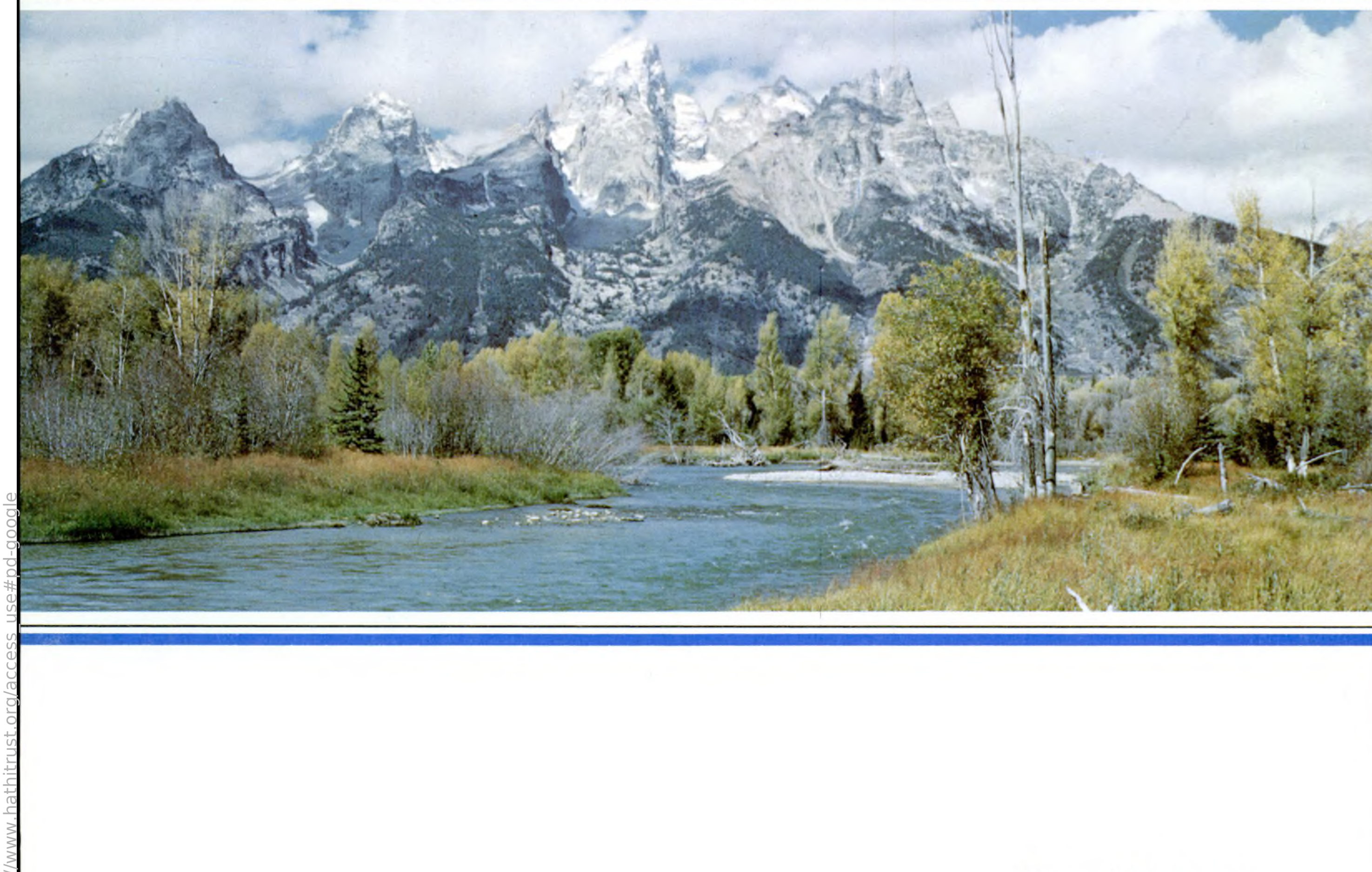
THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Lower Colorado Region



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

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December 1978

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 052-045-00073-8

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 identifies 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.

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Illustrations

Physiography

Description

The Lower Colorado Region, with a total area of 154,848 square miles,[1] includes several closed basins in Arizona, western New Mexico, southern Nevada, and southwestern Utah and some other areas in Arizona and New Mexico which drain into Mexico. Except for a portion in southern California, the region is hydrologically defined by the drainage area of the Colorado River below Lee Ferry, Arizona. The Lower Colorado Region represents about 5 percent of the area of the contiguous United States (Figure 15-1).

The Colorado River system is one of the most controlled, overburdened, and most oversubscribed river systems in the Nation. The river supplies water to metropolitan complexes in southern California and the Las Vegas, Nevada, area, and will soon serve central Arizona. A major part of the West is largely dependent on Colorado River water, and in spite of the river's relatively small water supply, more water is exported from this region than is exported from any other major river system in the United States.

The region has a wide variety of vegetative cover. Forest areas extend from small alpine meadows on top of Humphrey's Peak in the San Francisco Mountains through the coniferous forest zones of spruce-fir and ponderosa pine to pinon-juniper, oak woodlands, and chaparral forests. Rangeland varies from forests to desert grasslands and a small area of true desert near the mouth of the Colorado River adjacent to the boundary between Mexico and Arizona (Figure 15-2).

Geology-Topography

The geology of the Lower Colorado Region includes a broad spectrum of sedimentary, metamorphic, and igneous rocks which produce a wide variety of soils. The region lies within the (1) Basin and Range Province and (2) Colorado Plateau Province of the Southwest. A complex of mountains, deserts, plains, and plateaus range in elevations from 100 feet above sea level near Yuma to 12,611 feet at the summit of Humphrey's Peak north of Flagstaff.

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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 140,560 square miles.

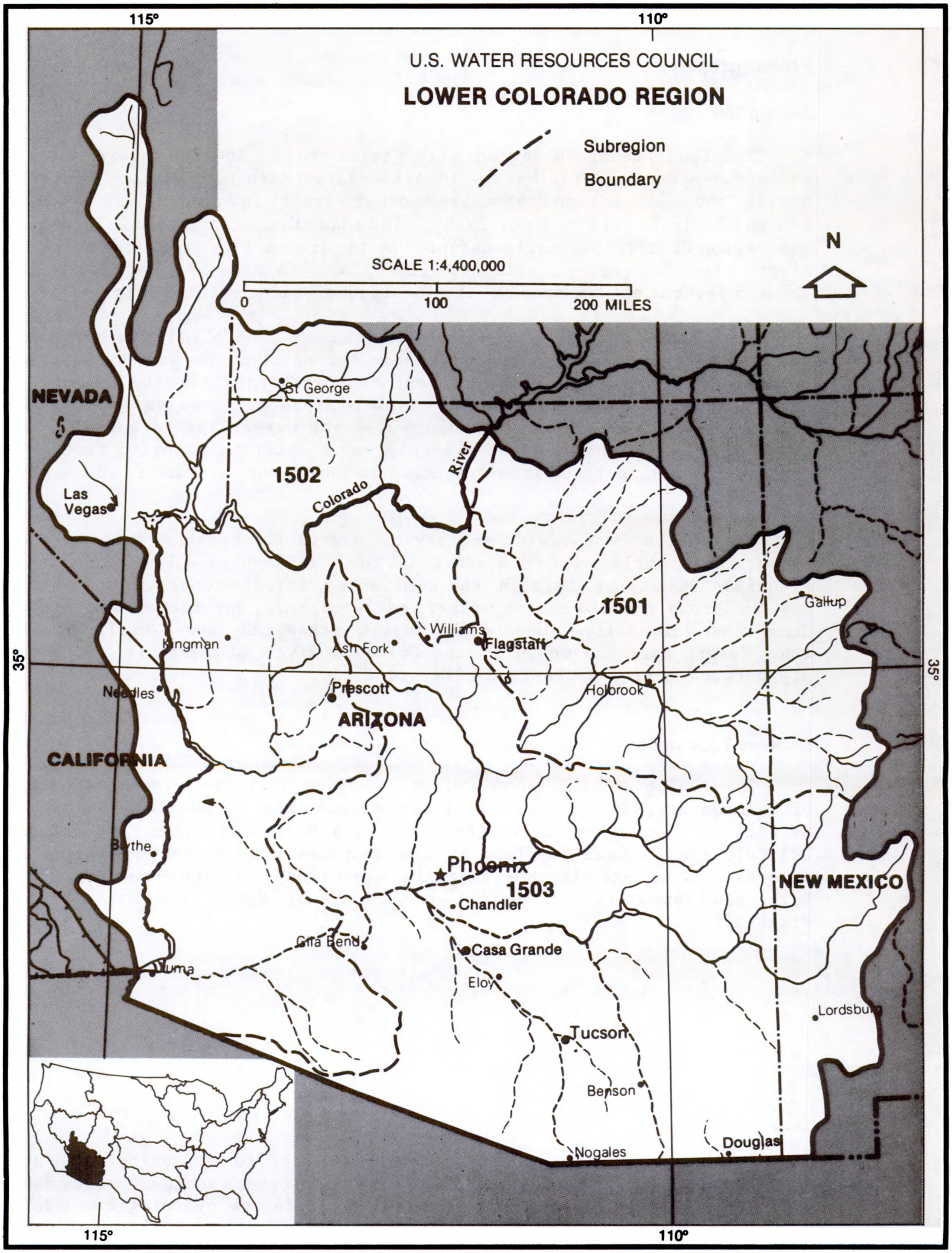


Figure 15-1. Region Map

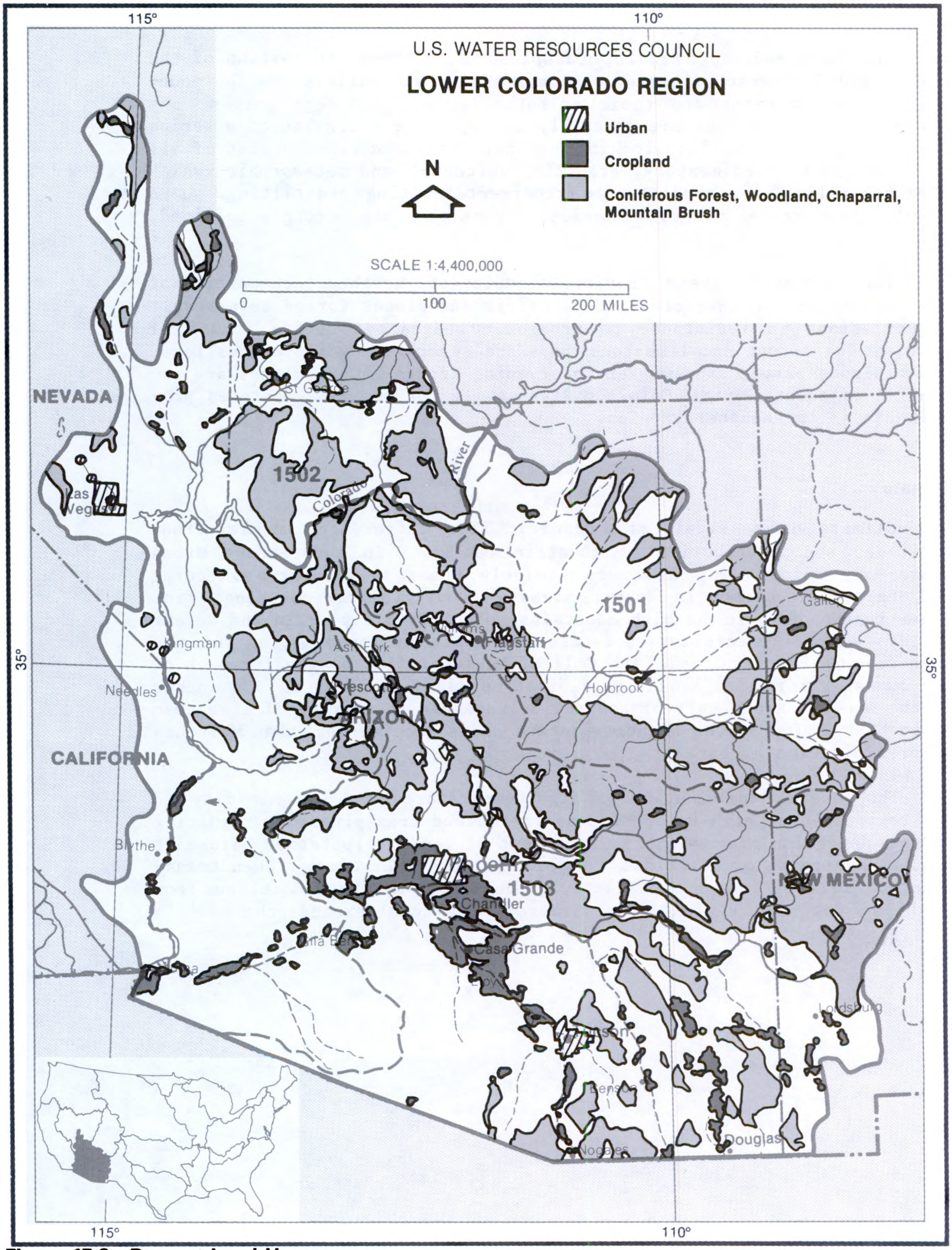


Figure 15-2. Present Land Use

The Basin and Range Province occupies the southwestern portion of the region and is characterized by mountain chains and valleys. In the mountain ranges, streams and their tributaries have cut deep gorges, but where buttes and ranges are generally small, valleys consist of a series of partially filled, interlocking basins. The basin rims consist of all types of rocks--sedimentary, granitic, volcanic, and metamorphic--which have generally been subjected to recurrent faulting and tilting. As a result, many ranges consist of masses of rock that are strongly inclined, lying on end, or locally overturned.

The Colorado Plateau Province occupies the northeastern portion of the region and is characterized by cliffs and slopes formed as a result of variations in resistance to erosion. Ledges and cliffs formed of resident sandstone and limestone beds are separated by slopes, valleys, and badlands carved from weaker intervening strata. Canyonlands are extensive adjacent to the Colorado River while low mesalike features predominate in the southern region.

Climate

Climate varies widely as a result of large differences in elevation, latitude, and distribution of mountain ranges. In mountainous areas winter temperatures drop below zero regularly; summer temperatures exceeding 100 degrees are common in desert areas. Frost-free periods range from fewer than 60 days in the high mountains to nearly all year in the desert valleys. Winter precipitation is associated with moisture moving into the area from the Pacific Ocean. The Gulf of Mexico is the source for much of the summer rainfall. Annual precipitation may be as low as 2.5 inches in the desert. About half of the region receives an average of less than 10 inches. A few of the higher mountain peaks receive more than 30 inches of precipitation a year.

The general combination of high temperatures and low humidity in the region causes high rates of evaporation and transpiration, resulting in the depletion of more than 95 percent of the precipitation before it can reach streams or percolate to ground-water reservoirs. When transpiration and evaporation supplied by ground-water mining and inflows from the Upper Colorado Region are considered, the total exceeds the basin's precipitation.

People and the Resources

Population

The entire Colorado River Basin is sparsely populated compared to national averages. Density varies from five to 28 persons per square mile in subregions 1501 (Little Colorado) to 1503 (Gila) respectively. Future population growth is projected to increase from about 2.4 million in 1975 to about 3.6 million in 2000.

Economy

About 940,000 people were employed in the region in 1975. Total personal income measured in 1975 dollars was $14.0 billion, resulting in a per capita income of $5,819. Table 15-1 shows the distribution of earnings in the region. Major earnings from manufacturing are expected to continue to be a major source of income through 2000. ("Other" earnings, which are much larger, include many categories.) Immigration of people to the region has been primarily influenced by the availability of land suitable for many uses, rich mineral resources, and an attractive mixture of scenery and climate. The primary limiting factor has been the inadequate and poorly distributed water supply.

Parts of the region have become meccas for retirement, recreation, and entertainment, boosting the regional noncommodity dollar output. Economic growth is expected to be concentrated principally in manufacturing, tourism, and mineral industries. Arizona led the Nation during the past 10 years in rate of growth of manufacturing employment. The most spectacular growth occurred in high value compact goods, such as electronic components. Agricultural production is expected to remain relatively stable with a slight decrease in acres irrigated. Total earnings are expected to increase by 2.8 times by 2000 with employment reaching 1.47 million.

Table 15-1.--Lower Colorado Region earnings--1975, 1985, 2000 (million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing---------	1,539	2,450	4,254
Agriculture-----------	450	447	531
Mining----------------	448	574	772
Other-----------------	8,830	14,083	26,057
Total---------------	11,267	17,554	31,614

Natural Resources

The Lower Colorado Region is richly endowed with favorable climate and abundant land, mineral, and other resources. However, the region probably comes closer than almost any other to utilizing the last drop of available water for man's needs. The region contains slightly over 36 million acres of land suited for irrigation development, but only about 1.3 percent (1,283,000 acres) of the total land area is presently irrigated, due largely to water supply limitations. Yields per acre for most irrigated crops are among the highest in the Nation.

The region is largely open space, with 80 percent of the land utilized for pasture, rangeland, and forest. Cropland occupies only 1.5 percent of the land area, with the portion irrigated totaling 1.3 percent. Urban and built-up areas total less than 1 percent of the land area. The region has available vast land resources, but the limited water supply limits the use. Major land-use categories are listed in Table 15-2.

Changes in land use in relation to total area are minor. However, land-use changes revolve largely around availability of water supply and as such are of economic significance. Land for irrigated agriculture is expected to decrease by about 12 percent, and the urbanized area to increase by nearly 36 percent by the year 2000.

Table 15-2.--Lower Colorado Region surface area and 1975 land use

Surface area or land use type	1,000 acres	Percentage of total surface area
Surface area		
Total------------------------	99,103	100.0
Water------------------------	456	0.5
Land-------------------------	98,647	99.5
Land use		
Cropland---------------------	1,485	1.5
Pasture & range--------------	52,243	52.7
Forest & woodland------------	26,749	27.0
Other agriculture------------	2,732	2.7
Urban------------------------	621	0.6
Other------------------------	14,817	15.0

The region has nationally significant mineral resources. During recent years the Lower Colorado Region has supplied 55 to 60 percent of the U.S. copper production; furthermore, the rate of discovery has been high, and so in the next several decades an even greater proportion of copper is expected to come from the region.

Coal resources of the Lower Colorado Region total about 17.5 billion tons. More than 98 percent of the resources are in subregion 1501, mostly in McKinley County, New Mexico, and in the Black Mesa field of northern Apache and Navajo counties, Arizona. There are major deposits of uranium in the region largely concentrated in subregion 1501.

Many nationally significant parks, forests, recreation areas, and historic sites are located in the region. Arizona has more national parks and monuments than any other State in the Nation. The Lake Mead National

Recreation Area extends about 180 miles and encompasses one-half million acres. The main features which attracted 7 million visitors in 1976 were Hoover Dam, two fresh-water reservoirs (Lakes Mead and Mohave), and associated recreational opportunities.

The Grand Canyon of the Colorado is 217 miles long and possesses five of the seven botanical life zones in the Northern Hemisphere. There is no other place in the world where such a vast panorama of geologic history can be seen so clearly. Other popular National Park Service areas include Petrified Forest National Park and Glen Canyon National Recreation Area in Arizona and Zion National Park in Utah.

Agriculture

Cropland production in the Lower Colorado Region is concentrated on irrigated areas where the climate is suited to a wide variety of crops that can be grown year round. Cotton is the principal crop; the second most valuable crop is vegetables, followed by hay and feed grains.

In some of the northern parts of the region, where high plateaus and forested areas provide range for summer grazing, livestock accounts for the bulk of agricultural income. Larger feeder operations have developed in which alfalfa and feed grains are grown throughout the year. The livestock industry provided over 50 percent of the total value of crop and livestock marketing in 1974. The economic role of irrigated agriculture is expected to remain relatively stable through the year 2000 with a slight decrease in acres irrigated (Table 15-3).

Table 15-3.--Projected changes in cropland and irrigated farmland in the Lower Colorado Region--1975, 1985, 2000
(1,000 acres)

Land category	1975	1985	2000
Total cropland------------	1,485	1,444	1,393
Cropland harvested--------	1,227	1,199	1,258
Irrigated farmland--------	1,283	1,183	1,127

Since 1940, most new irrigated land developments in the region have been supplied by pumped ground water. Nearly 50 percent of the total irrigated acreage entirely depends on ground water, and nearly half the ground water is mined.

Since 1968, the region's irrigated agriculture has remained relatively stable. Lands going out of production due to such causes as urbanization, deficient water supplies, and uneconomical pumping lifts have been balanced by developments on Indian lands and additional development of ground-water aquifers.

Energy

Hoover, Parker, and Davis dams on the Colorado River have a total hydroelectric generating capacity of 1,685 megawatts and produce about 5.4 billion kWh of energy annually. This is equivalent to burning about 10 million barrels of oil.

Total electric energy generation is expected to increase by about 3.2 times by the year 2000 with an increase in water depletions of about 63 mgd (NF)--an increase of 100 percent over present consumption. This assumes extensive use of dry cooling towers, which lower efficiency and raise costs. If conventional wet cooling towers are utilized, water consumption in year 2000 would be nearly 5 times that in 1975 even though cooling water required for the thermal electric generating plants would be largely supplied by recycled waste water. Electrical energy projections are listed in Table 15-4.

Table 15-4.--Lower Colorado Region electric power generation--1975, 1985, 2000 (gigawatt-hours)

Fuel source	1975	1985	2000
Fossil	23,762	48,294	51,480
Nuclear	0	7,438	42,556
Conventional hydropower	8,887	9,086	8,842
Total generation	32,649	64,818	102,878

The shortage and cost of petroleum fuels is resulting in a necessity to utilize other forms of energy. Since the region offers excellent potential for solar development, it is expected to gain wide acceptance when the process becomes economically and technically feasible.

The Geothermal Steam Act of 1970 authorized investigations into the technical and economic feasibility of utilizing geothermal water as a supplemental water supply and energy source. The Bureau of Reclamation and the Geological Survey, both agencies of the U.S. Department of Interior, and the U.S. Department of Energy are collaborating in an investigation of the geothermal potential in the region.

Coal deposits of commercial potential are located in northern Arizona and northwestern New Mexico, mostly on Indian lands. Some of this potential is already supplying the Navajo Powerplant and will be used for the Coronado Powerplant in subregion 1501. The region has no known oil shale deposits.

Navigation

There is no commercial navigation on streams in the region. For navigation purposes, the Colorado River channel downstream from Yuma, Arizona, ceases to exist. The many regulatory and diversion structures on the river do not provide facilities that can feasibly accommodate navigation.

Environment

Increasing numbers of people are turning to open spaces for outdoor recreation. Visitors and residents of the Southwest may choose such year-round activities as camping, golfing, boating, hunting, and fishing. The region is known for its archeological heritage and for the influence Indian life has had on modern development. Archeological centers in Las Vegas, Phoenix, and many national parks and monuments display the history and the artifacts of Indians living along the banks of the Colorado and in the interiors of Arizona and New Mexico.

Most of the public lands are managed under a multiple-use concept, whereby the most goods and services possible are produced from the resource base. Much land is classified as rangeland and forestland, and recent emphasis has focused on new wilderness areas, recreation areas, and other public uses of Federal lands. There are now 12 designated wilderness areas, six national wildlife refuges, and 10 National Park Service natural areas. Though no rivers in the region are presently included in the national wild and scenic rivers system, more than 1,300 miles of streams have been suggested for study. Thousands of recreationists make float trips down the available rivers. Other uses of public lands include farming, mining, and forestry. Figure 15-3 shows the locations of recreation and unique environmental resources.

Land is distributed approximately as follows: about 18 percent is in private ownership; 18 percent, in Indian trust; 12 percent, State and municipal ownership; and the remaining 52 percent in Federal ownership. Of the federally owned land, 32 percent is administered by the Department of Agriculture, 59 percent by the Department of the Interior, and 9 percent by the Department of Defense.

The population is concentrated in only a few locations. The fragile desert environment and the extremely limited water supplies require that particular attention be given to the environmental impacts which may result from development. Main items of concern include: preservation of cultural, scenic, and natural values; protection and management of land resources; safeguarding the quality of water supplies; maintenance of the agricultural environment; enhancement of fisheries; and preservation of wildlife habitat.

Regional wildlife varies according to climate, terrain, and vegetation. More than 750 varieties of birds and animals occur. The largest expanses of prime habitat are located in subregion 1503. Pronghorn antelope, elk, mourning dove, deer, cougars, javelina, bobcats, coyotes, and small rodents live here. There are about 85 species of fish in the region. Approximately 25 are game species; the others have value as forage fish, as pollution indicators, and for scientific study.

There are 15 animals in the region which are considered by Federal or State governments to be threatened or endangered. They are: Arizona trout, black-footed ferret, Pahranagat bonytail, humpback chub, Moapa dace, Mexican wolf, masked bobwhite, Yuma clapper rail, Utah prairie dog, Sonoran pronghorn, Gila trout, Gila topminnow, Mexican duck, Colorado River squawfish, and woundfin.

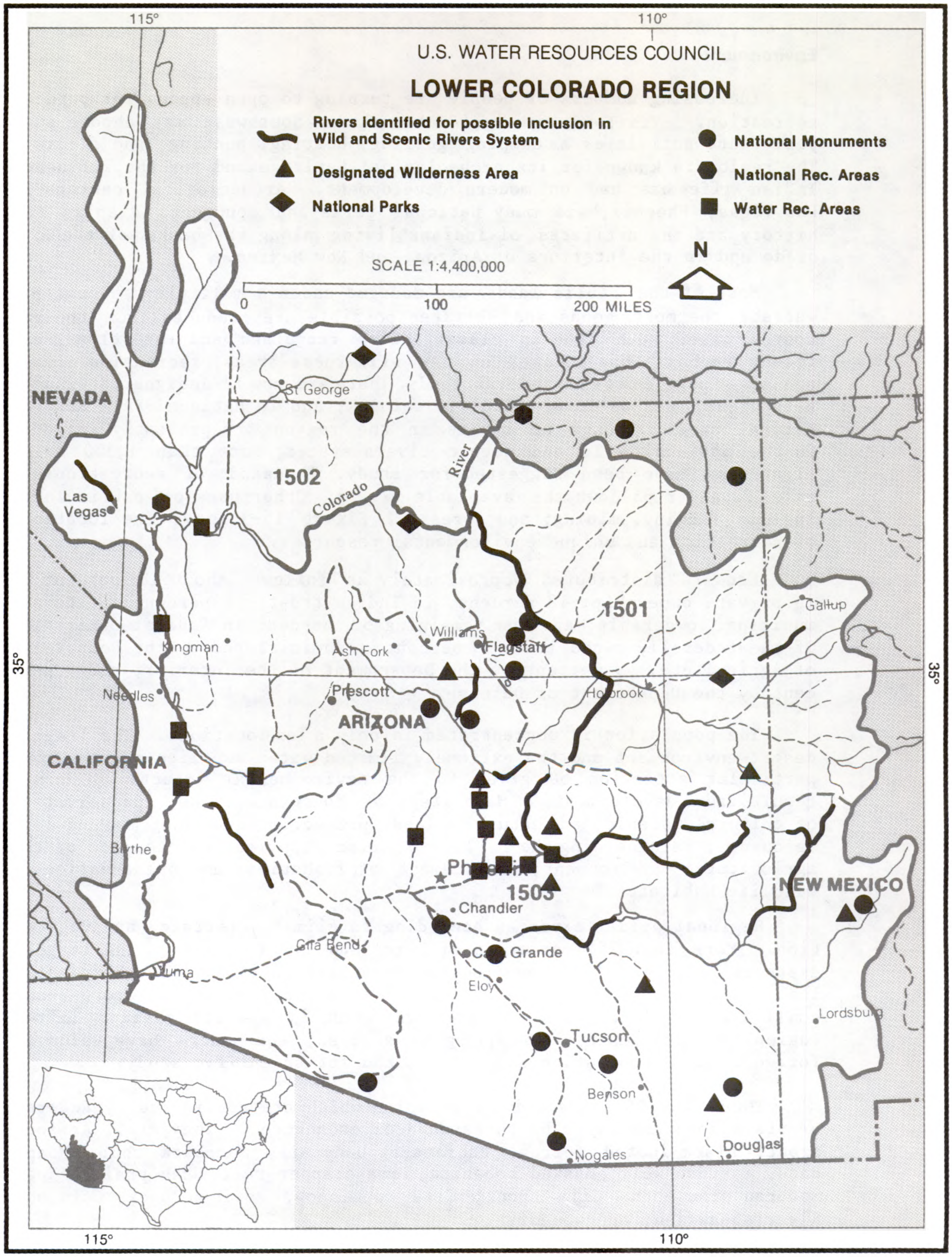


Figure 15-3. Environmental Resources

Water

Essentially all renewable surface- and ground-water resources have been or are being developed. Three main sources of water available in 1975 for use in the Lower Colorado Region according to SRF data are:

1. Apportionment of 3.15 million acre-feet (2.82 bgd) of Colorado River water by a body of law referred to as the "Law of the River."

2. Local runoff originating within the regional boundaries.

3. Local ground-water reserves.

Surface Flows

There is a wide variation of annual runoff within the region. In the desert areas, where runoff directly depends on rainfall, the bulk of the flow, if any, occurs during the summer--July through September. Above the major storage reservoirs, peak monthly runoff generally occurs from March through June as a result of snowmelt in the high mountains.

The subregion distribution of estimated average annual outflows are as follows:

	Million gallons per day
Subregion 1501 (Little Colorado)	272
Subregion 1502 (Lower Main Stem)	1,550
Subregion 1503 (Gila)	20

Flood flows in the Colorado River today are almost completely controlled by the Upper Colorado River Basin storage projects and Lake Mead, which have a combined storage capacity of about 60 million acre-feet. The release of water from Glen Canyon Dam, 17 miles upstream from Lee's Ferry Compact Point, depends on many variables. However, Article IIId of the Colorado River Compact provides that the river at the Compact Point will not be depleted below an aggregate of 75 million acre-feet for any period of 10 consecutive water years or, on the average, 7.5 million acre-feet per year or 6,684 mgd. The Boulder Canyon Project Act authorized the construction of Hoover Dam and the All-American Canal. Hoover Dam storage began in 1935 and provided the first major storage reservoir and flood control to the Lower Colorado River. Since then various other surface-water control works have been built to provide flood control and electrical power and to regulate flows for downstream irrigators and Mexican Water Treaty commitments.

The estimated average annual undepleted inflow of the Colorado River to the region from 1906 to 1975 is 13.96 billion gallons per day (15,659,000 acre-feet). Annual virgin flow has varied from 4.9 bgd in 1977 to 21.4 bgd in 1917. The estimated 1975 average annual outflow of the Colorado

River into the region is 10.0 bgd (11,220,000 acre-feet per year) as modified by the 1975 level of upstream depletions of 3.96 bgd (4,438,600 acre-feet) in the Upper Colorado Region. Projected increased depletions in the Upper Colorado Region would reduce the average annual modified inflow to 9.2 bgd (10.3 million acre-feet) in 1985 and 8.9 bgd (9.99 million acre-feet) in 2000. Other recent projections indicate a less rapid rate of development. Thus, it appears that the average annual modified flow of the Colorado River will be adequate to meet the compact requirements until sometime after 2000. Figure 15-4 shows the average annual water inflow to and outflow from the region based on 1975 conditions. Outflow is closely regulated to meet the requirements of the Mexican Water Treaty and to minimize waste.

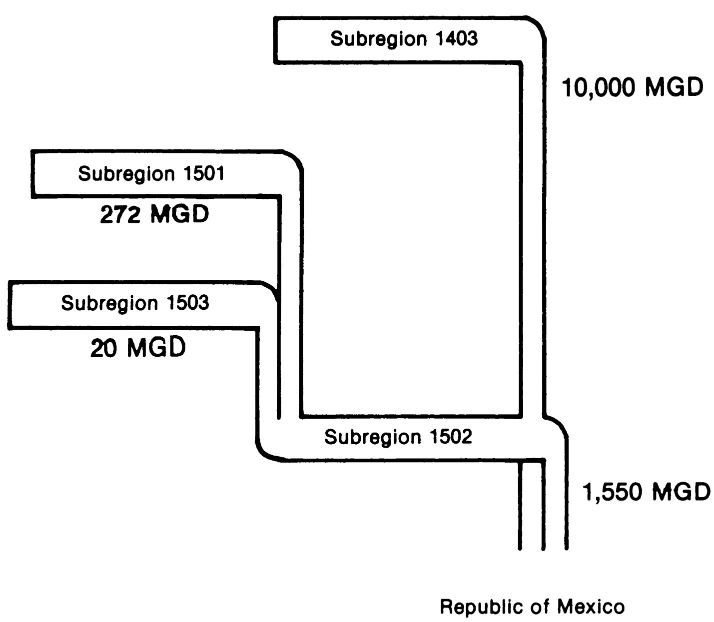


Figure 15-4. Streamflow

Ground Water

The estimated volume of recoverable ground water to a depth of 700 feet below land surface that can be withdrawn from storage under optimum conditions in the Lower Colorado Region is 1 billion acre-feet. Major aquifers are shown on Figure 15-5. Although the amount of ground water in storage in the main alluvial aquifers is large, many problems relative to pumping and use preclude the withdrawal of all the stored water. Land subsidence has occurred in Nevada and Arizona where large amounts of ground water have been withdrawn. Although ground water occurs at depths of 200 feet or less below about 8,700,000 acres in the region, only about 1,283,000 acres is under irrigated cropland, and many areas that contain easily available ground water are remote from areas of potential use. Some of the available ground water is highly mineralized and would require treatment for most uses. Legal constraints and unpredictable economic and technologic factors may affect the practicality of withdrawing deep water or of transporting water long distances to points of use.

In south-central Arizona, annual ground-water levels are declining an average of 4 to 10 feet per year and are believed to be the principal cause of land subsidence and earth fissures that have occurred in many areas. Although levels will continue to drop, the Central Arizona Project and Southern Nevada Water Project will lessen the rate by 60 percent in 1985 and will provide for the distribution of the region's remaining available water supply to the areas of need.

Withdrawals

The total average water withdrawal from streams and ground water under 1975 conditions totaled about 8.9 bgd and is expected to decrease to about 7.9 bgd by 2000 as shown in Figure 15-6. The SRF reports a withdrawal of 8 bgd in 1975 increasing to 8.9 bgd in 2000. The difference between the NF and SRF in 1975 results from differences in assumptions for irrigated agriculture, thermal electric powerplant cooling, and level of economic activity. These differences are discussed later in the section entitled "Comparative Analysis."

The Lower Colorado Region's water resources are used primarily for irrigation and domestic and industrial purposes. At present, only minor quantities are used consumptively for cooling thermal powerplants, mineral production, livestock watering, fish and wildlife, and recreation. Over 56 percent of all water withdrawals are from ground water.

The rapid growth in regional population and economy has resulted in increased use of water for domestic and industrial purposes. The percentage of total regional withdrawals for these uses has grown from approximately 3 percent in the early 1950's to about 4.7 percent in 1975, and these requirements are expected to increase to 8 percent of total withdrawals by 2000.

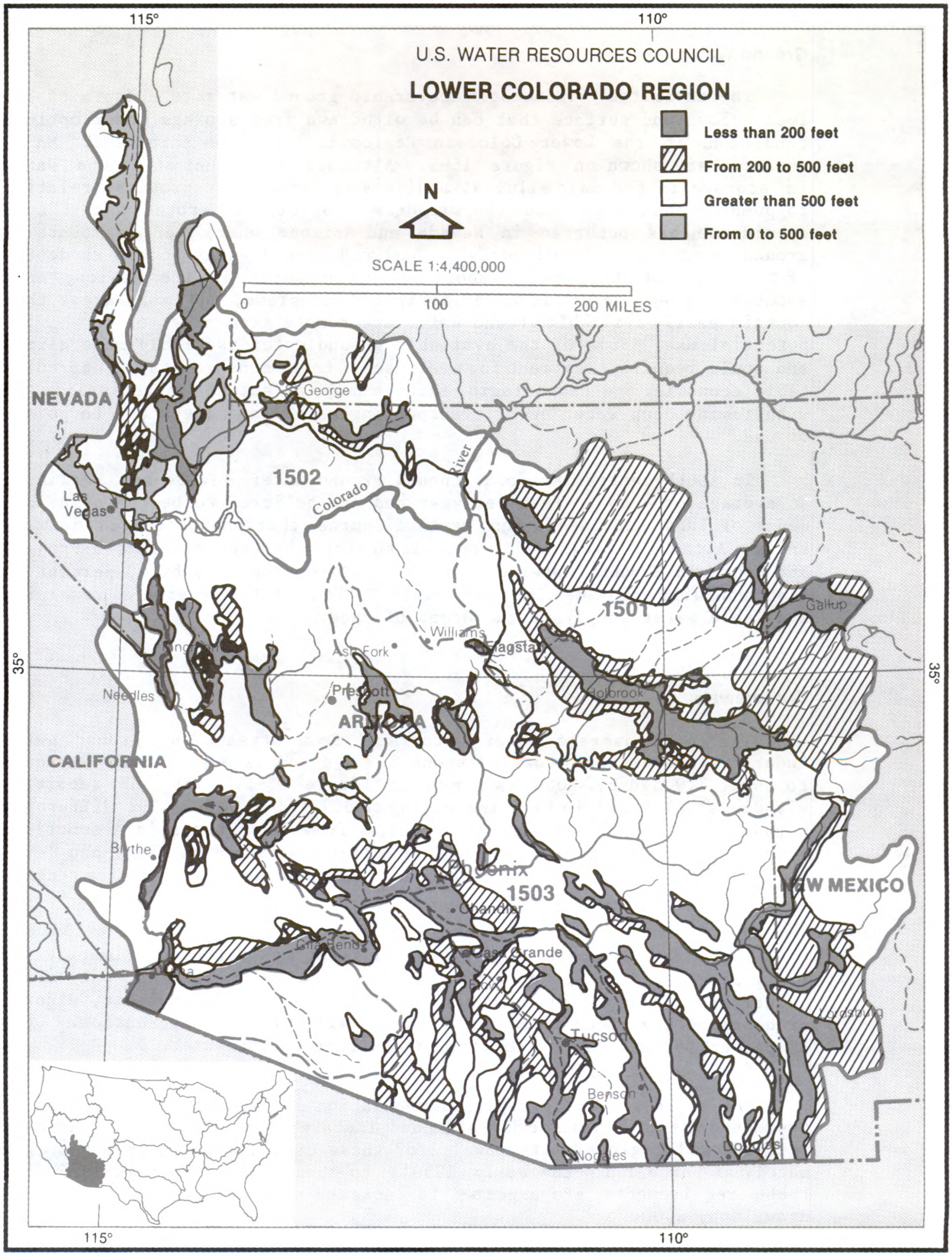
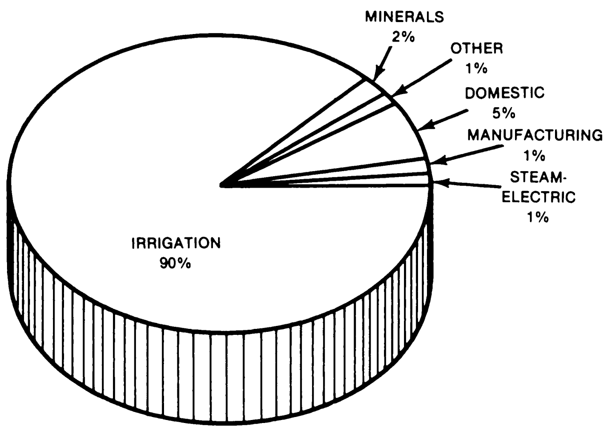
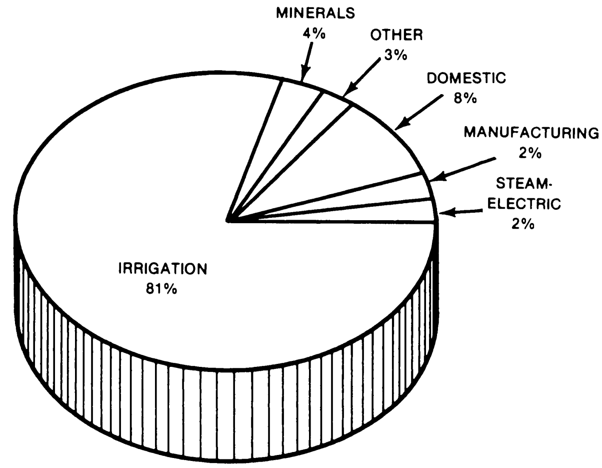


Figure 15-5. Major Aquifers

ANNUAL FRESHWATER WITHDRAWALS

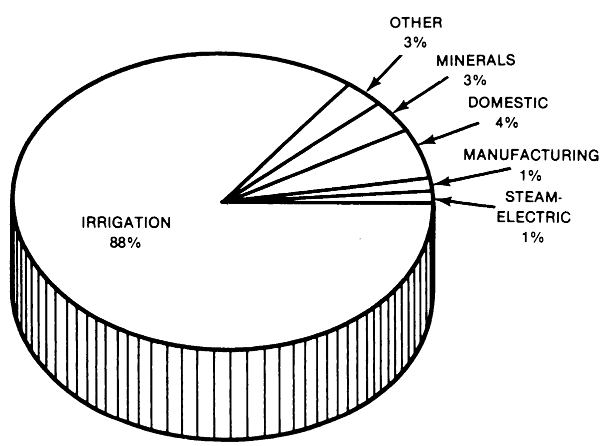


1975
Total Withdrawals — 8,917 MGD

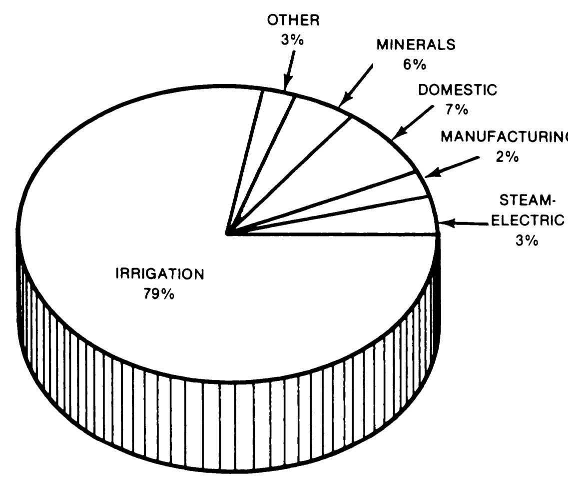


2000
Total Withdrawals — 7,857 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 4,595 MGD



2000
Total Consumption — 4,708 MGD

Figure 15-6. Withdrawals and Consumption

During 1975, the total water withdrawal requirements for irrigated agriculture was about 8.0 bgd or 90 percent of the region's total withdrawals. A decrease to 6.3 bgd is projected by 2000. Domestic use is projected to increase by 1.6 times from 423 mgd to 658 mgd. Water withdrawals for electric energy generation are projected to increase by a factor of about 2.3. This increase reflects dependence on thermal electric generation with reduced imports, no increase in hydroelectric generation, and extensive use of dry cooling towers. The efficiency of water use is high throughout most of the region. Most return flows either percolate to the ground-water aquifer to be reused or become part of the streamflow and are reused downstream. However, these return flows frequently result in adverse water quality impacts. There is essentially no outflow from the region in the natural channel except some return flows occurring near the regional boundary in the vicinity of Yuma, Arizona, because of diversions to California and Mexico.

Water consumption is projected to increase about 2.4 percent in the NF projections by 2000, while SRF projections indicate an increase of about 14 percent. NF projections are shown in Figures 15-6. The NF projections include a decline in irrigation water consumption from 4,026 to 3,720 mgd.

An expanding population, energy exports to other regions, and an increasing per capita consumption of electricity have resulted in a dramatic increase over the past two decades in water consumed for energy. The projected increase in population will continue increases in the demand for energy, and steam electric water consumption is projected to increase from 63 mgd in 1975 to 126 mgd (NF) by 2000. This NF estimate is predicated on the use of dry cooling towers for generating stations constructed in the region after 1985. The region does not believe this is realistic due to the loss of generating efficiency and high cost. Consequently, the SRF estimated steam electric water consumption for 2000 is almost twice that of the NF projection.

The decline in water consumption for irrigation of about 306 mgd results from a NF projected decline of about 156,000 acres of irrigated agriculture by 2000. Irrigation consumption will decline from 88 to about 79 percent of the total consumption.[1] Water consumption for domestic and manufacturing use is projected in NF estimates to increase by about 56 and 91 percent respectively by the year 2000, while the SRF projects the increase to be about 72 and 95 percent based on higher population projections.

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[1]Total depletions include consumptive uses, exports, and pond and reservoir evaporation. Consumption is about 45 percent of present depletions. Since exports are expected to decline, this will increase to about 48 percent in 2000. Thus irrigation consumption is only about 39 percent of total depletions in the region now and will be about 38 percent in the year 2000.

Instream Uses

There are many stream uses which do not require actual removal of water. Principal among these uses are recreation, fish and wildlife use, waste disposal, and hydroelectric power. These purposes do require minimum levels of water quantity and quality for satisfactory use. However, the instream flow approximation of 6,864 mgd for fish and wildlife far exceeds the Mexican treaty obligation and cannot be met under existing conditions of exports and depletions.

The prime factor for recreational enjoyment of water in the region centers around its availability, and most recreational uses of water are nonconsumptive. Water used basically for recreation and esthetic purposes by swimming pools, golf courses, etc., is included in the municipal and industrial category. Water surface evaporation from lakes and reservoirs is included as evaporation losses. The water consumption for fish and wildlife uses is small compared to that for other uses.

Supply and Demand

At the 1975 level of development, 56 percent of the water withdrawals are from ground water. Ground-water reserves which have been accumulated over thousands of years in aquifers are being depleted at the rate of about 2.4 bgd. Ground-water levels in some areas are declining by as much as 4 to 10 feet per year. There is essentially no surface outflow from the region except to meet the Mexican treaty obligation. The completion of the second stage of the Southern Nevada Water Project in 1981 and the Central Arizona Project in 1985 will convey the region's remaining share of Colorado River water to areas of need, thus reducing ground-water overdraft by about 60 percent. Essentially all renewable surface- and ground-water supplies in the region will then be utilized.

If the total renewable water supply available to the region could be captured and distributed, ground-water mining continued, and no outflow permitted, there would be adequate water supplies through 2000. However, this is obviously not possible and the SRF estimates that ground-water overdraft will be about 1.4 bgd in 1985 with the Central Arizona Project and Second Stage Southern Nevada Water Project in operation, and between 2.0 and 2.2 bgd in the year 2000.

Obviously the competition for water to supply the needs of an increasing population will become even more intense. Ground-water levels will continue to decline, though at a lesser rate with the completion of the two projects now under construction.

Difficult decisions will be needed as to the future use of the Lower Colorado Region's limited water supply for the social, economic, and environmental welfare of the region. Long-term planning is essential in order that the most appropriate adjustments can be made in the region's economy without undue hardship. The region must consider the alternatives of a future based upon augmentation of its natural fresh-water resources or a future based on living within the resources currently available by modifying use patterns, habits, and the legal and institutional arrangements within the region. It is of vital importance that the region continue to have available for use its full apportionment of Colorado River water.

The NF estimates indicate that Colorado River water cannot supply the future depletions in the Upper and Lower Colorado regions and still meet the Mexican treaty commitments unless ground-water mining can be continued. A decline in exports to southern California will be less than increased depletions in the Upper Colorado Region.

Demands for more exports to central Colorado, central Utah, and southern California can be expected to increase. Water shortages in the individual problem areas described later in this report can be expected to worsen as ground-water tables decline. Programs and projects will be needed to reduce consumption or to augment the flows of the Colorado River before the year 2000 and will become increasingly critical afterward. The SRF data estimate a somewhat better water supply for the main stem but also depend on continued ground-water mining.

The instream flow approximation cannot be met without stopping nearly all exports and most other depletions. Public Law 90-537 states "The Congress declares that the satisfaction of the requirements of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to Section 201 of this Act and authorized by Congress."

Comparative Analysis

Table 15-5 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water needs in the Lower Colorado Region. The total withdrawal requirements of the SRF and NF estimates for 1985 are in close agreement. SRF withdrawal values for the year 2000 are 13 percent higher than the NF values. Even with similar total withdrawal values, significant internal differences exist.

The SRF projections of domestic and manufacturing requirements for withdrawal and consumption are consistently higher than the NF projections; the SRF projections reflect high populations and a slightly higher per capita consumption.

The SRF and NF differ significantly on water requirements for the minerals industry. The SRF water requirements came from a survey of the mining companies to collect data for the Arizona State Water Plan. About 97 percent of the water for the region's minerals industry is used in Arizona. The basic difference is the degree of recycling assumed in the two projections. Water for mining in the region is generally in short supply and expensive. The water is recycled several times during ore processing before being conveyed to lined evaporative disposal ponds. Except for sand and gravel operations, little water is returned to streams or ground-water aquifers. It is not now nor will it be acceptable to return the waste water from mining activities to streams or ground-water aquifers as implied in the NF projections.

The NF consumptive use coefficient is based on optimum crop growth with 50 percent drought probability. The SRF consumptive use coefficient is lower than that of the NF. The SRF coefficient is based on an average year and somewhat less than optimum crop growth. These differences apply to the withdrawal requirements as well. The SRF data assume a slightly higher irrigation efficiency.

The 1975 SRF water withdrawal and consumptive use figures for steam electric power generation are smaller than the NF values by 18 and 16 percent, respectively. The 1985 SRF withdrawal requirements are 11 percent higher than those of the NF. The SRF projections assume that nearly all steam electric plants in the region will continue to use wet cooling towers and recycle the water. In most of the plants, little, if any, water is returned to the stream system. Water quality standards encourage this practice. In the year 2000, the SRF projections of both withdrawal and consumptive use are considerably higher than the NF projections. The NF estimate assumes that after 1985 new steam electric plants will use dry cooling towers. The SRF projection does not assume that there will be a significant use of dry cooling towers by this date because of the efficiency lost and high cost.

Table 15-5.--Socioeconomic and volumetric data summary: the Lower Colorado Region

Category	1975		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	2,412	2,683	2,915	3,740	3,629	5,071
Total employment	940	1,031	1,165	1,491	1,466	2,044
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	6,170	NE	6,170	NE	6,170	NE
Streamflow at outflow point(s)	1,550	1,340[a]	-1,433	1,340[a]	-1,544	1,340[a]
Fresh-water withdrawals	8,917	7,962	8,528	8,522	7,857	8,882
Agriculture	8,036	6,955	7,351	6,838	6,403	6,635
Steam electric	68	56	150	167	154	267
Manufacturing	89	124	92	192	138	247
Domestic	423	580	520	879	658	1,110
Commercial	75	[b]	92	[b]	114	[b]
Minerals	184	156	252	281	311	436
Public lands	20	23	49	57	56	65
Fish hatcheries	22	NE	22	NE	23	NE
Other	0	68	0	108	0	122
Fresh-water consumption	4,595	4,891	4,754	5,268	4,708	5,556
Agriculture	4,073	4,229	4,014	4,161	3,780	4,062
Steam electric	63	53	134	162	126	250
Manufacturing	55	63	54	94	104	123
Domestic	199	317	245	440	310	544
Commercial	35	[b]	43	[b]	54	[b]
Minerals	151	142	217	262	280	412
Public lands	19	23	47	56	54	65
Fish hatcheries	0	NE	0	NE	0	NE
Other	0	64	0	93	0	100
Ground-water withdrawals	5,008	4,324	NE	2,447	NE	3,609
Exports	4,498	4,465	4,129	3,929	4,032	3,929
Evaporation	1,202	1,230	1,222	1,232	1,236	1,240
Instream approximation						
Fish and wildlife	6,864	0	6,864	0	6,864	0

NE - Not estimated.

[a] SRF streamflow is the minimum flow required by the Mexican Water Treaty.
[b] SRF domestic water use includes commercial and institutional requirements.

Problems

Water Quantity

Of all the major river basins in the world, the Colorado River system is one of the most developed and extensively utilized. Unfortunately, even with careful management through conservation and reuse the system's average annual water supply will not be enough to meet all the increasing demands and the requirements of the Mexican treaty.

The dependable surface- and ground-water supply is inadequate to meet present uses in several locations, and the present economy is sustained through ground-water overdrafts totaling about 2.1 bgd (2.4 million acre-feet), or about 50 percent of the region's total consumptive use in 1975. The water level in these heavily pumped aquifers is rapidly declining, and thus energy consumption and pumping costs are increasing.

Conflicts continue to arise among urban, agricultural, and mining interests, and environmentalists, wildlife interests, and recreationists. By the year 2000, competition for water will become more severe among all users, with many demands remaining unmet, unless the water supply of the Colorado River system is augumented by measures other than those now projected.

The ground-water overdraft is projected in the SRF estimates to be reduced to about 1.4 bgd by 1985 with completion of the Central Arizona Project and the second stage of the Southern Nevada Water Project. The overdraft is projected to reach 2.2 bgd by the year 2000. In addition to quantity problems, the ground-water overdraft and extensive reuse of return flows contribute to other problems pertaining to surface-water quality, land subsidence, and loss of fauna.

Water Quality

High levels of dissolved mineral salts in surface and ground waters are a major water quality problem in the region. Surface- and ground-water supplies frequently have mineral concentrations exceeding 500 mg/l, and many exceed 1,000 mg/l. The salinity of the supplies affects domestic, industrial, and agricultural uses.

In the last several years the Colorado River entered the region at concentrations exceeding 500 mg/l, varied between 500 and 900 mg/l at most diversion points, with increases to as high as 1,150 mg/l having been reported for short periods of time at Imperial Dam. About 8 million tons of dissolved solids are transported into the region from the Upper Colorado Region annually, mostly from diffused sources. Increased salinity concentrations in the Colorado River from Lee Ferry, Arizona, to Imperial Dam are due principally to inputs from saline springs and return flows and the concentrating effects of consumptive use, reservoir evaporation, and diversions out of the region.

In the headwaters of the Gila River, dissolved solids concentrations are generally less than 500 mg/l. In the middle reaches below points of major diversions, the dissolved solids content usually ranges from about 500 to 1,000 mg/l. Although some salt springs discharge to the Gila River, most of the increase in dissolved solids results from the concentrating effects of consumptive uses.

Mineral quality is generally good in most of the headwaters of the Little Colorado River. The middle reaches of the Little Colorado vary considerably in salt content. The Little Colorado River near its mouth is very high in dissolved solids, as most of the flow originates from saline springs.

Future dissolved solids concentrations in the Lower Colorado River were estimated for 1980, 2000, and 2020. Dissolved solids concentrations in the Colorado River, assuming no salinity improvement programs, are projected to increase by 35 to 50 percent by 2000. This would increase total damages attributable to salinity to as much as $165 million per year. The major cause of the projected salinity increases is increased development in the Upper Colorado Basin, which includes the additional stream depletions for municipal and industrial use, irrigation, thermal power production, exports, and reservoir evaporation and for the additional salts leached from newly irrigated lands.

Opportunities to improve water quality through careful land management appear to be of the utmost significance. Land management activities contribute to water quality problems; sediment and inorganic salts and minerals have a primary impact. Animal wastes, agricultural chemicals, infectious agents, turbidity, and heat are also of concern. In some areas, nitrate and fluoride concentrations exceed recommended limits for domestic water supplies. A few localized problems exist where water is high in toxic materials such as arsenic and hexavalent chromium.

Water Surface

Water surface area for recreation centers around the 3 million acres of the Lake Mead National Recreation Area. National Park Service statistics record over 350,000 recreational boats launched on Lake Mead in 1976. Float trips by raft, canoe, and kayak through the Grand Canyon and other scenic areas in the Southwest are also becoming increasingly popular. Reservoirs on the Salt and Verde rivers provide recreation in central Arizona. An additional 185,000 acres of water surface will be needed to meet expected demands by the year 2000.

Flooding

Almost one-half of the developed urban area and 90 percent of the irrigated cropland in the Lower Colorado Region are subject to flooding. Flood problems are such that almost all land having topography suitable for general development is subject to flood damage. Historically, developments have occurred in flood plains regardless of hazards. This has been due, in part, to inadequate knowledge about flood zones. In an effort to disseminate more flood-plain information, the National Flood Insurance Act of 1968 and the National Flood Disaster Protection Act of 1973, along with State and local ordinances, provide the framework for identifying flood-plain hazards, restricting unwise flood-plain use, guiding proposed construction away from flood-prone areas, and improving long-range land management and flood-plain use.

Various methods of controlling future flood damage are available and include: improved methods of flood forecasting; increased flood control storage; construction of levees and channels; watershed land treatment and management; and especially, flood-plain management, which includes structural and nonstructural measures. In many cases, floodproofing or abandonment of existing structures can reduce flood damages.

Flood problems and damages are still expected to increase because all projected future developments cannot be made on lands exempt from flood damages. Regional economic growth, characterized by an increase in population, will require significant land areas for development.

Erosion and Sedimentation

Erosion in the region is primarily a natural geologic process, with an estimated 25,000 square miles eroding at rates greater than 0.75 acre-feet per square mile. The most severe erosion occurs on deserts and grasslands where it does extreme damage to grazing lands and wildlife habitat.

Sediment, the product of erosion, accounts for 107,000 acre-feet of silt in the Colorado River each year. It accumulates in reservoirs and stream channels, increases the cost of treatment for municipal and industrial (M & I) supplies, clogs irrigation and drainage improvements, smothers growing plants, destroys harvestable crops, decreases the recreational value of water, and adversely affects fisheries resources.

Land-management programs have been designed to reduce this soil erosion and sedimentation while controlling runoff, suppressing wildfire, and improving production capacity. Program measures include proper use of the amount and kind of native vegetation, vegetative management, erosion control, structures, range seeding, and water facility development.

Pollution

There are more than 200 waste-water treatment plants in the region (including municipalities). While most of these facilities do not discharge directly into surface waters, most could have impacts on future water quality conditions--particularly on ground waters--as a result of intermittent percolation of storm runoff.

Degradation of water quality conditions in the region occurs where municipal treatment facilities are overloaded, where operators of small "package" plants fail to achieve optimum operating practices, where high density populations are served by septic tank-leach field systems, where infiltration or effluent discharge exists, and where bacteria and viral pollution results from inadequately treated sewage effluent from recreation areas.

Individual Problem Areas

The following specific areas in the Lower Colorado Region have urgent problems concerning water and related land resources:

Lower Colorado River Water Quantity Deficiencies

Lower Colorado River Mainstream Water Quality Deficiencies

McKinley County, New Mexico

Apache and Navajo Counties, Arizona

Coconino County, Arizona

Las Vegas Valley, Nevada

Lower Colorado River Valley, Arizona and Nevada

Catron, Grant, and Hidalgo Counties, New Mexico

Greenlee and Graham Counties, Arizona

Cochise County, Arizona

Maricopa County, Arizona

Pima and Pinal Counties, Arizona

Figure 15-7a shows the location of these problem areas within the Lower Colorado Region, and Figure 15-7b presents a tabulation of problem issues by subregion. A description of each of the problem areas listed above follows.

Lower Colorado River Water Quantity Deficiencies

Description

This problem area includes the entire Colorado River service area. The Colorado River, supplying water to metropolitan complexes along the coast of southern California, the eastern slope of the Rocky Mountains in Colorado, the upper Rio Grande of New Mexico, and the Wasatch Front in Utah, has a service area extending far beyond its physical area. The Colorado River Basin States produce 15.2 percent of the Nation's total value of agricultural crop production on 7.2 percent of the total crop-land. The basin States also produce 13 percent of the Nation's total value of livestock.

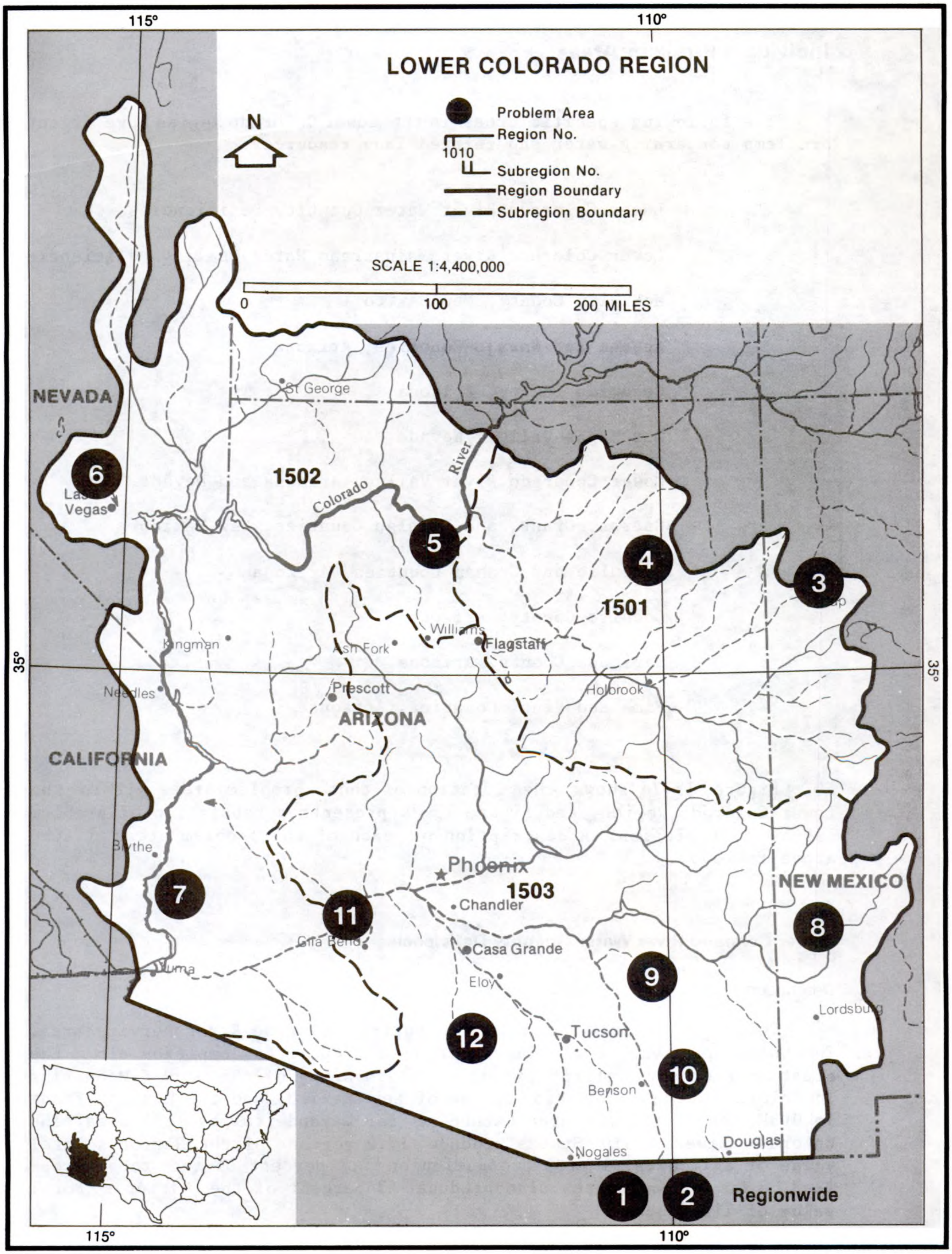

Figure 15-7a. Problem Map

LOWER COLORADO REGION (15)

PROBLEM MATRIX

Problem issues: O Identified by Federal Agency Representatives; X Identified by State Regional Representatives

Problem area: No. on map	Problem area: Name	Water quantity: Fresh surface	Water quantity: Ground	Water quantity: Marine and estuarine	Water quantity: Surface depth	Water quality: Fresh surface	Water quality: Ground	Water quality: Marine and estuarine	Water quality: Surface depth	Related lands: Flooding	Related lands: Drainage	Related lands: Erosion and sedimentation	Related lands: Dredge and fill	Related lands: Water related use conflicts	Other
Regionwide															
Area 1	Lower Colorado River	X												X	
2	Lower Colorado River					X									
Subregion 1501	Little Colorado	X	X			X						X			X
Area 3	McKinley County, New Mexico	X	X			X	X			X		X			X
4	Apache and Navajo Counties, Arizona	X	X			X	X			X		X			X
Subregion 1502	Lower Colorado Main Stem	O	O			O						O	O		O
Area 5	Coconino County, Arizona	X				X	X			X		X		X	
6	Las Vegas Valley, Nevada	X	X			X	X			X					
7	Lower Colorado River Valley, Arizona & Nevada	X	X			X	X			X	X	X		X	X
Subregion 1503	Gila	O	O			O				O		O	O		O
Area 8	Catron, Grant, Hidalgo Counties, New Mexico	X	X				X			X		X		X	X
9	Greenlee and Graham Counties, Arizona	X	X			X	X			X		X		X	X
10	Cochise County, Arizona		X							X		X		X	X
11	Maricopa County, Arizona	X	X			X	X			X		X		X	X
12	Pima-Pinal Counties, Arizona	X	X			X	X			X		X		X	X

Figure 15-7b. Problem Matrix

Within the region, Colorado River water serves Clark County, Nevada, and Mohave and Yuma counties, Arizona, including the cities of Las Vegas, Nevada, and Yuma, Arizona. Upon completion of the Central Arizona Project, Colorado River water will be transported to Maricopa, Pima, and Pinal counties in Arizona, which include the metropolitan areas of Phoenix and Tucson. It will also provide for water exchanges with other areas in Arizona and with southwestern New Mexico.

Problems—Water Issues

Though the demands on the Colorado River are large and growing rapidly, the long-time average annual virgin flow is small when compared to other major rivers. The Colorado River is not only the most physically developed and controlled river in the Nation, but it is also one of the most institutionally encompassed rivers in the country. No other river in the Western Hemisphere has been the subject of as many disputes of such wide scope during the last half century. These controversies have permeated the political, social, economic, and legal facets of seven Colorado River Basin States. Many lawsuits and international and interstate compacts have resulted from a water supply which is inadequate to meet the existing and potential water demands.

The increase in future water needs is largely a direct function of a growing population. The increase includes municipal and industrial water, cooling water for thermal powerplants, and water for recreation and fish and wildlife enhancement. It is vital to achieve economic development and improve the quality of life on Indian reservations.

In total, the Colorado River is the lifeline of the economy and well-being of the people of the Southwest. The region produces a wide variety of crops that are important to the Nation. The average annual water supply will probably become inadequate in the years ahead to meet compact apportionments and treaty entitlements. Deficiencies are expected to begin about the year 2000, and competition for water will become increasingly severe for all uses, with many demands remaining unmet.

Institutional and Financial Issues

Public Law 90-537 states that the "The Congress declares that the satisfaction of the requirements of the Mexican Water Treaty from the Colorado River constitutes a national obligation. . . ." It also states that "the Colorado Basin States not be relieved of this obligation . . . until such time as a feasibility plan showing the most economical means of augmenting the water supply available in the Colorado River below Lee Ferry by 2-1/2 million acre-feet shall be authorized by the Congress and is in operation as provided in this Act." Such studies need to be completed by 1985. The year 2000 is the latest date for such augmentation to be in operation to insure that the States continue to receive their full apportionment of Colorado River water. A large Federal investment will be necessary to relieve the Colorado River Basin States of the Mexican Water Treaty obligation as stated in Public Law 90-537. Conflicts exist concerning the priority of water use and the transfer of water between uses.

Lower Colorado River Mainstream Water Quality Deficiencies

Description

This area includes the entire Colorado River service area. As already noted, the Colorado River, supplying water to metropolitan complexes along the coast of southern California, the eastern slope of the Rocky Mountains in Colorado, the Upper Rio Grande of New Mexico, and the Wasatch Front in Utah, has a service area extending far beyond its physical area.

Problems—Water Quality

High salinity concentrations impair the usefulness of Colorado River water for municipal, commercial, industrial, and irrigation purposes. Increased salinity results in loss of agricultural production, limits crop varieties, increases operating costs, and increases agricultural water requirements. Projected future salinity levels will result in further adverse effects unless salinity controls are implemented. Over one million acres of irrigated farmland and over 12 million people are affected in the Lower Colorado River service area.

The total damages attributable to salinity in the Colorado River system for 1973 were estimated at about $53 million in the United States. By the year 2000 these damages are expected to climb as high as $165 million per year unless control measures are applied. These economic impacts are based on past studies by the Bureau of Reclamation. The studies show estimated total direct and indirect losses of about $230,000 per mg/l increase in salinity at Imperial Dam. A more recent study indicates greater damage, but results of this study are not final. The damage arises in agriculture from decreased crop yields, increased leaching requirements, increased management costs, and application of various adaptive practices. In the municipal and industrial sector, the detriments arise primarily from increased water treatment costs, accelerated pipe corrosion and appliance wear, increased use of soap and detergents, and decreased potability of drinking water.

Minute No. 242 of the International Boundary Water Commission specifies that the United States shall adopt measures to assure that the water delivered to Mexico at Morelos Dam has an average salinity of no more than 115 mg/l $\pm$ 30 mg/l greater than the flow-weighted average salinity of the Colorado River waters that arrive at Imperial Dam.

Institutional Issues

Assurance is needed that the quality of Colorado River water delivered to Mexico will comply with Minute No. 242 without further penalty to the Basin States' Colorado River water supply.

Although Public Law 93-320 has been passed and four salinity control units have been authorized under Title II, investigations and funding must be completed on 12 additional units, and research on other possible measures must be continued.

McKinley County, New Mexico

Description

Problem area three consists of McKinley County, New Mexico, in the northwestern part of the State along the Arizona border. It encompasses 5,461 square miles.

Problems

Water supplies are inadequate for the towns and the cities of Gallup and Zuni Pueblo, which have a total population of about 24,000 (1975). Ground water is the main source for municipal use, but it contains excessive suspended sediments. Reports on total dissolved solids for domestic wells range up to 1,600 mg/l, which is over three times that recommended for domestic use.

Ground-water quality is frequently unsuitable for irrigated agriculture and is a limiting factor for irrigation development. In many areas the ground-water yield is very low and limits its utilization for all purposes, including mineral development. There are major coal and uranium resources available which need a water supply for development and utilization.

Croplands and small communities are subject to frequent floods and sediment deposition in streams and reservoirs. Erosion is severe, resulting in loss of productive capacity for crops, livestock, and wildlife.

Adverse Effects

Unless these problems are solved, water supplies in McKinley County will not meet future needs. Croplands and communities will continue to be plagued by floods, and sediment will continue to fill streams and reservoirs. Economic impacts will include the loss of production for cropland, livestock, and wildlife, and residents will be forced to move out of the area into urban centers.

Conclusions and Recommendations

Evaluation of water requirements and potential water sources for rapidly developing uranium mining and milling and coal mining is needed. A study and comparative evaluation of alternative sources including San Juan River water for the City of Gallup are underway. Authorization and funding for implementation of the most feasible plan are needed.

Apache and Navajo Counties, Arizona

Description

Problem area four consists of Navajo and Apache counties in northeastern Arizona. They include 21,081 square miles or 14 percent of the region's area.

Problems

The major water problems in Apache and Navajo counties are related to deficient water supplies on the Navajo Indian Reservation, inadequate water storage facilities, excessive sediment concentrations in surface water, low yield, poor quality ground water, excessive soil erosion, and flood hazards. The problems are prevalent, and without corrective action their severity will increase.

There is a shortage of surface water and storage on the Navajo Indian Reservation for all uses and a lack of dependable streamflow for recreation and fish and wildlife habitat. In many areas the ground-water yield is very low, limiting its utilization. Many Indian communities are without a water supply. In addition, excessive suspended sediments in surface-water supplies often make them unsuitable for domestic and irrigation use. Because of the water shortages, potential development of coal resources is limited and development of thermal electric generation is constrained.

Holbrook, Arizona, is very susceptible to flooding, and small communities on the Navajo Indian Reservation are frequently flooded. Excessive erosion is causing loss of productive capacity for crops, livestock, and wildlife. Sediment deposition in streams causes loss of channel capacity and greatly reduces the storage life of reservoirs.

Institutional

A conflict exists between water rights of Federal, State, Indian, and private lands. Cultural barriers exist with regard to effective range management on the Navajo Indian Reservation.

Financial

Local programs on the Navajo reservation are limited by inadequate finances, and Federal programs are needed to develop the resources to their ultimate capacities.

Adverse Effects

The problems of inadequate water storage, excessive sediment concentrations, deficient supplies, low yield, and poor quality ground water will become increasingly severe unless controls are implemented. In many Indian communities, the ground-water supply is inadequate to meet minimum needs. Deficient water supplies constrain the development of coal resources, thermal electric generation, and improvement in the economic well-being and quality of life on the Indian reservations.

Conclusions and Recommendations

Funding is needed for the authorized study of erosion, flooding, and associated problems on the Navajo Indian Reservation. The Department of Agriculture and the Arizona Water Commission are conducting a cooperative study on the Little Colorado River, which includes a major portion of the Navajo and Hopi reservations.

Coconino County, Arizona

Description

Problem area five consists of Coconino County, Arizona, in the north central part of the State, extending from the Mogollon Rim to the Utah border. It is the largest county in Arizona and the second largest, in area, in the conterminous United States. It includes 18,573 square miles.

Problems

There is a shortage of surface water and storage, especially on Indian lands. In many areas the ground-water yield is very low and unsuitable for domestic and irrigation use. The major water supply problem areas are Flagstaff and Williams, which have long had an inadequate supply and which must occasionally import water by tank car to meet demands.

The Little Colorado River carries large quantities of suspended sediment, which greatly impairs its utilization. Inflow from Blue Springs contributes significantly to the salinity of the Colorado River.

Several communities in the county, including some on the Indian reservations, are subject to floods. Related erosion results in loss of productive capacity for crops, livestock, and wildlife. Sedimentation damages rural and urban communities, surface-water developments, and croplands and reduces the carrying capacity of streams.

Adverse Effects

Flagstaff and Williams, Arizona, need additional high quality surface water to meet the demand of increasing populations. Without controls, flooding and related erosion will continue to reduce crop production, livestock, and wildlife.

Conclusion

A multiobjective, multidisciplinary study on a comprehensive basis is needed to develop alternative measures for evaluation of the several interrelated problems.

Las Vegas Valley, Nevada

Description

This problem area is concentrated in the Las Vegas metropolitan area and its neighbor, Boulder City. Although the Standard Metropolitan Statistical Area is delineated by the Clark County boundary, the Las Vegas Valley comprises only 350 square miles of the total county area of 7,927 square miles.

Problems

The severe water and land resource problems of the Las Vegas metropolitan problem area are related to limited water resources, water quality, flooding, and the impacts of continuing rapid population growth on the area's natural resources.

The problems related to water quantity include surface-water quantity, ground-water overdraft, land subsidence, and loss of fauna. Water supplies that will meet the needs of the rapidly growing population require completion of the second stage of the Southern Nevada Water Project by the scheduled date of 1981 and long-range planning to meet future needs.

Municipal and industrial waste water from the Las Vegas Valley has been discharged into Las Vegas Wash for many years, polluting Lake Mead and the Colorado River downstream. The waste originates from several sources: secondary effluent from the Clark County Sanitation District's sewage treatment plant; saline cooling water from two powerplants; drainage from gravel pits; saline industrial wastes from the BMI complex; treated secondary effluent from the city of Henderson and the BMI sewage treatment plants; and return flows from agricultural irrigation, domestic irrigation, and septic tanks. An advanced treatment plant and the Las Vegas Wash unit of the Colorado River Quality Improvement Program, presently under construction, should help alleviate some of these problems.

Flood problems have increased with the increase in population. Urban development, which has spread onto the flood plains, continues at a rapid rate, and the flood threat grows each year as more property is subjected to flood damage. Large floods occurred in 1923, 1931, 1955, 1974, and 1975.

Adverse Effects

Without completion of the second stage of the Southern Nevada Water Project, water problems related to surface-water quantity, ground-water overdraft, land subsidence, and loss of fauna will continue.

Conclusions and Recommendations

Adequate funding is needed to assure completion of the second stage of the Southern Nevada Water Project by the scheduled date of 1981. Means of further water conservation in the Las Vegas metropolitan area, including reduction of per capita consumption, need evaluation. Alternatives for balancing long-term water use with supplies need to be explored along with socioeconomic factors. Southern Nevada should be included in a regional water augmentation study. A comprehensive flood control plan for the Las Vegas metropolitan area is needed.

Lower Colorado River Valley, Arizona and Nevada

Description

This area includes the Colorado River Valley of Arizona and Nevada from Hoover Dam to the international boundary with Mexico. The Colorado River flows southward forming the border between Arizona and Nevada and, farther south, Arizona and California until it reaches the Mexican border.

Problems

Problems are associated with increasing demands on land and water resources, and rapid population growth in the valley and the metropolitan areas of southern California and Arizona. The Colorado River Valley is a major recreational resource for millions of people. It provides valuable and unique fish and wildlife habitats; its citrus and winter vegetable crops are of national importance; its water is transported to the populous coastal areas of southern California and will soon be transported to the central Arizona area; its hydroelectric plants are a major source of electric energy; and it supplies water to the Republic of Mexico.

Limited water supply constrains the development of additional irrigated agriculture in the Colorado River Valley and recreational and thermal electric power developments. Indian reservations in the valley are limited to water allocations provided for in the Arizona v. California Supreme Court Decree. The conflict in the use of limited water supplies for livestock and wildlife constrains proper range management.

Considerable ground-water consumption by phreatophytes reduces availability of water for other uses. It is estimated that 60,000 acre-feet of water per year could be salvaged by phreatophyte control. However, this vegetation also provides important fish and wildlife habitat.

High salinity concentrations and chemicals in ground water cause economic damage to municipal and industrial water users, loss of agricultural productivity, limitations of crop varieties, and increased farm operating costs.

Flash floods originating in upland tributary areas result in property losses and hazards to life in developed and undeveloped recreational areas and communities along the Colorado River. The recreational development at Nelson's Landing on Lake Mohave in Nevada was destroyed and several persons died in flash floods in September 1974.

Erosion and sediment aggradation impairs boating, causes drainage problems and water loss, and increases flood hazards.

Institutional

Public Law 90-537 states that the first obligation of any water augmentation project will be satisfaction of the requirements of the

Mexican Water Treaty and that this shall be a national obligation. A large Federal investment will be necessary to alleviate the burden of the Colorado River Basin States in carrying out this obligation.

A major water issue in Arizona is that there are more requests for water delivery contracts than the available supply can satisfy. In addition, conflicts exist between preservation of wildlife habitat and land development for diverse uses.

Adverse Effects

The limited water supply of the Lower Colorado River Valley has national implications. If agricultural production slows because of deficiencies, a large source of the Nation's winter vegetables and fruits will be affected. In addition, the United States assumed an international obligation when it agreed to provide Mexico with 1.5 million acre-feet annually of Colorado River water.

Conclusions and Recommendations

Studies of water conservation through vegetative management and river channelization with consideration of wildlife, recreation, and scenic values should continue. Water conservation for irrigated agricultural and urban uses should be expanded. A natural resource and socioeconomic data base should be developed from which effects of water deficiencies for various use categories could be evaluated. A multiobjective study to complete and consolidate the land use and water resource management on the Lower Colorado River is needed. It would include the development of a natural resource and socioeconomic data base.

Catron, Grant, and Hidalgo Counties, New Mexico

Description

Catron, Grant, and Hidalgo counties are located in southwestern New Mexico. The combined area of the three counties is 14,315 square miles, of which 9,649 lie in the Lower Colorado River Basin and 4,666 in the Rio Grande Basin.

Problems

The severe water and land resource problems are related to legal constraints which prevent full utilization of available water supplies. A lack of storage facilities causes erratic flows and flooding. Severe erosion results in high stream sediment loads.

Surface flows in the Gila and San Francisco rivers and ground water are adequate, but legal constraints restricting use have resulted in inadequate supplies for projected mineral production for industry, and for domestic and agricultural needs. Additional water is needed by the year 2000 to avoid loss of a considerable portion of the presently irrigated lands.

It is anticipated that completion of the authorized Hooker Dam or a suitable alternative as part of the Central Arizona Project in the late 1980's will provide water to help alleviate this problem. A study of the means of supplying additional water to Catron, Grant, and Hidalgo counties should be a part of the regional water augmentation studies.

The total dissolved solids in domestic water supplies in some areas approach or exceed 1,000 mg/l, affecting the quality of water for drinking and other household purposes. The flood hazard is severe in communities and on croplands along the Gila and San Francisco rivers and their tributaries. Headcutting and sheet erosion associated with flooding add sediment to streams, destroy rangelands, and affect livestock grazing capabilities.

Institutional

Phreatophytes provide wildlife habitat in the area but consume large quantities of water. This has led to conflict between maintaining phreatophytes for wildlife and other water user interests.

Adverse Effects

Catron, Grant, and Hidalgo counties will continue to suffer the same problems as other water-deficient areas. Even with the completion of the Central Arizona Project in 1985, additional water will be needed by the year 2000 to avoid loss of a considerable portion of the presently irrigated lands.

Conclusions and Recommendations

Construction of the authorized Hooker Dam on the Gila River in New Mexico or a suitable alternative needs to be completed by 1985.

Greenlee and Graham Counties, Arizona

Description

Graham and Greenlee counties are located in southeastern Arizona. Graham County occupies 4,618 square miles and Greenlee County occupies 1,879 square miles. Together they total 5.8 percent of the State.

Problems

The major water-related problems in Graham and Greenlee counties are lack of flow regulation on the Gila River; deficient water supplies for the projected increase in mineral development; increased salinity loads of Gila River flows in the downstream portion of Safford Valley; large flood damage risk; severe erosion on deserts and grasslands; and excessively high sediment content in Gila River flows. The water supply is inadequate to meet the requirements of present uses, and the major increase in mineral production now underway will require additional water supplies. All surface flows are fully adjudicated, and present annual ground-water overdraft is estimated at 27,000 acre-feet and is projected to reach 50,000 acre-feet annually by the year 2000. Gila River flows are extremely erratic and frequently nonexistent during the summer months.

Quality of ground water varies by area and depth, depending on the mineralogical makeup of the aquifer being pumped. Wells typically produce water ranging from 300 mg/l to 4,500 mg/l total dissolved solids. The average ground-water quality was 955 mg/l in 1965 and was unsuitable in many portions of the San Simon Valley for domestic, crop, and livestock uses.

In the Gila River area, agricultural return flows result in high salinity concentrations in both surface and ground water in the lower reaches of the Safford Valley. Crop varieties are severely restricted, and production has been reduced. The Gila River at the head of the Safford Valley has carried a maximum daily sediment load of about 9.1 million tons and a minimum of 0.5 tons per day. These high sediment loads increase the maintenance cost of irrigation facilities, constrain water storage development, reduce the life of existing water storage facilities, and degrade the recreational and fisheries resources.

There is a severe flood hazard to urban and agricultural areas of the Duncan and Safford valleys. The deposition of silt, growth of phreatophytes, accumulation of snags, and flood-plain development on the Gila River have increased the flood hazard. With the lack of regulation upstream, floods occur frequently.

Institutional

Provisions of the Gila River Decree constrain development of stream-regulating facilities and limit options available in water management operations. Phreatophytes infringe on the Gila River channel and use large quantities of water; however, they do provide wildlife habitat and removal has been opposed by preservationist and wildlife groups.

Adverse Effects

Without attention, the major water-related problems in Graham and Greenlee counties will continue to worsen. Salinity concentrations will increase, erosion and flood damage will continue to present hazards and expense, and phreatophytes will grow unchecked.

Conclusions and Recommendations

An expanded program is needed for water management, systems improvement, and optimization of water supply. Alternatives for the balancing of water use with supply need to be explored. The socioeconomic and environmental effects and food and fiber production losses need to be evaluated. An integration of conjunctive ground- and surface-water management programs with ongoing water quality studies is needed.

Cochise County, Arizona

Description

Cochise County forms the southeastern corner of Arizona, occupying 4 million acres of land.

Problems

The major problem is a water supply deficient to meet present and future needs. Irrigated agriculture is sustained only through excessive overdraft of the ground-water aquifer in the Douglas, San Simon, and Wilcox areas. The dependable water supply is deficient for all uses. In 1975, there was an overdraft of the ground-water aquifer of about 324,000 acre-feet. An expected decrease in irrigated agriculture would reduce this overdraft to about 254,000 acre-feet annually by the year 2000. Subsidence associated with ground-water overdraft has resulted in earth fissures.

There is also a large risk of flood damage to both urban and agricultural areas. Erosion in much of the area is excessive. There are problems of mine and tailings pond water entering the San Pedro River from mines in Mexico.

Adverse Effects

Without immediate attention, the deficient water supplies in Cochise County will worsen, creating decreases in agricultural production, livestock, and wildlife habitat. Land subsidence will become a more prevalent problem as aquifers become dewatered. Erosion and flooding will continue as serious problems.

Conclusions and Recommendations

A multiobjective, multidisciplinary study on a comprehensive basis is needed to develop alternative solutions to the several interrelated problems.

Maricopa County, Arizona

Description

Maricopa County lies in south central Arizona, occupying 5,900,000 acres of land.

Problems

The major problems are a water supply deficient to meet present and future needs and a large risk of flood damage in both urban and agricultural areas.

The dependable surface- and ground-water supply is inadequate to meet present uses, and the present economy is sustained only through excessive ground-water overdrafts totaling about 900,000 acre-feet in 1975. As ground-water levels decline, energy consumption and pumping costs increase. In 1975, the ground-water aquifer was the source of about two-thirds of the water withdrawn for use.

Completion of the Central Arizona Project in about 1985 will relieve about 50 percent of the ground-water overdraft occurring in 1985, but the overdraft is projected to total about 450,000 acre-feet annually from 1985 to 2000. The continuing depletion of the ground-water aquifer will increase pumping depths and costs, further reducing irrigated agriculture and wildlife habitat. Some aquifers will become dewatered, leaving areas without a water supply. Land subsidence has been a major problem in the area west of Phoenix. Potential for massive land subsidence is great east and west of Phoenix.

Increasing demand on ground-water supplies increases the possibility that salinity and other contamination will impair domestic use and irrigation. Surface-water return flows from the Buckeye and Gila Bend areas upstream are already highly saline with total dissolved salts exceeding 2,000 mg/l. Ground-water quality is poor for all uses in the Buckeye-Gila Bend area. Total dissolved solids range from 1,000 to 3,000 mg/l.

Flood damage is a large risk in developed areas of communities and on irrigated land along the Gila River from the Salt River to Gillespie Dam. Similar flood hazards apply to the Salt River Indian Reservation. Bacterial and viral pollution from inadequately treated sewage effluent at recreation areas poses another hazard.

Excessive soil erosion is prevalent in much of the area and has reduced agricultural and rangeland productivity and wildlife habitat. Sedimentation requires increased maintenance of irrigation facilities, shortens the life of the stock ponds and reservoirs, and damages rural, urban, and commercial properties.

Institutional

There are conflicts in the use of flood plains. Productive agricultural land and open space are being converted to urban use. Urbanization also often conflicts with preservation of archeological, geological, and historical resources and takes prime agricultural land out of production. This could significantly reduce the U.S. production of specialty vegetable and citrus crops. Population concentrates in urban centers as deficient water supplies cause abandonment of agricultural lands and rural communities.

There is a need to establish a common State-Federal-Indian agreement on priority of water use for competing water demands under deficient water supply conditions.

Adverse Effects

Maricopa County's dependable surface- and ground-water supply will continue to insufficiently meet demands of increasing population unless the Central Arizona Project is completed on schedule. The continuing depletion of the ground-water aquifers will soon increase pumping depths and costs, further reducing irrigated agriculture and wildlife habitat. Contamination from excessive salinity, dissolved solids, and bacterial and viral pollution will become more prevalent as greater demands place greater stress on ground-water and surface-water supplies. Excessive soil erosion, sedimentation, and flood damage will continue to reduce productivity of rangeland, agricultural land, and wildlife habitat.

Conclusions and Recommendations

Adequate funding is needed for completion of the Central Arizona Project by the mid-1980's for the aqueduct system and by the early 1990's for other project features. An expanded program is needed to measure and relate historic ground subsidence and ground-water overdraft for use in predicting future subsidence. Colorado River augmentation to assure continuance of a long-term full water supply to central Arizona through augmentation is needed.

An expanded program for water management, systems improvement, and optimization of water supply is needed. Alternatives for the reduction of water use to be more closely in balance with supply, thus reducing ground-water overdraft, need evaluation. Socioeconomic and environmental effects of food and fiber production that result from water use reduction and transfer of water between uses need evaluation.

Pima and Pinal Counties, Arizona

Description

Pima and Pinal counties are located in south central Arizona. Pima County occupies 9,240 square miles and Pinal County occupies 5,386 square miles.

Problems

The major problems are a water supply deficient to meet present and future needs and a large risk of flood damage in urban and agricultural areas.

Other than the Gila River, there is no dependable surface water supply. Streamflows are erratic and generally flow only after rainstorms. Competition for water is intense.

About 40 percent, or 890,000 acre-feet, of Arizona's ground-water overdrafts occur in Pima and Pinal counties. On the Papago and San Xavier Indian reservations, wells go dry for both domestic and irrigation uses. Some of the developed agricultural lands are idle, and water supplies are inadequate for livestock operations, mineral resource, and recreational development. Water supplies are inadequate to meet the needs of increasing population. Although the Central Arizona Project is expected to reduce ground-water overdraft by over 90 percent by 1990, increases in water requirements for municipal uses and mineral production combined with declining Central Arizona Project water supplies are expected to result in an annual overdraft of 261,000 acre-feet by the year 2000.

Water from wells often becomes saline. Recharge of secondary treated sewage effluent in normally dry stream channels causes increased nitrate and nitrite concentrations in domestic ground-water supplies.

Areas of Tucson, Arizona, are subject to serious flooding, and there is a large risk of floods on croplands and developed areas of communities such as Eloy, Casa Grande, Maricopa, and Chui Chui. Communities on the Papago and San Xavier Indian reservations are frequently damaged by summer flash floods.

Soil erosion is excessive over much of the area and reduces the productive capacity of cropland and rangeland.

Related Land

Urbanization often conflicts with the preservation of archeological, geological, and historical resources, and with productive farmland. There are many conflicts between urban, agricultural, and fish and wildlife land uses.

Subsidence ranges commonly from three to five feet in portions of the area. Earth fissures damage cropland, irrigation facilities, and transportation facilities and threaten residences. The damages will increase with continued dewatering of the ground-water aquifer.

Institutional

In order to attempt an arrest of the excessive increases in ground-water overdrafts, Arizona's ground-water laws will need modification. Federal, Indian, State, and private water rights are not clearly identified.

Adverse Effects

Conflicts between urban, agricultural, and wildlife uses need to be resolved to make management of the deficient resources more practicable. Without attention, the problems of Pima and Pinal counties will intensify and cause additional damage from flooding, sedimentation, and erosion. Mineral, recreational, agricultural, and livestock operations will also be impaired. Land subsidence will increase damage to highways, railroads, and other structures and will change present drainage conditions.

Conclusions and Recommendations

An expanded program is needed to measure and relate historic subsidence and ground-water overdraft for use in predicting future subsidence. Adequate funding is needed to complete the Central Arizona Project by the scheduled date of 1985 to meet increasing water demands and curb the increasing rate of ground-water overdraft. Assurance of a long-term full water supply through the Central Arizona Project is needed through augmentation of the Colorado River.

Expanded water management studies are needed that would lead to early implementation of programs to maximize water supply and implement additional water conservation practices. Evaluation is needed of the effects of ground-water recharge from irrigation and the effects of waste disposal on ground-water quality.

Other Problem Areas

The following problem areas were judged as not having severe water resource problems, and information on effects was not developed in previous regional studies under the National Assessment. However, recommendations are included in this report, as follows:

Washington County, Utah

Federal Government assistance is needed to expedite action on the Allen-Warner Valley energy system.

Virgin Valley Area, Utah-Arizona-Nevada

The ongoing Colorado River Basin salinity control studies being conducted by the Bureau of Reclamation and the Department of Agriculture should be accelerated with implementation at the earliest possible date.

Chino-Verde Valley, Arizona

In 1974, an appraisal was completed as a part of the Westwide Studies. These studies identified the need for additional ground-water information, flood protection, preservation of the scenic beauty and wildlife habitat, and preservation and enhancement of the recreation resources.

Hualapai-Sacramento Valley, Arizona

Additional ground-water information is needed.

Planning

There were no level B studies identified by the Regional Sponsor. The needs for the investigations that have been proposed are related to the needs for additional ground-water information, research and development, and needs which would lead to early implementation of existing programs. Further consideration should be given to the need for Level B studies. Such studies are (by definition) multiobjective, multidisciplinary, and comprehensive and are warranted when the problems are of sufficient complexity.

Data and Research

Research is needed to develop more complete and accurate modeling of the surface-and ground-water systems.

Summary

The Colorado River system is one of the most oversubscribed river systems in the Nation. More than half the population of the West depends on the system's relatively insufficient supply. The generally flat, arid landscape provides an excellent climate for agricultural production, but nearly all lands must be irrigated. Natural resources include minerals, many national parks and monuments, timber, scenic vistas, favorable climate, and outstanding recreational opportunities.

The economy centers around manufacturing and agriculture in Arizona and tourism in both Arizona and southern Nevada. The 1975 total per capita income of the 2.4 million residents was $14 billion, or about $5,819 per person. Manufacturing contributed about 14 percent of the total earnings. Manufacturing and service industries are expected to continue to provide a major source of income through the year 2000.

Population increased over 40 percent from 1965 to 1975 and is still increasing 4 or 5 percent per year. Most people live in the metropolitan areas of Las Vegas, Nevada, and Phoenix and Tucson, Arizona. Immigration of people has been influenced by the availability of land, rich mineral resources, and attractive scenery and climate. The major factor limiting growth has been the inadequate and poorly distributed water supply.

Agricultural production in the region is concentrated on 1.3 million acres of southern desert where the climate is suited to a wide variety of crops which can be grown year round. Cotton is the principal crop with an annual production value averaging $220 million from 1974 to 1976. The second most valuable crop is vegetables, followed by hay and feed grains.

Thermoelectric generating stations produced nearly 24,000 gWh of energy in 1975, and hydroelectric generation totaled nearly 9,000 gWh. The total electric power generation is expected to increase from 32,600 gWh in 1975 to 103,000 gWh in the year 2000. The increasing cost of electricity and natural gas in the region has resulted in investigations into alternative forms of energy such as solar and geothermal.

The three main sources of water available for use are: (1) the 3.15 million acre-feet apportionment of Colorado River water annually; (2) local ground-water reserves; and (3) local runoff. The full Lower Colorado River apportionment for offstream purposes cannot be fully utilized until facilities are completed to transport water to areas of heavy demand. The lack of distribution facilities has caused extensive ground-water mining. Almost half of the irrigated acres in the Lower Colorado Region depend entirely on ground water. As these ground-water levels continue to drop, other problems--such as increased pumping costs, dewatering of some aquifers, land subsidence, and earth fissures--will become more prevalent.

Current ground-water withdrawals are exceeding replenishment by about 2.1 bgd (2.4 million acre-feet per year), primarily in central Arizona and southern Nevada. Withdrawn water is mainly used for irrigation, which accounted for 90 percent of the regions's total withdrawals in 1975.

Total water consumption is projected by the NF to increase by a little more than 100 mgd with decreases in irrigated agriculture offsetting increases in other functional uses. The SRF projects a water consumption increase of 665 mgd with a smaller decrease in irrigation consumption than NF figures. However, if the ability to pay is the primary factor in allocating water between uses, it could be assumed that the municipal, industrial, and mineral sectors will continue to obtain the water they require. The cost to the region and the Nation would then be largely the reductions in agricultural production and the associated degradation of economic, social, and environmental values. Some of the problems are itemized below.

Implications of National Significance

-Loss of agricultural production, especially specialized crops.

-Increased energy consumption required to pump water from greater depths.

-Increased agricultural production costs.

-Lack of opportunity for economic betterment and quality of life improvement on Indian reservations.

-Loss of employment opportunity for unskilled farm workers, especially minority group members.

-Shortage of water for instream uses, including treaty commitments.

Implications of Regional Significance

-Decline in job opportunities in rural areas.

-Further decline in rural population; outmigration of the young.

-Loss of county and municipal tax base in rural areas.

-Economic instability of rural counties.

-Ground-surface subsidence from dewatering of the ground-water aquifer causing damage to transportation facilities, structures, and land.

-Degradation of ground-water quality.

-Loss of agricultural land resulting in a less productive habitat for many wildlife species.

-Income distribution further concentrated in urban centers.

Planning and implementation must take into account the provisions of the Mexican Water Treaty, which requires that 1.5 million acre-feet of water (11.34 bgd) be delivered to Mexico annually.

Other regional problems associated with erosion, sedimentation, pollution, flooding, and water quality can be resolved through education, adequate funding, and other measures discussed in the Individual Problem Areas section.

Conclusions and Recommendations

It is the goal of the States of the region to protect, maintain, and improve the quality of public water supplies for domestic, agricultural, industrial, recreational, fish and wildlife, and other beneficial uses. Primary elements in achieving this goal are: to prevent the discharge of municipal waste into any water of the region unless it has been treated adequately to protect the beneficial uses of such waters; and to control the salinity in the Colorado River mainstream.

Federal Role

The Federal Government has assumed the responsibilty for helping resolve most of the high priority problems. The Federal Government should continue to provide the States and counties with a vehicle for the cooperative analysis and resolution of water and related land resources problems.

Regional Problems

Water management studies are needed that would lead to early implementation of programs to maximize water supply, conserve water, and improve management practices. Included should be means of increasing ground-water recharge, evaluation of undeveloped regional ground-water basins, ability of ground-water aquifers to withstand continued overdrafts, and the optimization and management of ground-water systems with consideration of water quality.

The evaluation of potential geothermal resources throughout the region should be continued. An appraisal of potential means of augmenting the Colorado River is needed. Investigations are needed to determine available water supplies and present and future water requirements of Indian reservations. Research concerning improved methods of applying irrigation water to reduce non-crop consumptive use should be continued.

The Federal cost-sharing program needs to be expanded for the installation of improved farm irrigation systems and other land and water conservation practices. The interrelationships of water quality and quantity planning need evaluation and application. Of primary importance is the impact that implementation of water quality measures will have on the availability of water supply. The problems and potential for integrating water resources and land use planning need to be studied. A careful assessment of the social, economic, and environmental impacts of water use transfers between economic sectors is needed. The Colorado River Water Quality Improvement Program should be accelerated.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1979—O-306-626

ACKNOWLEDGMENTS

The Second National Water Assessment program, including the technical data input and the final report, was the responsibility of the U.S. Water Resources Council's National Programs and Assessment Task Group. Participants in the Group included technical representatives from the Federal member agencies, Regional Sponsors, Regional Study Directors, numerous State agencies, Council staff, and others as listed on the facing cover.

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[1] The Washington staff of the Federal agencies was augmented by field office staff who participated with Washington offices or through the Regional Study Teams.
[2] Several States had representatives on more than one Regional Study Team. Contributions of those not named were greatly appreciated.

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Authorization

The United States Water Resources Council was established by the Water Resources Planning Act of 1965 (Public Law 89-80).
The purpose of the Council is to encourage the conservation, development, and utilization 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.