northwestern Arkansas, and northeast Oklahoma and that enter the Arkansas below Tulsa, Oklahoma. That city now obtains water from Lake Spavinaw, a smaller tributary, and suggestions have been made that additional water be obtained from Illinois Creek. These reservoirs are multipurpose in operation, providing for maintenance of navigation levels in the Arkansas River, flood control, hydroelectric power, and recreation, in addition to water supply for municipalities and industry.

The White River Basin is generally free of water quality problems, and contains a series of large reservoirs for power generation, flood control, and recreation; however, at present these supply only a minor amount of water for municipal and industrial (M and I) needs. There is a surplus of water in this basin when its needs alone are considered. Therefore, some water could be transferred to areas outside the White River Basin, where needs cannot otherwise be satisfied.

The three major river systems, the Arkansas, White and Red Rivers, include portions of seven States and all of Oklahoma in their drainage basins. Many of the solutions to water supply shortage that involve alterations in the allocations of their waters will require that agreements, formalized by compacts, be arranged between the States concerned, with approval of the Congress. A compact covering the lower Red River is in the formulation stage.

Water Surface

Water surface for recreation is considered to be in short supply in Colorado below Pueblo, and in western Kansas, Oklahoma, and Texas. This is caused mainly by (1) water supply shortages as such and (2) the use of available water (a good deal of which is consumed and does not return to the streams) by established water right users in accordance with State laws.

There is a severe shortage of water areas for water-based hunting, fishing, and recreation along the Arkansas in Colorado. The present need is 39,000 acres of water area in subregion 1102; the need is projected to be 53,000 acres in 2000. The Fryingpan-Arkansas Project and John Martin Reservoir will provide 9,500 water acres for recreation uses. Existing privately owned irrigation reservoirs have the capacity to meet these needs; however, their water levels fluctuate, and they, for the most part, do not maintain permanent pools. The problem is to develop permanent pools for public use in these private irrigation reservoirs through purchase of water and cooperative agreements. Since the direct beneficiaries of recreation, hunting, and fishing customarily pay little of the costs for such facilities, the solution to this problem seems to be for the private water right owners to agree to some plan that would be financed by the State or Federal Government or both.

Environmental

Many environmental problems in the region threaten to become more severe with growth in the region and the changes in land use and water management that appear likely. Among the more severe problems are (1) the flooding of river bottomland by reservoirs, (2) the added hazards to some endangered species of conversion of dry lands to irrigated farming, and (3) the general pressures of growing populations and economic activities.

Water lost through transpiration by phreatophytic plants is significant in subregions 1102, 1103, 1105, and 1106 and some attempts have been made to control those plants. But removal of phreatophytes, such as salt cedar, alters the habitat of the white-winged dove and other wildlife.

Indian Rights

The utilization of the mainstream of the Arkansas River in Oklahoma may be altered by a court ruling that Indians own the river bed in parts of the State. Currently, the river is developed and utilized for navigation of barges between Tulsa and the lower Mississippi River. Extension of the navigation channel to Wichita, Kansas, has been proposed, but may not be realized due to uncertainty of maintaining adequate channel depths. This proposal may also require reconsideration with regard to the vested interests of the Indians.

Individual Problem Areas

The Arkansas-White-Red Basins Interagency Committee has identified specific areas with urgent problems concerning water and related land resources. For each of these areas, the problems were described and evaluated. The problem areas requiring most immediate attention are:

High Plains Ground-water Irrigation (5 States)
Ozarks Area, Subregion 1101, Arkansas
Ozarks Areas, Benton and Washington Counties, Arkansas
Arkansas, Statewide
Arkansas Drainage above Pueblo, Colorado, Subregion 1102
Arkansas Drainage, Pueblo to Kansas-Colorado State Line
Red River Area in Louisiana
Springfield Area, Missouri
Joplin Area, Missouri
Subregion 1105, New Mexico
Subregion 1103, Oklahoma
Subregion 1104, Oklahoma
Subregion 1105, Oklahoma
Subregion 1106, Oklahoma
Subregion 1107, Oklahoma
Flooding and Related Problems, Texas
Water Supply & Quality Problems, Texas

Figure 11-8a, shows the location of these areas. A tabulation of the type of problems found in each problem area is presented in Figure 11-8b. The figure illustrates the problems identified for each aggregated subregion by State representatives of the Arkansas-White-Red Basins Interagency Committee and Federal agencies. Summary sheets describing each area, its problems, and their effects, follow the figure.

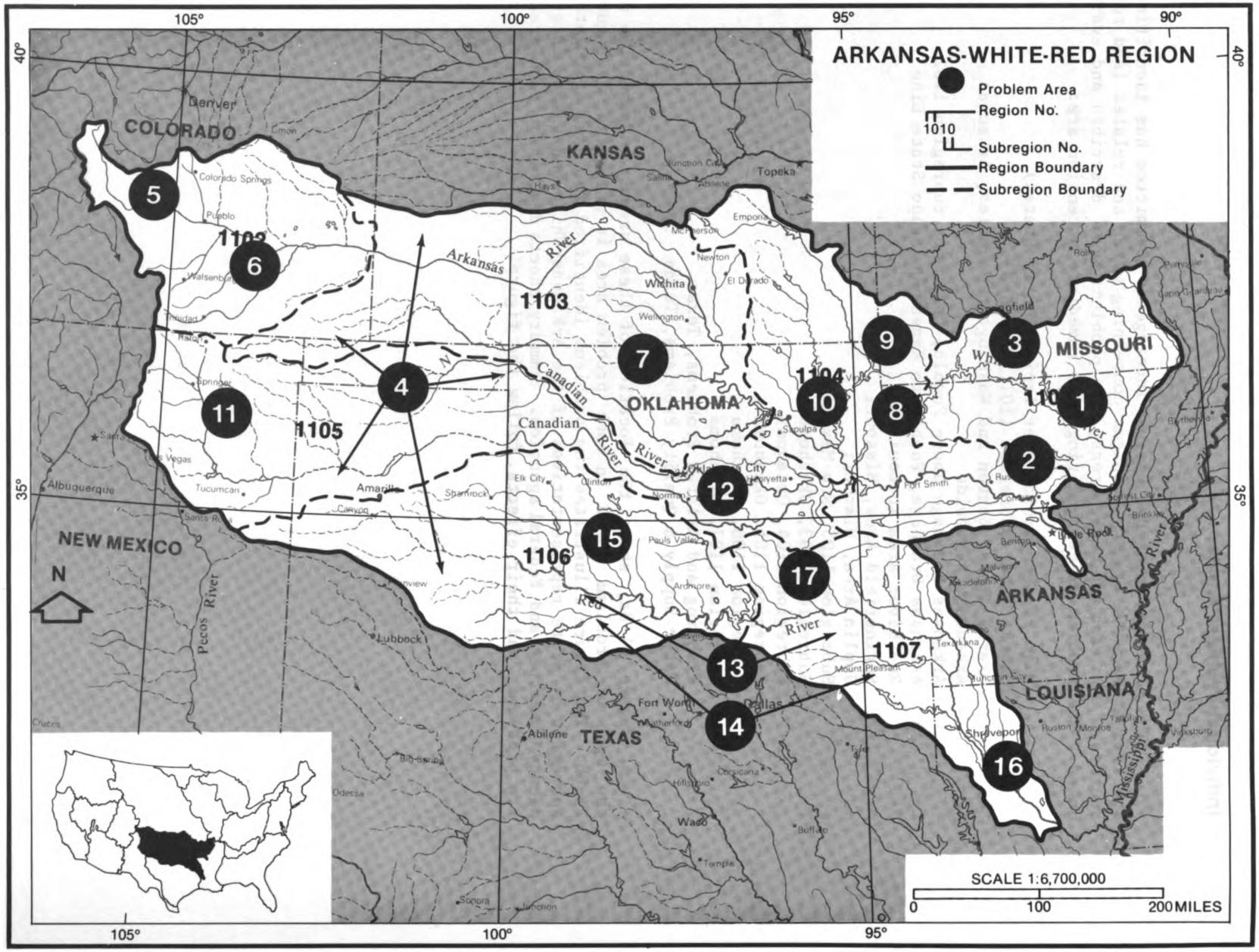


Figure 11-8a. Problem Map

ARKANSAS-WHITE-RED REGION (11)

PROBLEM MATRIX

Problem area		Problem issues O= Identified by Federal Agency Representatives X= Identified by State-Regional Representative													
		Water quantity				Water quality				Related lands					
No. on map	Name	Fresh surface	Ground	Marine and estuarine	Surface/depth	Fresh surface	Ground	Marine and estuarine	Surface/depth	Flooding	Drainage	Erosion and sedimentation	Dredge and fill	Water related use conflicts	Other
Subregion 1101	Upper White									O					
Area 1	Ozarks Area, Arkansas	X	X				X			X	X				
2	Arkansas Statewide	X					X			X					
3	Springfield Area, Missouri	X	X			X	X			X	X			X	
Subregion 1102	Upper Arkansas		O				O								O
Area 4	High Plains Ogallala Formation		X												
5	Arkansas Drainage above Pueblo, Colorado	X			X	X				X			X	X	
6	Arkansas Drainage Pueblo to Kansas Border	X			X	X				X		X			X
Subregion 1103	Arkansas-Cimarron	O	O			O				O		O			O
Area 4	High Plains Ogallala Formation		X												
7	Oklahoma	X	X			X	X			X	X				
Subregion 1104	Lower Arkansas	O				O				O		O			O
Area 8	Ozarks Areas, Benton & Washington Counties, Arkansas	X	X			X	X			X	X	X			
2	Arkansas Statewide	X					X			X					
9	Joplin Area, Missouri	X	X			X	X								
10	Oklahoma	X			X	X				X		X	X	X	X
Subregion 1105	Canadian	O	O			O									O
Area 4	High Plains Ogallala Formation		X												X
11	New Mexico	X	X			X	X			X		X		X	
12	Oklahoma	X	X			X	X			X	X	X			X
13	Texas Statewide: Flooding									X		X		X	X
14	Small Cities & Rural Communities, Texas	X	X			X	X								
Subregion 1106	Red-Washita		O			O									
Area 4	High Plains Ogallala Formation		X												
15	Oklahoma	X	X			X	X			X					
13	Texas Statewide: Flooding									X		X		X	X
14	Small Cities and Rural Communities, Texas	X	X			X	X								
Subregion 1107	Red-Sulphur									O		O			
Area 2	Arkansas Statewide	X				X				X					
16	Red River Area, Louisiana	X				X	X			X	X	X			X
17	Oklahoma	X	X		X	X				X	X	X			X
13	Texas Statewide: Flooding									X		X		X	X
14	Small Cities and Rural Communities, Texas	X	X			X	X								

Figure 11-8b. Problem Matrix

Problem Area : High Plains Ground-Water Irrigation

Description

This problem area covers portions of six States--Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas--and portions of three assessment regions--Missouri, Arkansas-White-Red, and Texas Gulf. It is located on the High Plains of southwestern Nebraska, eastern Colorado, western Kansas, Oklahoma, Texas, and eastern New Mexico. During the past 35 years, private irrigation has developed in the area mainly by pumping ground water from the Ogallala Formation, where in portions of the area withdrawals now exceed recharge rates. The whole area includes 13.1 million acres of irrigated land and withdrawals of nearly 20 million acre-feet of water annually in 1975.

In the Arkansas-White-Red Region the total irrigated area in 1975 was 4.8 million acres. The withdrawal of water was about 11.2 million acre-feet annually, of which 6.1 million acre-feet was mined ground water. The economy of the High Plains has grown from this development, and the lowering of water levels foreshadows difficult times ahead in portions of the area.

Water Issues

Declining ground-water levels due to irrigation pumping is the main water issue. Lowering of water levels reduces the yield of wells, and, in some areas, lowers the quality of water. These effects may jeopardize the economy of portions of the area in the near future.

Related Issues

Since ground-water irrigation is a significant portion of agriculture and since agriculture is a significant portion of the whole economy of the High Plains, the trends in further development of ground water are very important to everyone concerned. As of 1975, the States of Colorado, Kansas, Oklahoma, New Mexico, and Texas indicate that ground-water development in the High Plains will increase by 2000, although portions of the area are now withdrawing water faster than it is being recharged. The Ogallala Formation extends over a larger area than is now developed. On the other hand, the State of Texas indicates that irrigation of the High Plains may decline by 2000 unless positive action is taken to supplement water supplies.

In any event, the economies of the entire area relate to the continued growth or decline of the irrigation development of the High Plains.

Adverse Effects

Each year some of the wells must be deepened and pumps set lower to

reach the water; the costs of pumping rise accordingly. In addition, costs of energy to operate the pumps are increasing, which further escalates water costs. Also, the quality of the ground water declines as the aquifer becomes dewatered; in some portions of the region, the water has become unsuitable for domestic use. This will jeopardize the economy first in those areas where the declining water table makes it unprofitable for farmers to continue irrigation; thus they will depend on dry farming. The State of Colorado has estimated that this would reduce the economy of the area by $581 per acre per year, based on 1975 dollars. But the most severe effect would be the loss of homes and businesses through bankruptcies and general community decay.

Texas has also estimated the adverse effects through loss of groundwater irrigation. Texas estimates that a decline in water below the 1975 level in the region will total 15.3 million acre-feet in the next 25 years, resulting in production losses amounting to $999.1 million from 1975 to 2000. This is a direct loss in marketing crops. It is estimated to result in a loss of 159,000 jobs over the State both in agriculture and in other businesses that directly or indirectly service agriculture. The production losses are estimated to reduce statewide personal income by $1.6 billion over the same period.

Problem Area : Ozarks Area, Subregion 1101, Arkansas

Description

This area includes fourteen north Arkansas counties, all of which lie in the White River Basin. One problem issue extends into Problem Area 3, which includes Benton and Washington Counties. The total area is 7,811 square miles. Terrain is generally hilly, but with local relief seldom exceeding 200 feet. However, the southeastern portion of the area extends into the Boston Mountains, where local reliefs of 1,600 feet are common and extreme stream dissection has resulted in deep valleys and steepsided mountains.

About 166,000 people were living in the area in 1975, and the population is growing. Increases in population have resulted in part from an influx of retired persons into developments near the many excellent fishing lakes. Tourism also has been a major industry in northern Arkansas.

Water Issues

There is a lack of data on ground water for domestic and municipal uses. Because of the low population density, individual wells are frequently the only feasible sources for rural domestic and livestock water. Smaller towns and communities must also depend upon ground-water supplies because the high cost of reservoir developments cannot be financed by the small number of users.

Lack of detailed ground-water inventories makes the search for water a hit or miss proposition. Efforts of planners who attempt to develop regional and local water supplies are crippled by this lack of knowledge. The fact that adequate funds are not available makes it imperative that funds be used to develop expensive surface water supplies first in areas known to have insufficient ground water.

Plans for the Carroll-Boone Water Distribution District are well underway and being funded. This project involves pumping water from Beaver Lake across two counties to towns on the very banks of Bull Shoals Lake. However, authority is lacking for the use of the Bull Shoals project for water regulation. As a result, a greater financial burden has been placed on people in the area.

Conflicts have arisen concerning interstate flows on the Black River due to lack of an interstate compact. As development occurs, more frequent difficulties are sure to arise.

Adverse Effects

Since no detailed inventory of ground-water resources exists, accurate predictions of yield and depth of water are impossible for most locations. Several reports describing ground-water supplies have been generated; however, they are not comprehensive.

Bull Shoals Lake, which has over 3 million acre-feet of normal storage, has no legal provision for extraction of municipal water. This growing area must have water to meet the growing needs of industry and people. Without reservoir regulations, the cheapest source of water often is not available. As mitigation for loss of warm-water habitat incurred when the White River reservoirs were built, trout fisheries were established in the cold tailwaters below Bull Shoals, Beaver, and Table Rock Lakes. During periods of low power demand and high ambient temperature, the flow of cold water from the depths of the lakes is sometimes insufficient to maintain the low temperatures required by trout.

The lack of an interstate compact adversely effects both Arkansas and Missouri in the development of tourism as well as industry in the Ozarks region.

Problem Area : Ozarks Area, Benton and Washington Counties, Arkansas

Description

Washington and Benton Counties constitute this area. Washington County is primarily drained by tributaries of the Grand Neosho River, which discharges into the Arkansas River. Most streams in Benton County drain into the White River. The total area is 1,849 square miles.

Approximately two-thirds of the area is within the Ozark Plateau Province. Terrain in this section is hilly, but extensive level areas occur in both counties. Elevation ranges from 500 to 1,500 feet. Local relief seldom exceeds 300 feet. In 1975 the population was 146,653 and is expected to double by 2000. In 1975 a total of 23.4 mgd (million gallons per day) of water was used; about one-third of this was from ground water and two-thirds from surface water. The major economic income was from agriculture, manufacturing, and tourism in 1975.

Water Issues

There is a lack of data on ground water. A small research project by the University of Arkansas revealed that, in the area included in the study, 80 percent of the ground-water sources tested were polluted with coliform. The study encompassed 100 square miles and results indicate that 90 percent of the area may be affected. If the same proportion of the entire carbonate area is affected, 1,231 square miles of the fastest growing area in the State is subject to ground-water pollution.

Each year, backwater flooding occurs along the rivers, causing losses amounting to millions of dollars per year. Unless flooding is controlled, these losses will continue and will increase as development and property values increase. At present, development of land is taking place without adequate regard to possible damage to or contamination of aquifer recharge areas.

Adverse Effects

Contamination of aquifer recharge areas occurs partly because of lack of knowledge of recharge areas and their susceptibility to contamination. In the worst possible case, almost all users of ground water could eventually be affected in some degree by lowered water quality. The number of users could total 255,660 persons.

Problem Area : Arkansas, Statewide

Description

This area includes the entire State of Arkansas. Major drainage is by the Arkansas, White, Red, Ouachita, and St. Francis Rivers. The total land area is 53,102 square miles. The terrain varies from flat delta to steep, mountainous areas with local relief exceeding 1,600 feet. Elevation varies from 2,823 feet to less than 200 feet above mean sea level.

Arkansas's climate is generally classified as humid-subtropical, but considerable variation exists between high elevations in the northern and the southern extremes of the State. Minimum temperatures occasionally fall below freezing in the southern portion of the State and frequently below zero in the northern highlands.

The population in 1975 was 2 million and is forecast to grow about 30 percent by 2000. Historically, agriculture has been the chief source of earnings, but projections indicate that manufacturing will move ahead.

Water Issues

Flooding and high flows for Arkansas and a possible regional water export to Texas because of lack of water in the High Plains are the key water issues.

Related Land Issues

Land issues are flood control and the impact of land use upon ground-water quality.

Adverse Effects

The feasibility of flood control by export needs to be explored. A study funded by the State of Texas is placing major emphasis on developing a source of water for Texas rather than possible flooding relief for Arkansas. General design parameters in the present study would make water export useless as a flood control measure.

At present, little data on ground-water quality is available. At least as important as quality is susceptibility to contamination; this also is unknown over most of the State. Knowledge of the relation between recharge area development and quality is essential to protect the quality of water for future uses.

Problem Area : Arkansas Drainage Area Above Pueblo, Colorado

Description

The area is the mountainous portion of the southern Rocky Mountain region drained by the Arkansas River from the Continental Divide to Pueblo, Colorado, and the Front Range and plains area drained by Fountain Creek. The total area is 3.6 million acres. Elevations range from over 14,000 feet down to 4,640 feet at Pueblo. There is a wide range in the climate as illustrated by data at Leadville and at Pueblo. The annual precipitation at Leadville is 18.5 inches, and the snowfall is 125 inches. The maximum temperature is 82°F., and the mean annual temperature is 37°F. At Pueblo the mean annual precipitation is 12.1 inches, and the snowfall is 31 inches. The maximum temperature at Pueblo is 105°F., and the mean annual temperature is 51°F.

The mountain slopes are forested from about 7,500 feet to 11,000

feet of elevation. The valley floors are primarily light brush, open hay, and meadowlands. There are about 42,000 acres of irrigated hay land and 15,000 acres of irrigated field crops in the Arkansas River Valley above Pueblo. There are about 12,000 acres of irrigated hay and field crops in the Fountain Creek drainage. Approximately 46 percent of the problem area is in Federal lands administered by the Forest Service, the Bureau of Land Management, and the military.

In 1967, there were 111,600 acres of urban and built-up land; this land is estimated to have increased to 140,000 acres by 1975. The total population of the area in 1975 was 458,670. Of this total, 423,670 people live in the Colorado Springs and Pueblo areas. The principal economic activities are agriculture, manufacturing, mining, and tourism.

The melt of snowfall from the mountains provides the major portion of the water supply, but the area has a history of flood-producing storms occurring over the Arkansas River watershed below Canon City and over Fountain Creek watershed.

Water Issues

During a normal year of streamflow and imports of water, Colorado Springs and Pueblo have just enough water to satisfy their 1975 domestic requirements of 105.7 mgd (1975 requirements). However, during a series of drought years and low surface runoff years, there are shortages on the order of 25.0 mgd.

The domestic requirements for Colorado Springs and Pueblo are expected to increase by about 52 mgd by 2000. When completed, the Fryingpan-Arkansas Project will provide 25.1 mgd annually of this increase, leaving about 27 mgd annually in shortage. In drought years this shortage could double.

During late season and dry periods, the flow in the streams becomes too low to sustain good fisheries. There is a shortage of water areas in lakes and reservoirs to meet the water-based recreation, fishing, and hunting demands.

Related Land Issues

Floods on the Arkansas River, Fountain Creek, and their tributaries are a serious problem. Urban and built-up areas of Colorado Springs, Fountain, Security, and Pueblo are subject to damaging floods on Fountain Creek. Local flooding occurs at the communities of Salida, Cotopaxi, Canon City, Florence, and Portland from the Arkansas River and tributaries.

Prime irrigated farmlands are being converted to urban uses in the rapidly developing Colorado Springs and Pueblo areas. Water rights for agricultural lands are usually converted to rights for domestic

uses along with the land. It is estimated that irrigation water from 12,000 acres will be used for urban development between 1975 and 2000.

Institutional Issues

The issue of Federal claims for water rights on public lands, with dates of priority as the date of public land withdrawal, should be settled. These Federal claims should be quantified. The State of Colorado lacks a strong land-use policy to control the transfer of prime irrigated croplands and attached water rights to urban uses.

Financial Issues

Federal agencies having land management responsibilities need increased funding for recreational facilities. Additional State funding is needed to meet the cost-sharing responsibilities for proposed recreation development of water projects. Dependable and regular Federal and State funding is needed for agricultural water management, flood control, and related land-use projects.

Adverse Effects

Failure to increase the projected water supply to Colorado Springs and Pueblo by 2000 will require frequent restrictions on water uses for a projected population of 567,760. The 57,000 acres of irrigated land along the Arkansas River and tributaries above Pueblo will continue to have water shortages during dry periods.

Pollution of water in California Gulch and other streams in the upper Arkansas will damage fishing and other recreation uses on 10 miles of the Arkansas River and 20 miles of tributary streams. Similarly, pollution in Four Mile Creek near Cripple Creek is damaging fisheries.

Flood protection and flood-prevention measures are needed in the Fountain Creek watershed. The intense storms and resulting flood in Fountain Creek and its tributaries in June 1965 produced a peak flow of 68,000 cfs at Pueblo, where 370 residents and 53 business properties were inundated. Railroad and highway facilities were destroyed so that Colorado Springs, Fountain, and Security were virtually isolated. The estimated damages from the June 1965 flood on Fountain Creek amounted to about $6 million.

Damaging floods at other places are, at times, locally severe and a hazard to life and health.

Prime irrigated farmlands being converted to urban use in the Colorado Springs and Pueblo areas will result in a loss to the agricultural economy of $1.7 million by 2000. However, financial gains to the local

economy from urbanization may offset or exceed agricultural losses. This remains to be determined.

Failure to settle the Federal claims for water rights of an unknown quantity of water on public lands, with the date of priority as the date of the public land withdrawal, has a far reaching effect on the future uses of land and the future availability of water under the existing water rights.

Problem Area : Arkansas Drainage, Pueblo to Kansas-Colorado State Line

Description

The Arkansas River watershed between Pueblo and the Colorado-Kansas State line, excluding the High Plains, constitutes this problem area. The total area is approximately 21.2 million acres. The watershed is a broad rolling plain through which the Arkansas River has formed a wide valley of flood plains and river terraces. The perennial tributary streams, the St. Charles, Huerfano, Aphishapa, and Purgatoire Rivers, originate along the eastern face of the Rocky Mountains south of Pueblo, and flow northeasterly to enter the Arkansas River upstream of John Martin Reservoir.

In 1975 the population was about 69,250 and is projected to slightly exceed 70,000 by 2000. The economy is based upon agriculture. There are approximately 380,000 acres of irrigated cropland about 500,000 acres of Federal lands administered by the Forest Service and the Bureau of Land Management.

The annual discharge of the Arkansas River at Las Animas, for example, varies widely. Here the maximum flow is about 34 times greater than the average annual flow and about 77 times greater than the minimum annual flow. The average flow is about 23 times greater than the minimum annual flow; this great variation is one of the major problems in water supply.

The problem area has a history of floods causing severe damage to urban and rural areas.

The quality of water in the Arkansas River deteriorates progressively downstream from Pueblo as a result of the leaching of soils from use and reuse of irrigation water. The average concentration of dissolved solids in the river at Pueblo is about 365 ppm; at the Colorado-Kansas State line it is about 3,600 ppm. The source of municipal water for the cities is obtained mostly from ground-water wells in the valley fill.

Water Issues

Water quantity is insufficient to meet the requirements of irrigation and municipal water systems. The low flows in the streams in the fall and during other dry periods are insufficient to sustain fisheries.

There is a severe shortage of water for water-based hunting, fishing, and recreation.

The high salt content of the river water adversely affects crop production. The dissolved solids in the surface and ground water used for public supplies exceed the recommended standards for domestic consumption.

Related Land Issues

Very intense cloudbursts occur over the Arkansas River watershed leaving very few communities and agricultural areas free from flood damage to varying degrees. The Arkansas River and local tributaries have flooded Lamar, La Junta, and Las Animas.

Streambank erosion and sedimentation on valuable cropland during high streamflow and floods are a serious problem.

Institutional Issues

The Arkansas River Compact between the State of Colorado, the State of Kansas, and the United States for operation of John Martin Reservoir should be revised to permit better utilization of the water in the Arkansas River. The compact stipulates in part that during the summer storage season (April 1 to October 31) water being held in storage may be released upon demand by both States concurrently or separately in amounts dependent upon the magnitude of storage. With concurrent demand, Colorado is entitled to 60 percent of the release and Kansas 40 percent. The problem is that the need for irrigation water is not necessarily simultaneous in the two States. Therefore, when one State demands release of water in storage, the other State also demands release of storage water in order to be assured of its proportionate share of the water.

Financial Issues

Increased funding for recreational facilities is needed for Federal agencies having land management responsibilities. Also, additional State funding is needed to meet cost-sharing responsibilities for recreation development on water projects. Dependable and regular Federal and State funding is needed for agricultural water management and related land-use programs.

Adverse Effects

The average annual withdrawal of irrigation water is 407,500 acre-feet short of meeting the requirement for a full supply for 380,200 acres of cropland. The Fryingpan-Arkansas Project, scheduled for completion by 1985, will alleviate the shortage by 148,000 acre-feet, leaving a shortage of 259,500 acre-feet. The U.S. Bureau of Reclamation estimated

that the on-farm value of an acre-foot of supplemental irrigation water for the Fryingpan-Arkansas Project was $27.80, 1967 prices. Thus, the loss of on-farm income by virtue of the shortage of irrigation is $11.3 million annually, and after 1985, it will be reduced to $7.2 million annually. It was determined in a Nebraska study that the on-farm, direct, induced, and (stemming from economic) value was 7.58 times that of on-farm direct. Assuming such an economic gain is applicable here, it would amount to a total of over $85 million annually until 1985, and over $54 million annually after 1985.

The poor quality of Arkansas River water used for irrigation retards the growth of plants and limits the crops grown to those tolerant of salts. If the salts accumulate too much, the soil becomes barren.

The domestic water supply for about 44,000 people living in the municipalities and villages in the Arkansas River Valley does not meet approved standards because of the high salt content. Of these people, approximately 18,000 have insufficient water supplies to meet their requirements. About 30 percent, or around 13,000 people, have home water systems and purifiers, costing about $120 per year per person or a total of $1.6 million annually. Approximately 26,000 people living outside the Arkansas River Valley receive a good quality of domestic water but experience to some degree annual shortages of water. Until 1985, when the Arkansas River Pipeline is scheduled to be completed, the people in the area will have to contend with inadequate water supply and poor water quality.

Floods, erosion, and sedimentation continue to cause damage to agricultural and urban areas.

Continued economic losses will result from the failure of Federal and State governments to increase and regularly fund ongoing planning programs and to provide funds to implement the recommended plans.

Problem Area : Red River Area in Louisiana

Description

This area involves all of the parishes in the Louisiana portion of the study area that lie adjacent to the Red River. All of the problems are related to the Red River. The areas immediately adjacent to the Red River, specifically the flood plains, receive the greatest impact from the problems.

The problem area includes the parishes of Caddo, Bossier, Webster, Bienville, Red River, and Natchitoches. It is predominately a rural area with one major urban center, Shreveport-Bossier. The area population was 395,111 in 1970, with Shreveport accounting for 321,182. The major sources of employment are wholesale and retail trade, manufacturing,

government, and services. Caddo and Bossier Parishes account for most of the employment. Agriculture is still a significant source of employment in Red River and Natchitoches Parishes. In Bienville, Bossier, Natchitoches, Red River, and Webster Parishes, lumber industries predominate. Caddo Parish contains the largest number of manufacturing establishments, with the publishing, food, lumber, machinery, and fabricated metals industries being most common.

The topography varies from that of an alluvial valley at or near flood level of the Red River and its tributaries to upland flat woods of intermediate elevations. Vegetation is wetland hardwoods giving way to mixed pine and upland hardwoods.

The climate is classified as moist subhumid to humid. Precipitation generally exceeds evapotranspiration. Rainfall averages 53 inches annually. Normal monthly temperatures range from a low average of 49°F. in January to a high average of 82.8°F. in July.

Water Issues

The major water problems are associated with the Red River. First, the water quality is inadequate for most uses. Second, the depth of the river is insufficient for navigation; and third, flooding and bank erosion damage property. Studies have shown that the benefits from rendering the Red River navigable would exceed costs.

Institutional Issues

Institutional problems include the lack of an interstate agreement apportioning waters of the Red River and the responsibility of local interests to provide spoil dikes during channel dredging.

Adverse Effects

Because of the high salinity, dissolved solids, sediment, herbicides, and pesticides, water from the Red River is unsuitable at low flow for irrigation and public use without very expensive treatment. At present there are no estimates of the cost to the economy because of the poor quality of Red River water.

The depth of the Red River is insufficient for commercial navigation, and in many months is insufficient for recreational activities.

Flooding along the Red River and its tributaries occurs on a regular basis. Damages primarily involve agricultural production, although roads, bridges, and other property are also affected. Financial losses due to flooding and erosion which can be eliminated through structural measures are estimated to be $9.1 million annually. Erosion causes the loss of many acres of bottomland, and high turbidity damages fish and wildlife.

The fact that there is no agreement among the States bordering or encompassing the Red River leaves future supplies available to Louisiana in doubt.

The responsibility of providing spoil dikes is an onerous one to local government since it is a Federal requirement which the States believe should be a Federal expense. This requirement will be a significant cost to the State of Louisiana for a project as large as the Red River Waterway.

Problem Area : Springfield Area, Missouri

Description

This problem area is located in the southwest portion of the State and consists of Greene and Christian Counties. Springfield, the third largest city in the State, has been classified as an SMSA (Standard Metropolitan Statistical Area). The two counties have an area of about 1,244 square miles.

Springfield is located on a drainage divide, with the Sac River to the north and the James River to the south. Topography is varied, ranging from gently rolling plains in the southwest to highly dissected plateaus in the northeast. Much of the area is 1,200 to 1,300 feet above sea level.

Mild winters and warm summers are characteristic of the area's humid continental climate. The average annual temperature is 57°F., and the annual precipitation averages 41 inches.

Major streams are sustained during low flow periods by inflow from natural underground reservoirs in the soluble carbonate rocks. Surface streams and ground-water sources in the study area are interconnected and can be regarded as parts of a single system, differing mainly in flow rates.

The population of the area in 1975 was about 200,000, and it is forecast to be about 300,000 by the year 2000.

Water Issues

Initial problems or issues include projected water shortages, increased water pollution due mainly to storm-water runoff, the karst terrain and its vulnerability to contamination of shallow and possibly deep ground water, increased water usage as the population increases, and destruction of the environmental quality of streams.

In recent years, the cavernous nature of the bedrock, the many sinkholes, and the losing streams--combined with a rapidly increasing population--have greatly increased the possibility of ground-water contamination. Auxiliary wells utilized by Springfield are in the deep aquifer. Increased

pumping of wells in the deep aquifer by the city and various industries is lowering the water level and causing a cone of depression that is centered in Springfield proper.

Dry Sac Creek and Wilson Creek are currently receiving treated wastes. Below the southwest sewage treatment plant, Wilson Creek contains high amounts of organic material due to effluent discharged from the plant.

Related Land Issues

Flooding, drainage, and water use conflicts exist. Increased urbanization increases the amount of storm-water runoff. The time lag between initial precipitation and runoff decreases significantly as the amounts of storm sewers and area of impervious surfaces increase. Increased runoff amounts increase the threat of more frequent severe floods and greater flood damages on urbanized flood plains in the area. Urban areas most susceptible to flooding are along Jordon, Fassnight, and South Creeks, which are tributaries of Wilson Creek, and along Pierson and Galloway Creeks, which are tributaries of the James River.

The initial flush of storm-water runoff is the largest threat to aquatic life. Water temperatures and toxic chemical concentrations are high, while oxygen content is extremely low.

Adverse Effects

Pumping costs increase with lowering of the water level. Lowering of the water level also increases the recharge potential through the shallow aquifer. Pollution in losing streams can be drawn to active wells. Contamination of water in the deep aquifer can also occur if wells are poorly constructed or improperly cased, allowing freer movement of polluted waters in the shallow aquifer to the deep aquifer.

All previous major fish kills of record occurred during periods of low flow in the James River, when thunderstorms over Springfield located in the upper Wilson Creek Basin produced a rise in Wilson Creek not accompanied by a rise in the James River.

The central sewer system in Springfield is limited. Peripheral areas rely on septic tanks for waste treatment. Because of the karst environment, effluent from septic tanks is not effectively filtered and readily enters the ground water. Adequate treatment facilities need to be provided for smaller urban centers and rural areas which are undergoing rapid urban development.

City utilities of Springfield estimated the 1976 daily water usage at 15 mgd. It has been determined that this amount could be sustained during severe drought conditions from current sources. By 1985, water needs are estimated to be at 24.2 mgd, and serious shortages could occur

during peak demand periods of extended drought unless additional sources are found.

Problem Area : Joplin Area, Missouri

Description

The Joplin problem area consists of Newton and Jasper Counties in the southwestern corner of Missouri. It is approximately 31 miles wide east to west, and 41 miles long north to south, and encloses 1,261 square miles.

The highest point is near the southeast corner with an elevation of about 1,360 feet above mean sea level, with the lowest area along the lower reaches of Shoal Creek in the west with elevations of about 850 feet. The difference is about 510 feet.

The entire area drains into the Lake of the Cherokees (Grand Lake). Principal tributaries leaving the area are Center Creek, Shoal Creek, and Five-Mile Creek, draining into the Spring River, which drains into the Neosho (Grand) River; Lost Creek, draining into Sycamore Creek, which drains into the Neosho River; and Buffalo Creek and Indian Creek, draining into the Elk (Cowskin) River.

The southern portion of the area has rough country with considerable woodland of relatively low timber value. The northern portion flattens in upland farmland. The central portion of the area is strewn with tailing piles and flooded shafts of abandoned lead and zinc mines. The economically-accessible ore deposits from the relatively shallow mines have been exhausted.

The population of Jasper and New Counties in 1975 was 120,800 and is projected to grow to 142,000 by 2000. Agriculture has always been an important segment of the Newton-Jasper-area economy. Joplin has become a center for manufacturing, transportation, and services, but mining supports much of the region's economy.

The average annual temperature is 56°F., and the average annual precipitation totals 41 inches, which includes water from an average snowfall of 13 inches. The area has abundant fresh-water resources which will support projected needs beyond this century if properly developed. Water is available from both surface and ground supplies.

Water Issues

Problems of pollution of both surface and ground water have persisted for many decades in the mined areas around Joplin. The study in progress (Section 208 of Public Law 92-500) finds heavy metal content of mine waters

to exceed permissible levels for viable life functions of aquatic organisms. Leachates from tailing piles have much greater heavy metal content than the mine waters have. Water from both sources discharges to streams.

Stream bottom sediments are being investigated and high levels of heavy metals are being found along some stream segments. Improperly constructed deep wells and wells which have become faulty permit polluted shallow ground water to enter the deep aquifers. In the 1930's a federally funded project plugged all the abandoned deep wells that could be found, and this has done much to guard the quality of the deep ground water. Unfortunately, however, not all the wells were located.

With growing populations, industrial centers, and demand for water, a number of alternatives exist to increase the water supply for Newton and Jasper Counties. These alternatives include increasing the supply of water obtained from ground water, increasing the supply of water by piping it from existing reservoirs, and, probably the most important, constructing reservoirs within the area. Already several sites have been considered on Center Creek and Shoal Creek. Prosperity Reservoir is considered the first choice, followed by Granby.

With the existing and additional needs for fresh water and the shortage of impoundments, there will be increased usage of the ground water which may cause shallow wells to go dry, thereby requiring deeper and more costly wells.

Adverse Effects

Industry is a major waste-water contributor. Industry in the Joplin-Carthage area has the most effect on the water quality of the Spring River Basin. Center Creek receives most of the industrial waste discharged to the Spring River Basin. Wastes discharged from chemical industries to Center Creek have been and are creating water quality problems in Center Creek. The large quantity of ammonia which is discharged has been responsible for toxic conditions in the creek and is thought to be the primary cause of oxygen deficits, which are commonly found. The water quality problem in Center Creek is quite complicated. Generally, though, only minor water quality control problems occur from municipal and industrial effluents on interstate and intrastate tributaries to the Neosho (Grand) River.

Problem Area: Subregion 1105, New Mexico

Description

Subregion 1105 in New Mexico includes the counties of Colfax, Harding, Mora, Quay, and Union, and the hydrologic boundaries also include portions of San Miguel and Curry Counties. The five counties have an area of 14,533 square miles, but the hydrologic area contains 17,722 square miles.

Most of the streams of this basin are tributaries of the Arkansas River. Principal tributary streams in New Mexico are the Cimarron, North Canadian, and Canadian Rivers.

The problem area is bounded on the west by the Sangre de Cristo Mountains; on the north by a series of plateaus, mesas, and hills (along the Colorado-New Mexico State line); on the south and southeast by a series of hills, mesas, etc., that separate the region from the Pecos River Basin; and by the Texas-Oklahoma-New-Mexico State line on the east. The eastern part of the basin consists primarily of the northern and part of the southern High Plains that extend from west Texas into eastern New Mexico.

Altitudes in the basin range from over 13,000 feet (Sangre de Cristo Mountains) to about 4,500 feet in the plains area. Mean annual precipitation ranges from about 14 inches to over 23 inches. Mean annual temperature ranges from about 44°F. to 58°F.

The 1975 population was about 36,000, about 50 percent urban and 50 percent rural. The major urban places and their midyear 1974 populations included Raton, 7,400, Tucumcari, 4,550, and Clayton, 3,050. Agriculture is the major economic base, accounting for about 22 percent of the total earnings. Manufacturing, minerals, recreation, and general services are important to the economy.

Water Issues

Surface-water supplies are limited and in most of the area these supplies are fully appropriated or committed, mostly for irrigation. Other uses would require a transfer of use from irrigation.

Throughout much of the area yields from ground-water aquifers are low to moderate, and the quality of water is generally poor. Where these conditions exist, the supplies are not adequate to meet projected increased municipal and mineral demands.

Related Land Issues

Surface-water runoff results in flood damage in urban and rural communities. Uncontrolled flooding along stream channels results in damage to diversion structures, bank-cutting, loss of irrigated cropland, and destruction of roads, bridges, powerlines, and other structures.

Headcutting and sheet erosion destroy range and croplands, add sediment to the streams, and affect crop production and livestock grazing capabilities.

A study by the U.S. Bureau of Outdoor Recreation indicates large deficiencies in surface-water supplies required for projected recreation demands in the subregion.

Adverse Effects

Where ground-water supplies are limited, most uses other than irrigation will require a transfer from irrigation use. This would dry up large irrigated acreages and would adversely affect economic, social, and environmental conditions in the region.

Quality and quantity of ground-water supplies are marginal in many areas, and expensive works are required to improve the quality for domestic and industrial uses.

Flood damage occurs in three urban communities and in dozens of small rural communities. Floods destroy irrigation works, cropland, roads, bridges, and other structures.

Headcutting and sheet erosion destroy range and cropland and result in rapid siltation of streambeds and reservoir areas.

Because of limited surface-water supplies, projected recreation and fish and wildlife demands probably cannot be met unless large acreages of irrigated lands are retired from production.

Problem Area : Subregion 1103, Oklahoma

Description

This problem area includes Alfalfa, Harper, Garfield, Grant, Kay, Kingfisher, Logan, Major, Payne, Noble, and Woods Counties. There are 9,594 square miles in the area. Major cities consist of Enid with a population of 49,986, Stillwater with 31,126, and Ponca City with 25,940. Elevation ranges from 1,100 feet above mean sea level in Grant County to 850 feet in Lincoln County. Rainfall fluctuates between 21 and 34 inches annually, with snowfall between 9 and 16 inches. Annual runoff varies from 1 to 5 inches, with daily mean temperatures ranging from 47°F. in January to 95°F. in July. The length of the annual growing season is 198 to 222 days. Total population is 249,400. The total number of employed persons is 94,800. The total earnings amount to $1,016 million, with a per capita income of $6,068, according to State reports.

Major ground-water aquifers consist of the Ogallala, Vamossa, Garber Standstone, and Wellington formation and alluvium and terrace deposits. Mined minerals include salt, gypsum, limestone, and dolomite. Industrial activities include 24 gasoline plants, four refineries, and two petrochemical plants. Industrial growth has been limited due to a lack of high quality water and natural resources. Agricultural earnings in 1975 dollars totaled $5.9 million. A total of 6.2 million acres of land was under cultivation, including 54,000 irrigated acres.

The problem area includes the Salt Fork of the Arkansas River and

the Cimarron River, both draining into the Arkansas River. Developed surface-water resources within the problem area include the Great Salt Plains Reservoir and the recently completed Kaw Reservoir.

Water Issues

There are ground-water shortages for crude oil secondary recovery and petroleum refining.

Related Land Issues

There are urban areas with high risk flooding, including Aline, Blackwell, Burlington, Cherokee, Coyle, Cresent, Dacoma, Dover, Driftwood, Drumright, Enid, Guthrie, Jefferson, Jet, Kingfisher, Medford, Nash, Newkirk, Okeene, Ponca City, Stillwater, Tonkawa, Wakita, and Waynoka.

In high-risk nonurban areas floods damage fences, buildings, and farming equipment as well as crops and pastures. Drainage problems occur when floods recede.

The combination of increased pumping depths, declining water table levels, and high energy costs will force farmers to return irrigated land to dryland farming in the coming decades. Phreatophytes transpire large quantities of ground water.

Institutional Issues

Additional water-oriented recreational facilities are needed to serve the growing population of this area at both Federal and State levels. Public policy and programs are needed to help move the Arkansas chloride control projects through planning to construction.

Adverse Effects

Damages from flooding total $7.7 million annually in terms of 1967 prices. Chemical pollution, deficiencies in recreation facilities, and water losses because of phreatophytes will remain unless decisive action is taken to solve these problems.

Problem Area : Subregion 1104, Oklahoma

Description

This problem area includes Creek, Tulsa, Pawnee, Miskogee, Wagoner, Sequoyah, Cherokee, Adair, Rogers, Mayes, Delaware, Ottawa, Craig, Nowata, and Osage Counties in Oklahoma. The drainage area is 14,001 square miles.

Major cities are Tulsa, Bartlesville, Sapulpa and Muskogee. Elevations range from 1,750 feet above sea level in the east to 400 feet above sea level in the west. Rainfall fluctuates between 34 and 56 inches annually across the area, with snowfall amounting to 5 to 9 inches. Annual runoff varies from 5 to 20 inches, and mean temperatures range from 51°F. in January to 74°F. in July. The length of the growing season is 190 to 210 days. Total population is 897,500, of which 592,100 is SMSA population. Total number of people employed is 341,100, and total earnings in 1975 dollars amount to $3,649 million with a per capita income of $5,913 per annum.

Major ground-water aquifers consist of the Vamoosa and Roubidoux Formations and alluvium and terrace deposits. Mined minerals include glass, sand, lead, zinc, limestone, dolomite, germanium, granite, and tripoli. Fuels include oil, gas, and coal. Industrial activities include over 1,000 establishments. The availability of natural resources and their resulting industries and the McClellan-Kerr Arkansas River navigation system have promoted the growth of industry. Agricultural earnings in 1967 dollars totaled $211.7 million. A total of 8.6 million acres of land were under cultivation, including 32,000 irrigated acres in 1975.

Developed surface water includes the following reservoirs: Fort Gibson, Oologah, Lake O'Cherokees, Spavinaw, Eucha, Tenkiller, Robert S. Kerr, Wister, Keystone, Heyburn, Kaw, Hulah, and Webbers Falls. Rivers include the Arkansas, Grand, Verdigris, Deep Fork, and Caney.

Water Issues

Bartlesville needs an additional water supply. There is the possibility of transfering water from Tenkiller to Tulsa for water supply.

There is a potential pump-back storage power unit at Markham Ferry and Fort Gibson Lakes.

Maintenance and alterations to the McClellan-Kerr Navigation Project are needed to optimize and preserve benefits. A national study on power development in inland waterways is needed.

Cooling water for steam electric power generation is an issue.

Related Land Issues

Flood damage is a risk in the communities of Bixby, Glenpool, Coweta, Tullahassee, Boynton, Braggs, Haskell, Muskogee, Oktaha, Porum, Taft, Wain, Wright, Warner, Webber Falls, Sapulpa, Checotah, Okay, Hulbert, Inola, Catoosa, Claremore, Oologah, Nowata, Chelsa, Vinita, Jay, Grove, Afton, Wyndotte, Miami, Peoria, Commerce, Picher, West Seneca, Fort Gibson, Bartlesville, and Poteau.

Flood damage is a risk to farmland and forests, and to land along

the navigation channel in communities and rural areas of the McClellan-Kerr Navigation Project. Elimination of bank erosion is needed to control stability of the navigation channel and to prevent sedimentation and the resulting need for dredging and filling. Also, a master plan for land use along the canal should be prepared to prevent conflict in uses and to insure achievement of benefits.

The Illinois River above Tenkiller is a State scenic river.

Institutional Issues

These issues include problems associated with (1) adoption of funding for the resolution of urban problems, (2) the need for flood-plain management programs, and (3) allocation and use of water between Kansas and Oklahoma and between Oklahoma and Arkansas under compact agreements.

There is a need for Federal, State, and local governments to work together to determine the best use of the McClellan-Kerr project and to protect it. Indian tribes claim ownership of the streambed in this reach, and all benefits from McClellan-Kerr cannot be appropriately distributed until this issue is satisfactorily settled.

Financing and Repayment Issues

Cost-sharing for river bank stabilization involving many different levels of government units is an issue. Local interests will be pressed to pay their share of financing to carry out a recommended solution to the problem.

Adverse Effects

Flooding, erosion, sedimentation, dredging and filling, and water use conflicts will remain problems until solutions are found and implemented. The need for additional water supply at Bartlesville should be met as soon as possible because delays will increase costs.

Problem Area : Subregion 1105, Oklahoma

Description

This area includes Canadian, Cleveland, Lincoln, Seminole, Pottawatomie, Oklahoma, Cimarron, Texas, Beaver, Harper, Woodward, Dewey, Blaine, Roger Mills, McClain, Pittsburg, Hughes, Caddo, Okfuskee, Custer, Grady, Major, and Haskell Counties. The subregion includes 19,548 square miles. Elevations range from 4,973 feet in Cimarron County to 500 feet above sea level in Haskell County. Rainfall fluctuates between 17 and 45 inches annually, with snowfall ranging from 13.5 to 16 inches. Annual runoff

varies from one to 13 inches, and temperatures range from a low of 18°F. in January to 92°F. in summer months. The length of the annual growing season is between 170 and 280 days. The total population is about 1 million, of which 794,900 are in SMSA's. Total employment is 388,600, and the per capita income is $5,519 per annum.

There are several major ground-water aquifers, including the Ogallala. Fuels include coal, oil, and gas. Many minerals are mined.

Related Land Issues

Flood damages occur in most major cities and in agricultural areas.

The combination of increased pumping depths, declining water levels, and increasing energy costs will force many farmers to return irrigated land to dryland farming in the coming decades.

Erosion, sedimentation, and drainage problems exist throughout the area.

There is an inadequate supply of natural gas for all uses.

Institutional Issues

Public polilcy and programs are needed to develop additional water recreation areas. Importation of water to the area from southeastern Oklahoma is being considered in the Central Oklahoma Project plans, and this consideration should be continued.

Financing and Repayment Issues

Ground-water conservation districts similar to the one being formed in Texas County are needed to manage the ground-water supply. In 1975, 11.5 million acres of land were under cultivation, of which 467,000 acres were irrigated. Since 1963 the number of wells in Texas County, Oklahoma, increased from 200 to 960, in Cimarron County, from 180 to 765, and in Beaver County, from 85 to 240. These irrigation wells range in capacity from a few gallons per minute to 2,000 gallons per minute.

Developed surface-water resources include Canton, Fort Supply, Hefner, Overholser, Thunderbird, McAlester, Eufala, and Shawnee Lakes.

Water Issues

Rivers and streams are not used for recreation because water quality in most parts is substandard.

The adequacy of the Garber-Wellington sandstone aquifers needs to be determined for meeting future municipal and industrial water supply needs.

Water quality in sections of the northern Rush Springs Sandstone is poor, thus limiting use for municipal purposes.

Adverse Effects

Flooding, particularly of agricultural cropland, is causing annual damages of over $153 million based on 1975 dollars.

Stream water often is low in both quantity and quality due to natural and manmade pollution. Because of waste discharges in Oklahoma City and satellite communities surrounding the stream channels, pollution is excessive. The water of the Canadian and North Canadian Rivers is too mineralized much of the time for municipal or domestic water supplies.

Ground water varies from good to poor for municipal purposes, but generally is suitable for irrigation.

Problem Area : Subregion 1106, Oklahoma

Description

Counties in the area include Roger Mills, Custer, Beckham, Greer, Harmon, Jackson, Tillman, Cotton, Washita, Kiowa, Caddo, Grady, Comanche, Jefferson, Stephens, Garvin, Murray, Carter, Love, Johnston, and Marshall. Major cities include Elk City, Clinton, Altus, Lawton, Anadarko, Chickasha, Duncan, Sulphur, Ardmore, Park Valley, and Weatherford. The drainage area is 16,999 square miles. Elevations range from 2,200 feet above sea level in Roger Mills County to 650 feet near Lake Texoma. Rainfall fluctuates between 22 and 40 inches annually, with snowfall of 8 to 12 inches. Annual runoff varies from 1 to 8 inches, and temperatures range from an average of 28°F. in winter to 114°F. maximum in the summer. The length of the growing season is 188 to 231 days.

Total population is 461,400, and total employment is 175,700. The per capita income is $4,788 according to State estimates.

There are several major ground-water aquifers, including the Ogallala. Developed surface-water resources include Altus, Clinton, Ellsworth, Fort Cobb, Foss, Lawtonka, Mountain Park, Humphreys, Fugua, Duncan, Clearcreek, Ardmore, Mountain Lake, Arbuckle, Waurika, Texoma, and Murray. The Red River and its tributary along with the Washita River stretch through the area.

Water Issues

Surface water has been fully appropriated in the upper Washita River Basin above Foss Dam, and surface-water use restrictions are necessary in the remaining Upper Washita River Basin. Also restrictions exist in the Lower Washita River Basin in parts of Caddo, Grady, Garvin, and McClain Counties.

Most surface water in the Washita River must be treated for municipal and industrial use due to natural pollution; the lower Washita River Basin suffers as well from oil field brine pollution.

There is insufficient water to meet water-oriented recreation needs.

Salt-water intrusion is a problem, most noticeably in southeast Caddo County. High chlorides are often encountered in wells drilled too deep.

Related Land Issues

Flood damages occur in most of the communities of the area. There are risks of severe damages in Cheyenne, Clinton, Cordell, Corn, Anadarko, Binger, Carnegie, Fort Cobb, Gracemont, Lookeba, Alex, Chickasha, Verden, Marlow, Pauls Valley, Wynnewood, Lindsey, Cherokee, Sulphur, Gene Autry, Springer, Fox, Graham, Tishomingo, Granite, Mangum, Hollis, Hobart, Lawton, and Duncan.

The combination of increased pumping depths, declining water levels and pumping yields, and high energy costs will force more farmers to return irrigated land to dryland farming or fallow in coming decades.

Institutional Issues

There is a need for public policy and programs to preserve ground water and to develop outdoor recreation.

Financing and Repayment Issues

Financial assistance is needed to develop municipal and irrigation water sources and related improvements.

Adverse Effects

Flooding damages to urban and built-up areas, to agricultural cropland, and to forests in terms of 1967 dollars totaled $24.1 million. A significant portion of these damages can be eliminated by flood control measures.

The full appropriation of surface waters will restrict future developments, but will protect authorized uses at Foss, Tom Steed, Altus, Fort Cobb, Lawtonka, Ellsworth, Waurika, and Arbuckles reservoirs, where the waters are fully appropriated at this time.

Without resolving problems, the needs for recreation facilities and other appropriate water and related land needs will not be met.

Problem Area : Subregion 1107, Oklahoma

Description

This problem area includes the counties of Otoka, Bryan, McCurtain, and Pushmataha in Oklahoma. The drainage area has 8,050 square miles. Principal cities include Ada, Antlers, Atoka, Broken Bow, Coalgate, Durant, Hugo, and Tishomingo. Elevations range from 300 feet in the southeast to 2,500 feet in the north. Rainfall fluctuates between 40 and 59 inches annually, and annual runoff varies from about eight inches to 20 inches. Temperatures range from a low of -22°F. to a high of 118°F., with an average of 65°F. The length of the growing season is eight months. Total population is 140,400, and the total number employed is 53,352. Annual per capita income is $3,595.

There are several major ground-water aquifers and developed surface waters in the area. The developed surface waters include Broken Bow, Pine Creek, Hugo, Atoka, and Texoma reservoirs. Mountain Fork, Glover, Upper Blue, and Blue, Red, and Little and Upper Kiamichi Rivers flow through the area.

Water Issues

Development of additional surface-water storage is needed to supply local communities and additional basin demands. This is a water rich area with potential for transfer to other areas of Oklahoma.

Natural chlorides pollute the water and make it unusable and a detriment to fish and wildlife.

Ground waters are less developed than in other sections of Oklahoma.

Related Land Issues

There is a large risk of flood damages in developed areas of Atoka, Durant, Antlers, Boswell, Fort Townson, Hugo, Broken Bow, Idabel, and Wright City. Flood damages occur to rural development and crops, particularly on Little River above Milwood Reservoir.

Drainage problems occur on croplands after floods.

Forest land-use problems relate to lack of adequate watershed management.

Erosion and sedimentation cause muddy waters around recreation facilities and fish and wildlife habitat.

Institutional Issues

Arkansas, Louisiana, Oklahoma, and Texas have agreed to underwrite a compact with respect to the waters of the Red River and its tributaries. No formal compact has been executed.

Adverse Effects

Ample surface water is available to meet the needs of the area. Storage is needed to regulate the supplies to meet the needs. In fact, studies by the State of Oklahoma indicate that this is a water surplus area which could be regulated by storage to furnish about 1.3 million acre-feet of water for potential interbasin transfers to more arid regions of the State. Without decisive action such transfers will not be accomplished, nor will the adverse effects of floods, erosion, sedimentation, drainage, and pollution be alleviated.

Problem Area : Flooding and Related Problems, Texas

Descripton

This problem area includes those portions of subregions 1105, 1106, and 1107 in Texas but excludes the High Plains portion summarized in Problem Area 4. It also includes portions of the North Canadian and Canadian Rivers, as well as the headwaters of the Red River and the south side of the Red River through Texas to Louisiana. The principal cities include Amarillo on the High Plains, Wichita Falls on the Red River near the center of the area, and Marshall, which is west of Shreveport, Louisiana. There are 28.1 million acres in the problem area.

Related Land Issues

Floods have resulted in the loss of human life and have caused serious economic damages to urban areas, agriculture, transportation, and utilities. Because of the wide variations in climate and physiography of Texas, the magnitude and character of floods differ widely, both within and between major river basins.

In western and central Texas, ground and tree cover is sparse. Stream slopes vary from moderately steep to steep. During intense rainfall, runoff is more rapid than in the eastern part of the State. High peak flows, high stream velocities, and short periods of land inundation occur.

In eastern Texas, where rainfall is abundant, streams flow through broad, flat valleys bordered by timber and dense growths of vegetation. Stream channels commonly have gentle slopes and small capacities, and follow meandering courses. Runoff is comparatively slow, and stream velocities are generally low. During intense rainfall, large volumes of water

accumulate in the valleys of the basins and are released slowly to the streams. The magnitude of the problem in this area is illustrated by estimated flood damages for the Red River, Sulphur River, and Cypress Creek Basins during the years 1950 through 1976. The dollar value of damages at the time of the flooding ranged from a low of $14,000 in 1960 to a high of $3.5 million in 1971. The high figure was almost equaled in 1955.

Adverse Effects

Flood damages will continue if flood control measures are not undertaken.

Problem Area : Water Supply and Quality Problems, Texas

Description

This problem area relates to the portions of subregions 1105, 1106, and 1107 in Texas. The problems, however, also relate to other portions of Texas in the Texas-Gulf and Rio Grande Regions.

Portions of the North Canadian and Canadian Rivers, the headwaters of the Red River, and the south side of the Red River through Texas to Louisiana are in the problem area. The principal cities include Amarillo on the High Plains, Wichita Falls on the Red River near the center of the area, and Marshall, which is near Shreveport, Louisiana. The land area of this problem area is 28.1 million acres.

Water Issues

Water quantity and quality are issues. An assessment was made by the Texas Water Development Board of all public water systems in the State which could not comply with the water quality parameters set forth in the Environmental Protection Agency's Interim Primary Drinking Water Standards of the Safe Drinking Water Act of 1974, (Public Law 93-563). Water quality information was obtained from the records of the Texas Department of Health Resources as of May 14, 1976.

The Texas assessment found about 600 public water systems in violation of the standards. The majority will be unable to meet the maximum standards set for fluoride, and many will be in noncompliance due to excessive nitrates or both. Compliance with the standards is mandatory, and many of the water systems will encounter financial difficulties in providing and operating the necessary treatment facilities or alternative sources of supply to meet the proposed standards.

An estimated 6 percent of all Texans, some 734,000 persons, reside in areas where current water supply systems cannot meet the EPA Primary

Standards of the 1974 Safe Drinking Water Act. Some of these people reside in the problem area under discussion.

There are 504 systems, estimated to serve 500,000 persons, for which improvement to meet requirements of the Interim Primary Standards is not deemed economically feasible. Almost all systems in need of improvement do not comply with the fluoride requirements. A large number of systems suffer from nitrate contamination.

Institutional and Financial Issues

If the contaminants cannot be removed through the installation of equipment financed through local taxes or revenue, some form of public assistance will be required. Many of the systems in need of treatment facilities are currently receiving loans and grants from the Federal Government. At present the State cannot directly assist private water systems that are financed largely through Federal funds because of statutory constraints.

Adverse Effects

Without a solution, the populations served by the noncomplying systems are in danger of losing their water supply. The severity of the problems associated with the Safe Drinking Water Act is also increasing since many rural areas are gaining from out-migration from urban areas.

Summary

The Arkansas-White-Red Region includes, among other features, mountains, extensive high plains, the forested Ozark Plateau, and three major rivers merging into the Lower Mississippi Region. The climate ranges from alpine-humid to semiarid, subhumid, and humid through the region from west to east. Rainfall is insufficient to produce abundant crops in the western and central portions of the region, and certain areas are irrigated to supplement lack of rain. Winters are cold, and summers are pleasant to hot. The rich soils of the plains and valleys have produced and are expected to continue to produce abundant crops.

Major metropolitan centers include Colorado Springs, Pueblo, Wichita, Springfield, Little Rock, Oklahoma City, Tulsa, Amarillo, and Shreveport. There are also innumerable small towns and many people living on farms from the mountains of Colorado to the lowlands of Louisiana. The region has a thriving and diversified economy based on agriculture, metallic and nonmetallic minerals (particularly oil and gas), manufacturing, a wide assortment of fish and wildlife, and a broad range of services. The largest employment is in services and related activities classified as "other" in the assessment (Figure 11-7). The population, employment, and the economy are expected to grow at a faster rate than the Nation as a whole according to SRF forecasts and at a slower rate than the Nation according to NF data.

The Arkansas and Red Rivers course through the region from west to east-southeast, whereas the White River flows from Missouri and Arkansas from the west to the southeast. All three rivers discharge waters into the Mississippi River system. These streams drain all of Oklahoma and parts of Colorado, Kansas, Missouri, Arkansas, New Mexico, Texas, and Louisiana, which constitutes about 7 percent of the U.S. land area. Many major dams and reservoirs aid in the regulation of the water supply for multiple uses, including outdoor activities such as fishing, hunting, and boating.

Water is diverted from the streams and withdrawn from ground water for irrigation, municipalities, powerplants, industries, and other uses. In 1975, 63 percent of this water was consumed. Consumption of water is expected to increase to 66 percent of withdrawals by 2000, according to NF estimates.

Withdrawals of water are projected to be 3.6 percent above 1975 levels in 2000.

The difficult water supply problems in the High Plains and central portion of the region will require cities and industries to change their pattern of water use to meet restrictions on discharging pollutants as well as to meet their basic water supply needs at economical costs. The overall water supply outlook is one of cautious optimism, since much water resource development will be needed to keep pace with growing needs even under the rigorous conditions of water supply that prevail and under the criteria for maintaining acceptable environmental conditions.

The Arkansas-White-Red Region is basically rural and agricultural. The regional viewpoint is influenced by the requirement to meet the needs of its present and projected population. Use and improvement of the region's water and land resources for agricultural purposes have provided the primary base for enhancement of the region's economy. Industrial production in the region has a strong relationship to the agricultural sector. The manufacturing and services sectors are largely related to agriculture. The regional concern therefore leans strongly to maintenance and enhancement of the agricultural base.

The region has energy resources--coal, oil, and gas--which are viewed as a potential base for industrial development. The industrial sector will hopefully provide employment for the increasing migration of workers to the region.

Part of the rapid rise of immigration to the region is motivated by the favorable environmental setting for retirement living. This is particularly true of the Ozark area of Arkansas, Oklahoma, and Missouri. These States have a strong motivation for protection and enhancement of the environmental setting.

Conclusions

Water and related land problems in the region include lack of water supply, salinity, organic pollution, flooding, erosion, and sedimentation. These problems need to be solved within the constraints imposed by good, yet practical, environmental quality objectives and by reasonable economic goals. The array of rules, regulations, and institutional constraints that govern formulation of water programs and projects should be administered to encourage practical solutions to water problems. The climate, weather, topography, and soils are so varied that successful solutions to problems must be based on local conditions. There are extreme variations within the region in water quantity and quality.

Accordingly, the following general conclusions and recommendations relate to ways and means of resolving the identified problems. These problems can be resolved through appropriate planning; data collection and research; changes in laws, institutions, and regulations; and cooperation of individuals, local authorities, and State and Federal interests.

Federal Role

Federal assistance in solving problems should be sought only after individuals, local representatives, and State authorities have determined that they have no other viable solutions.

The role of the Federal Government, once it becomes involved, should be one of positive action leading to solutions of problems and execution of plans or programs in full cooperation with local and State interests, so that the necessary objectives can be attained efficiently to meet the needs under relevant laws and regulations.

The confusing and conflicting environmental legislation and regulations that have been and are being thrust upon those qualified and competent to soundly plan and develop water resources should be revised and consolidated by the legislative and executive branches of the government into workable rules.

The role of the Arkansas-White-Red Basins Interagency Committee (AWRBIAC) is to bring State and Federal points of view into harmony on water resources and related land planning. It lacks the authority to execute decisions, but it can recommend action when there is consensus. This role should be continued, and AWRBIAC's role should be strengthened so that it will have authority to motivate State and Federal interests to act.

Historically the Corps of Engineers, Soil Conservation Service, and the Bureau of Reclamation have been and are still able to fulfill the Federal role in water supply, flood control, navigation, hydroelectric power, irrigation, and related purposes involved in comprehensive basin planning and development. Their abilities are recognized by the States of the region. Some of the States have so relied upon such services

that they have not staffed or organized sufficiently to undertake the work that is needed to make comprehensive water resource plans and to develop the works. The Federal role should be one of assistance, after it is found that needed water resource activities are beyond the abilities of private enterprise and the States.

Planning

The AWRBIAC considered the need for Level B studies throughout the region. These studies involve comprehensive basinwide planning of the reconnaissance type on a coordinated multiobjective, multidisciplinary basis, with the goal of recommending projects and programs that should be undertaken for resolution and action to meet the needs of governmental and nongovernmental interests. [1]

Planning in one form or another has been going on for many years, largely under sponsorship of Federal agencies. Many millions of dollars have been spent, and many files and bookcases have been filled with data as a result of such studies. Some studies have resulted in action on projects and programs that have been executed and are delivering their intended services. Other studies, however, proposed projects and programs that, although authorized, have not been executed. These projects and programs often relate to solutions of the serious problems of the region identified in this assessment. As a result, the AWRBIAC has concluded that Level B Studies in the region will not be recommended at this time.

Those projects and programs that have been studied, found justified and feasible, and have been and are supported by local and State interests, should be given highest priority.

By Public Law 94-587, approved October 22, 1976, the Congress authorized $6 million for the Secretary of Commerce, in cooperation with others, to develop plans to increase water supplies in the High Plains area which now utilizes water from the Ogallala aquifer. This has been identified as Problem Area 1, involving Colorado, Kansas, New Mexico, Oklahoma, and Texas in this region. The AWRBIAC concurs with the objectives of Public Law 94-587.

The seventeen individual problem areas identified for this region are concerned with water supply, water quality, flood control, navigation, irrigation, recreation, fish and wildlife, erosion, sedimentation, the environment, and other related matters. These problems involve local, State and Federal interests. The AWRBIAC recommends that the appropriate authorities take early action to advance solutions to these serious problems.

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[1] The U.S. Water Resources Council has defined three levels of study and planning. Levels A and B are generally supported financially by the Council. Level C involves implementation of planning by recommended entities, generally by Federal or State agencies.

Data Collection and Research

Data collection and research are needed to solve some of the identified problems. Additional data are needed, particularly on ground-water supplies and quality where it is the primary source of domestic, municipal, and industrial use. For example, Arkansas and Missouri have identified the lack of ground-water quantity or quality data as a serious detriment to the solution of the urgent problems identified in those States.

Data on pollution of ground waters in areas where ground water is the source, or the logical source of additional supplies, is a most important need for the entire region.

The AWRBIAC supports the continuation of data collection on surface and ground waters, with emphasis on identification of pollution of waters used for domestic, municipal, and industrial purposes.

Institutional Arrangements

Resolution of proposed or pending institutional arrangements is recommended to facilitate solutions to some of the problems.

Proposed agreements on two potential interstate compacts and revision of one existing compact have been identified. Arkansas has identified the need for a compact between Arkansas and Missouri on the White River in the Ozarks region, where tourism and industrial activity are developing rapidly.

Arkansas, Louisiana, Oklahoma, and Texas are making a compact relating to waters of the Red River. The legislature of Louisiana has approved the compact and the other States expect approval from their legislatures in the near future.

Colorado has pointed out the need for revisions or modifications in the operating procedures specified in the Arkansas River Compact between Colorado and Kansas to permit better and more timely utilization of the waters of the Arkansas River. The compact contains a stipulation that during the summer season (April 1 to October 31) water being held in storage may be released upon demand by both States, concurrently or separately, in amounts dependent upon the magnitude of storage. When demand is concurrent, Colorado is entitled to 60 percent of the release and Kansas to 40 percent. The problem is that the need for irrigation water is not necessarily the same in the two States at the same time, but when one State demands release of water in storage, the other State also demands release to assure that it receives its share.

Colorado also urges settlement of Federal claims for water rights to an unknown quantity of water on public lands, with the date of priority proposed as the date of public withdrawal. This has a far-reaching effect on the future uses of land and the future availability of water under existing water rights. Presently, waters in the Arkansas River

Basin are overappropriated, and each year many junior appropriators do not receive enough water to produce a full crop.

In Oklahoma, Indian tribes have claimed ownership of the Arkansas River streambed in subregion 1104. There is need for resolution of this claim since it directly affects the successful operation of the McClellan-Kerr Navigation Project from Tulsa to the Mississippi River.

Attainment of Principal Assessment Purpose

Logical conclusions relating to the principal purpose of the assessment, that of determining "the adequacy of supplies of water necessary to meet the water requirements in each water resource region in the United States and the national interest therein," can be made without resorting to hundreds of pages of statistical data, since the States and Federal agencies have made many estimates from time to time to solve problems where situations are critical. It is more important for these agencies to cooperate in bringing these estimates up to date, taking into account any changes in laws and requirements. An assessment backed by reliable water supply data and economic data can be attained only by the States and Federal agencies working together on basic criteria and assumptions and checking the base year data and agreeing on it.

Specific Conclusions and Recommendations by the States

Arkansas

The Soil Survey Program of the Soil Conservation Service should be expedited, and the Public Law 566 watershed program should be continued and expanded.

Federal legislation should be enacted to allow reallocation of storage water in Corps of Engineers' lakes. This would enable storage water to be allocated to municipal and industrial uses as well as wildlife protection.

Flood-plain information studies should be expedited, and the Flood Insurance Program should be improved.

Funds available to local entities for cost sharing on urban drainage and flood control should be increased and divided more equitably.

Comprehensive studies should be initiated to determine feasible sources to provide municipal and industrial water for those locations that are experiencing shortages or are projected to encounter shortages in the near future. The studies should project probable costs.

Statewide plans should be developed to correlate all existing or proposed flood-control projects in relation to the total need for protection of wetlands.

State water plans should designate as natural and scenic rivers those rivers that should be protected from development.

The USGS ground-water program should be expanded to produce a more usable inventory of water resources, especially for the Ozarks region which is in particular need of this kind of work.

Those involved in Red River Compact negotiations should resolve their differences.

State legislation allowing allocation and management of overtaxed ground-water resources should be enacted.

Existing water quality monitoring programs should be expanded to monitor sediment and pesticide loads as well as to increase the number of sampling stations.

Funds available for cost-sharing water supply construction with local entities should be increased on the Federal and State levels.

Negotiations to create an interstate compact between Missouri and Arkansas should begin as soon as Missouri gives negotiating authority to an appropriate agency.

Proposed State legislation to allow interbasin water transfer in Arkansas should be passed.

A detailed study of water export into arid portions of the country should begin.

Colorado

The Arkansas River Basin is experiencing all the problems associated with increased growth occurring in an area of limited water supplies. Basically, the critical issue facing the Arkansas River Basin is the lack of dependable, high-quality water to meet increasing municipal and industrial requirements without adversely affecting the agricultural economy of the region. In addition, the basin has many other significant water and related land-resources problems, including water quality, flooding, erosion, sedimentation, and the shortage of water-based recreation in the plains area. Most of the foregoing and other related problems have been created principally by the growing popularity of the area for new homes, businesses, and industries. The Colorado River Project is supplying municipal and industrial water and will help to alleviate some of these problems.

The Arkansas River Basin in Colorado (subregion 1102) is currently experiencing severe water and related land-use problems. Because of continuing growth, these problems will intensify. Although many studies have been made of the basin problems, the objectives generally have been

agency oriented, single purpose, geographically limited, and not sufficiently coordinated with other agency problems. For these reasons, a USDA Cooperative River Basin Study in the Arkansas River Basin in Colorado should be undertaken and completed as soon as possible. This study will benefit Colorado by defining the problems and needs in greater detail and by recommending plans for their resolution. Additionally, the Bureau of Reclamation has proposed a water management study for the Arkansas River Basin in fiscal year 1982.

Kansas

In the development of information and data for the assessment, in particular for the SRF for the Kansas portion of subregions 1103 and 1104, many problem areas were identified, all related to a program of development. Some of the identified problems were statewide; most had been scheduled for a planning or implementation activity. Consequently, an evaluation of these areas indicated they were primarily of the Group B category.

One major problem was identified and classified as severe and critical: the High Plains ground water depletion in the Ogallala area. This problem is of interstate and interbasin concern. In cooperation with the Economic Development Administration (EDA) of the U.S. Department of Commerce, the State is currently studying this problem. The Bureau of Reclamation is currently conducting the Republican and Solomon Rivers management studies. In addition, USGS is conducting a study in this area. It should be noted that in the identification of problems, no attempt was made to cover the basic issue of funding and personnel or the cooperative State-Federal programs. Nor did Kansas attempt to identify the basic problems of congressional/administrative/executive actions, which in many instances served only to add to prevalent confusion.

In the development of basic data and information, the efforts of the Water Resources Council and the field offices should be better coordinated. Current differences on historic or base-year data point up this problem; no attempt was made to obtain base-year data from the field, insofar as is known.

Presentation of data by subregion has been of no value to the States. This seems to be an inherent problem that everyone at the Federal level chooses to ignore and is one of the difficulties which has arisen with NF/SRF data.

Continued requirements to meet standards resulting from legislation or interpretation of legislation without full knowledge of facts and data present additional problems. Funding requirements and available funding are not always compatible.

Louisiana

The Red River has been identified as one of the greatest assets of the Louisiana portion of subregion 1107. It also presents a multitude of problems. One of the primary problems is periodic flooding as well as erosion of valuable agricultural lands. The sedimentation not only harms fish and wildlife but makes the river unattractive for recreation. Bank stabilization measures associated with the Red River Waterway Project will help to remedy erosion and sedimentation problems and to make the Red River navigable. This will benefit the area by providing an economic stimulus. Implementing the findings of the Red River Below Denison Dam, Comprehensive Basin Study, would aid the Louisiana portion of subregion 1107 as well as Texas and Arkansas. The Red River also has naturally high chloride quantities, which renders the water unfit for municipal and agricultural uses unless it is treated extensively.

High-quality ground water is seldom found in quantities sufficient for large pumpages. This problem hinders the development of large water-using industries and in some instances proves troublesome to municipalities. If economic development continues, this area will increase its dependence on surface water. Water transfers within the region may have to be studied, as well as the need for industry to increase its reuse of water.

A key institutional issue in northwestern Louisiana is the failure of the States contained in the Red River Basin to come to terms on an interstate compact. The absence of an agreement on the apportionment of the Red River waters leaves doubt regarding available future supplies. In all the plans envisioned for northwestern Louisiana, the Red River will play a major role, whether for water supply, navigation, or recreation. Failure to secure an adequate share of this water resource for Louisiana would have a detrimental impact on the continued economic and social progress of that state. There is no immediate impact because of the failure to agree on the Red River Compact; however, all States would stand to lose if apportionment of the waters developed piecemeal.

Louisiana would like to go on record as opposing the restudy of the importation of Mississippi River water to the High Plains. The money authorized under Public Law 94-587 should be spent studying other alternatives to solve the water supply problems of the region.

Missouri

Because of the limited State data available, Missouri does not necessarily agree or disagree with all conclusions. As State water planning work progresses, refined data and projections will be available and Missouri can better evaluate the results of the National Water Assessment.

The Springfield and Joplin areas are recognized as having major water resource problems needing further attention.

It is recommended that all future basin planning activities of this type present data on a State-by-State basis to make the basin projections and conclusions more usable to individual States.

New Mexico

The NF data provided by the Water Resources Council were compiled for subregions which in most cases ignored State boundaries and hydrologic areas within States. Comparison of SRF and NF data in New Mexico could not be made, and so differences could not be identified. For the most part, NF data have no useful application in New Mexico in providing economic, water, and related land-resource statistics.

Existing laws, regulations, and compacts that relate to water use within States or between States appear to be ignored. State laws and interstate compacts affect present and future use of water supplies, and both are important in determining availability of these supplieds for various uses.

The State of New Mexico recommends that future studies include State data and consideration of legal constraints that effect the use of water supplies.

In New Mexico, surface-water supplies are limited, and in most of the areas these supplies are fully appropriated or committed, mostly for irrigation purposes. Increased demands for uses other than irrigation could result in drying up large irrigated acreages and would have an adverse impact upon economic, social, and environmental conditions in the State.

Problems of ground-water quality and quantity, flooding, erosion, siltation, and sedimentation are being addressed by several existing studies and programs at the local, State, and Federal levels. The rate at which these problems are alleviated appears to depend upon available funds, and the State recommends that all the resources and conservation programs be expedited.

The High Plains Study authorized by Public Law 94-587 is designed to develop plans to increase water supplies and to examine the feasibility of various alternatives to provide adequate supplies for the High Plains area. The results of this study will be applicable in the Arkansas-White-Red and Texas-Gulf Regions of New Mexico, and the State of New Mexico supports this study.

Oklahoma

Additional studies are needed to address flooding problems due to changes in the runoff of the drainage basins caused by urban, rural, and related development. Additional upstream flood-control structures are needed to further stabilize downstream flood-control protection and allow downstream structures to reallocate initial project purposes to needs that have emerged.

The development and implementation of public policy and involvement are essential to stimulate the advancement of the Chloride Control Projects through the planning stages to the actual construction of the projects in subregion 1103.

A water transfer system is needed to alleviate existing problems encountered by numerous communities throughout the State. Such a system would benefit all citizens of Oklahoma.

Available surface water supplies in subregions 1105 and 1106 have been fully appropriated, and there is a need to transport water from areas of surplus to these areas of need.

The State needs to initiate an additional study to encompass those sectors of the Rush Springs Sandstone that lie in Dewey, Blaine, and northern Custer counties of subregion 1105 that have not previously been assessed. Also needed are ground-water hydrologic studies of fresh-water basins not addressed by prior reports in subregions 1105 and 1106 and the initiation of a program to study the water quality of ground-water basins.

Programs are needed to establish research and test plots for the analyses of alternative methods to control phreatophytes. Cooperative funding among appropriate agencies is needed to eradicate phreatophytes in those densely populated areas in subregion 1103 and in the Red River Basin.

The Oklahoma Water Resources Board should receive additional professional personnel and augmented appropriations to complete the Oklahoma Comprehensive Water Plan. The State legislature, in turn, should strive to adopt the plan and fully implement its recommendations. This water plan would put excess water of the State to maximum beneficial use.

Oklahoma is very concerned over the poor quality of water that exists in northwestern and southwestern Oklahoma. Natural salt pollutants have degraded the waters of the Cimarron and Arkansas Rivers in the north and the Red River in the south to the point that they are not usable for most purposes. Oklahoma fully supports the construction of the Chloride Control Projects on both the Arkansas and Red River Basins. Upon implementation of these projects, water supply sources in Oklahoma will be greatly expanded.

Ground-water depletion in the western part of the State, particularly in the Panhandle, is of major concern to water development authorities in Oklahoma. Ground-water mining has increased significantly in recent years, and the water table is dropping at an alarming rate. Measures should be taken to assure western Oklahoma an additional water supply in view of the diminishing ground-water source.

Another important problem is the inadequacy of the rural water systems in Oklahoma. Many of the hundreds of thousands of Oklahomans served by rural systems are faced with deteriorating distribution facilities, diminishing water supply, and decreasing water quality.

Statewide there is a need for creation of a water development funding program to provide financial assistance to cities, small towns, and rural water districts. The monetary aid offered by the funding program would be used to repair existing distribution facilities, to help construct water treatment plants, and to construct new delivery lines for systems in need of expansion. This funding program, to be established by legislative action, would consist of a revolving fund of not less than $100 million with reimbursement made by user revenues.

The ultimate solutions to the problems outlined here will take a lot of time, effort, and money. Augmentation of existing funding programs or creation of new ones is an absolute necessity if the State is to alleviate its various water problems.

Texas

A problem of major concern to Texas is ground-water depletion in the High Plains. The agricultural economy dependent upon that resource is a significant part of the overall Texas economy. Supported by Federal studies, Texas knows the depletion rate of the resource, the predictable loss of the resource, and the economic impact. Further studies of this type are not needed. What is needed is a realistic resolution of the problem by importation of a replacement water supply. Arkansas has identified surplus water of suitable quality that could be conveyed to the area. This potential and others should be studied jointly by Texas, other States of the area, and the Federal Government. Texas views the pending problem with great concern and feels that the impact on the economy and loss of agricultural production is great enough to be of national concern.

The Texas Department of Natural Resources has surveyed public water systems throughout the State. Six hundred systems serving 734,000 people cannot meet Primary Standards of the 1974 Safe Drinking Water Act. The relatively small size of many of these systems and the low density of customers present financial problems in meeting the new standards. It is estimated that the systems serving populations below 2,500 serve a total of 500,000 persons. It is recommended that the Federal Government implement a program to financially assist the State and local communities to construct facilities necessary to provide an acceptable water supply within the Safe Drinking Water Standards.

Surface water supplies within the Canadian River Basin and the Red River Basin above Denison Dam have excessive salinity. Both the Corps of Engineers and the Bureau of Reclamation are studying the problem. Most of the salinity comes from springs and seeps. Those identified sources can be controlled by various structural measures. Texas recommends that both the Bureau of Reclamation and the Corps of Engineers be funded to implement a salinity control program. The water supply in both streams is needed to meet projected demands.

Texas suffers large annual damages from stream flooding. In the Red, Sulphur, and Cypress Creek Basins the average annual damages experienced amount to about $860,000. The majority are crop and pasture damages which cannot be alleviated by flood-plain zoning. It is recommended that structural measures continue to be implemented for flood control. Such flood-control measures will have a positive impact upon agricultural productivity and the Texas and national economy.

Texas recognizes the need to achieve a balance between development and environmental concerns. However, water resource development prompted by strong economic needs has been unnecessarily delayed or obstructed by uncertain and vacillating environmental program administration. Texas recommends a more responsive and expeditious environmental program related to water resource development.

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of water and related land resources
on a comprehensive and coordinated basis
by the Federal government,
States, localities, and private enterprises
with the cooperation of all
affected Federal agencies,
States, local government, individual
corporations, business enterprises,
and others concerned.

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