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THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Upper Colorado Region



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

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THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Upper Colorado Region

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



December 1978

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Foreword

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

Phase I: Nationwide Analysis

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

Phase II: Specific Problem Analysis

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

Phase III: National Problem Analysis

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

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

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

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

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the

numerous documents that are part of the assessment, and identifies the individuals and agencies that contributed to the assessment.

Part 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, "Synopsis 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-withdrawal, 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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Physiography

Description

As shown in Figure 14-1, the Upper Colorado Region is a 102,888 square mile area in Arizona, Colorado, New Mexico, Utah, and Wyoming. About 872 square miles of this area is water surface. The region extends from north to south some 550 miles from the Wind River Mountains in west-central Wyoming into the high desert areas of northeast Arizona and northwest New Mexico. From east to west it extends from the Rocky Mountain Divide in Colorado to the Wasatch Mountains in Utah, a distance of about 300 miles.

Rising in the mountains of Colorado and Wyoming, the Colorado River flows south toward the Gulf of California. Its principal tributaries are the Green and San Juan Rivers.

The natural vegetation consists of forests in the mountainous areas and grass, forbs, and desert shrubs in the desert rangelands. Small areas of cropland are located in valleys where suitable soils can be irrigated (Figure 14-2).

Geology

The region is composed primarily of severely eroded sedimentary rocks. Stream erosion, the principal weathering agent, has dissected the formations, and rock layers of all ages are revealed. There is no soil cover over hundreds of square miles of the region and bare sandstone and shale are exposed. Deposits of coal, oil, gas, oil shale, trona, and uranium are located in the region.

On the mountain slopes, shallow soils predominate. Shallow soils are also extensive at lower elevations, but soils are several feet deep along stream valleys, on old pediment surfaces, and on uplands mantled by wind deposits.

Topography

The region is characterized by rugged mountains, high plateaus, broad expanses of desert, and narrow valleys. The main valleys were cut by the Colorado River and its principal tributaries. Elevations range from 3,100 feet at the southern boundary to more than 14,000 feet on some mountain peaks.

¹ The area of 102,888 square miles is the sum of the areas of counties included within the county boundary approximation of the region. The hydrologic boundary of the region includes 113,330 square miles of which 3,916 square miles are in the closed Great Divide Basin in Wyoming.

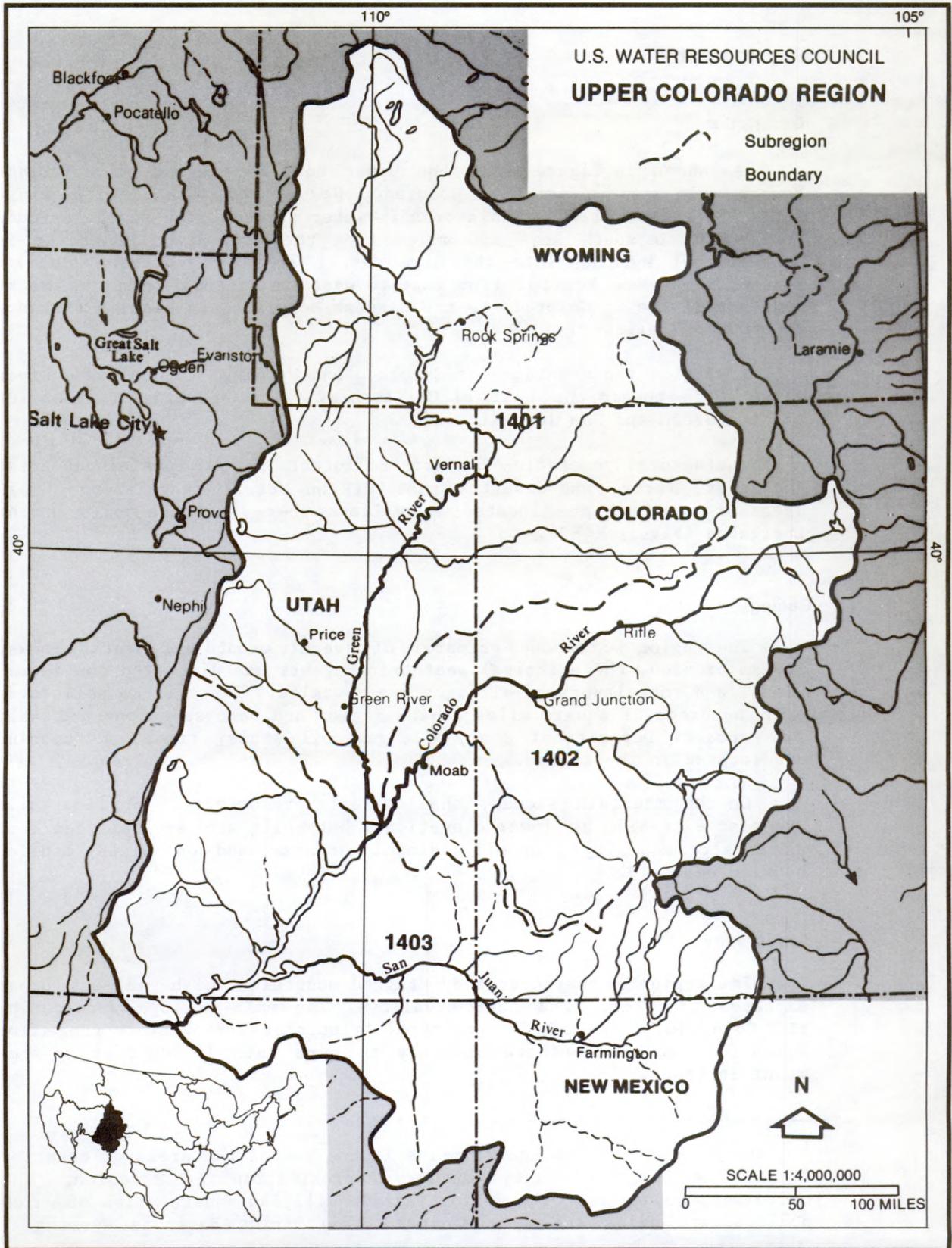


Figure 14-1. Region Map

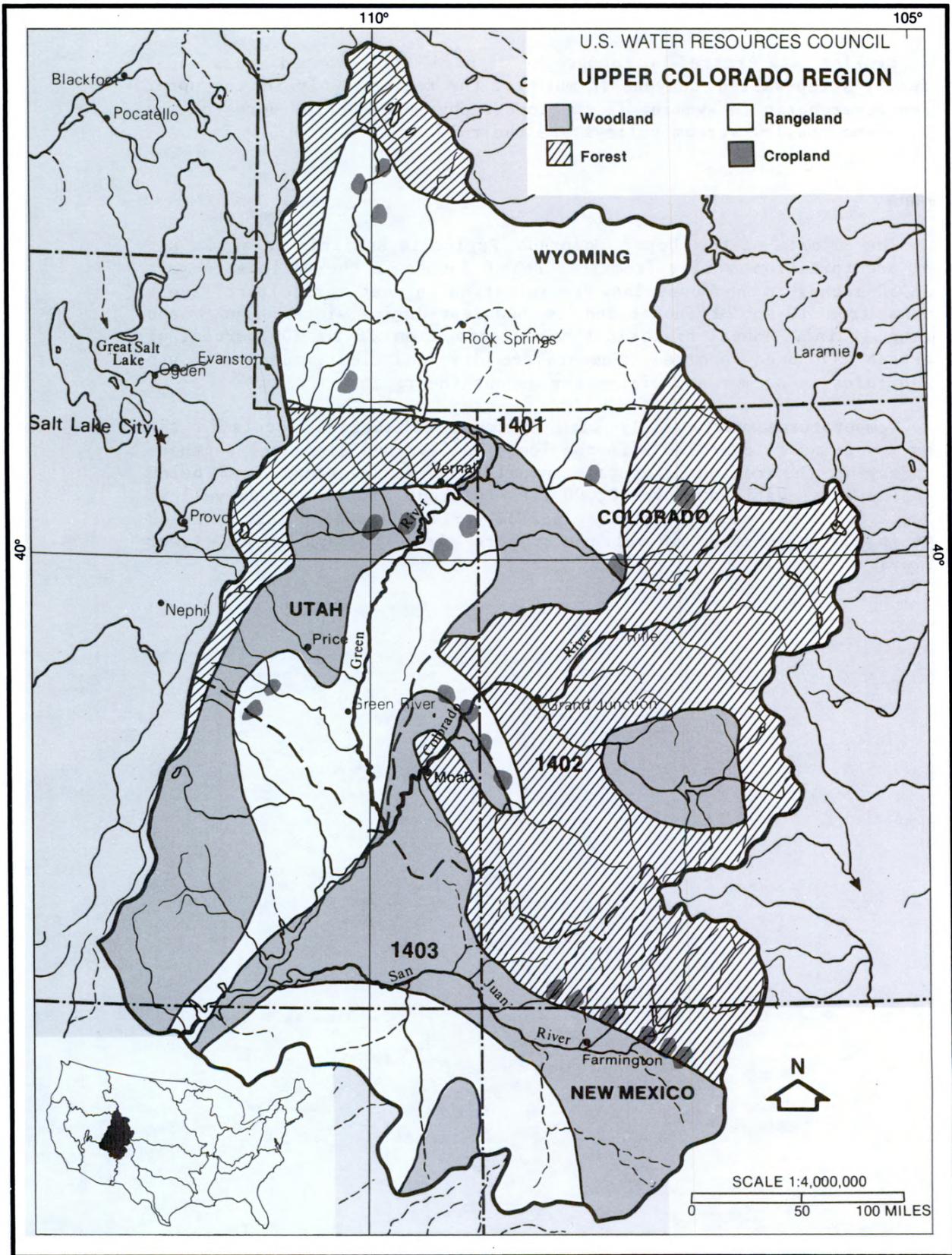


Figure 14-2. Present Land Use

4 | UPPER COLORADO REGION

Erosion has created a topography of high, flat-topped mesas separated by steep-walled canyons in much of the region. Only in the upper Green River basin in Wyoming is the topography more gentle. Here rolling plains and shallow stream valleys are the rule.

Climate

The climate of the Upper Colorado Region is semiarid to arid. Annual precipitation varies from less than 6 inches in the valleys to more than 50 inches in the mountains. Precipitation in most agricultural areas ranges from 10 to 20 inches and is heaviest during winter (snow) and spring (rain). Annual historical variations from 20 to 200 percent of averages have been recorded. Summers are dry, and clear, sunny days are predominant in summer and winter throughout the region.

Temperatures vary widely with extremes of subzero levels in the high mountains to over 100°F in the lower valleys and along the southern boundary of the region. Average annual temperatures range from below freezing at elevations above 10,000 feet to about 50°F for river valleys below 5,000 feet. The frost-free period varies from much less than 60 days in the high mountain valleys to more than 180 days in the lower valleys.

People and the Resources

Basic to any identification of problems of the people and their water and related land resources is an analysis of the current and future activities which give rise to these problems. Estimates and projections of the population, economy, land and water resources, and other parameters for the national water assessment were made as explained elsewhere in the report. These data for the Nation, the regions, and subregions are referred to as the National Future (NF). State and regional representatives were encouraged to prepare alternative estimates, called State/Regional Futures (SRF), if they felt NF data did not reflect their view of the region. A discussion of the differences between these sets of data and the implications of the variations is included at the end of this section. Data presented herein are consistent with NF data, except as indicated otherwise. Socioeconomic data are for the counties approximating the region.

Population

Although settlement of the region by white men started as early as 1832, the discovery of gold in 1859 first attracted a significant influx of settlers. As mining declined in the 1880's, the miners turned to raising livestock and growing feed crops. The region has remained essentially a rural society with agriculture associated with livestock representing the major industry. The few urban areas are oriented to agriculture or mining.

The population of the region was 344,000 in 1975, representing over only 0.2 percent of the national total. About 10 percent of the population consists of native Indians. Population density for the region is about three persons per square mile. By the year 2000, the regional population is expected to reach 368,000.

Economy

About 128,000 persons were employed in the region in 1975. The 1975 per capita income averaged \$5,044 measured in 1975 dollars. This is about 81 percent of the national average. Earnings in agriculture of \$154 million, and mining, \$146 million, are about equal and combined represent about 22 percent of the total regional earnings of \$1,332 million. The "other" category in Table 14-1 includes trade, government, services, transportation, insurance, finance, real estate, and construction and accounts for 72 percent of total earnings. Government is the largest employer in the region.

Table 14-1.--Upper Colorado Region earnings--1975, 1985, 2000
(million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing-----	77	113	186
Agriculture-----	154	160	200
Mining-----	146	164	206
Other-----	955	1,381	2,282
Total-----	1,332	1,818	2,874

Mining and steam electric generation, using coal, is expected to have the greatest growth in the next 25 years because of the emphasis being placed on supplying more of the Nation's energy needs from domestic sources. Earnings in this category are expected to increase more than 39 percent by the year 2000. Total earnings for the region are expected to more than double in the next 25 years, with per capita income doubling in the same period.

Natural Resources

The natural resources of the region consist primarily of land, water, minerals, forests, and scenery. Almost 3 percent of the land area is cropland, 2 percent being irrigated. Urban areas occupy less than 0.1 percent.

Range, pasture, and other agricultural lands occupy about 54 percent of the region, while forests occupy another 27 percent. About three-fourths of the forests and rangelands are used for livestock and wildlife grazing. The "other" category, which includes Federal Bureau of Land Management (BLM) land, airports, highways, and water areas under 40 acres, comprises 15 percent of the land area in the region (Table 14-2).

Table 14-2.--Upper 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-----	65,848	100.0
Water-----	558	0.8
Land-----	65,290	99.2
Land use		
Cropland-----	1,951	3.0
Pasture & range-----	35,369	53.7
Forest & woodland-----	17,881	27.2
Other agriculture-----	415	0.6
Urban-----	47	0.1
Other-----	9,627	14.6

Large reserves of bituminous coal are located in all five States. Oil and gas are also found in all States, but the reserves are not large. Oil shale and tar sands in the region are some of the largest in the world. Trona (soda ash) and uranium are also important minerals, and molybdenum mined in this region and an adjacent region furnishes about one-half the free world demand.

Agriculture

From 1975 to 2000, irrigated cropland is projected to increase by 262,000 acres (Table 14-3). Many irrigated lands are now inadequately supplied with water. Even though many lands are projected to receive additional water, major water shortages on irrigated lands will still prevail in 2000. Consumptive use of water for agriculture will increase from about 2,221 mgd (NF) in 1975 to about 2,775 mgd (NF) in 2000.

Table 14-3.--Projected changes in cropland and irrigated farmland in the Upper Colorado Region--1975, 1985, 2000
(1,000 acres)

Land category	1975	1985	2000
Total cropland-----	1,951	2,102	2,104
Cropland harvested-----	1,322	1,902	1,960
Irrigated farmland-----	1,365	1,513	1,627

Energy

Large electric powerplants in the region generated 23,864 gigawatt-hours in 1975. About 94 percent was produced by 10 fossil-fueled electric plants. More than 87 percent of the electric energy produced in the region is exported to other regions.

The electric power expected to be generated annually by 2000 is 90,568 gigawatt-hours. Nearly all of the increase is expected to come from coal-fired steam electric plants (Table 14-4). Withdrawals for steam electric generation are projected to increase from 103 mgd under 1975 conditions to 201 mgd in 2000.

Table 14-4.--Upper Colorado Region electric power generation -- 1975, 1985, 2000

Fuel source	1975	1985	2000
Fossil-----	22,545	56,877	73,855
Nuclear-----	0	0	13,490
Conventional hydropower-----	1,319	1,327	3,223
Total generation-----	23,864	58,204	90,568

By the year 2000, coal gasification plants and oil shale processing plants are projected to be operational and producing commercial quantities of gas and oil. Coal mined in Wyoming, Colorado, and Utah is also exported to other regions.

Environment

The relatively unspoiled environment of this region is the envy of many urban area residents in adjacent regions and throughout the Nation. The use of the region's water and related land resources for boating, camping, winter sports, hiking, fishing and hunting, touring, and picnicking by visitors from large population centers outside the region is creating a significant impact on the open spaces of the region.

The region contains some of the Nation's unique and most interesting natural areas, streams, and geological and archeological sites. Diverse landscapes are created by deep canyons, standing rocks, stone arches and bridges, plains, steep scarps, and intricately dissected canyons.

Nine wilderness areas containing over 1.35 million acres have been established in the region, and 84 other areas containing 1.6 million acres are under consideration for inclusion in the National Wilderness System. In addition, Federal agencies have designated significant acreages for natural areas and natural landmarks (Figure 14-3). Some 2,700 miles of streams in the region have been identified as having special qualities that make them candidates for study as wild or scenic rivers under the Wild and Scenic Rivers Act (Public Law 90-542). The region contains all or portions of 11 national forests where recreational areas are well developed and many unusual natural areas are protected.

There are four national recreation areas, six national parks, and seven national monuments in the region. Most prominent and popular among these are Glen Canyon and Flaming Gorge National Recreation Areas, Rocky Mountain, Bryce Canyon, and Mesa Verde National Parks, and Colorado National Monument.

There are also many State parks, monuments, and historical sites located throughout the region. Indian tribal parks and archeological sites are situated on the four Indian reservations in the region.

Commercial resorts are located at major lakes and in the national forests at major winter sports areas. Dude ranches are located in picturesque locations throughout the region.

An estimated 2.2 million water-dependent recreation activities occurred in the region in 1975, with an additional 1.4 million water-enhanced recreational activities. The participation in these activities is expected to increase about 17 and 20 percent, respectively, by 2000.

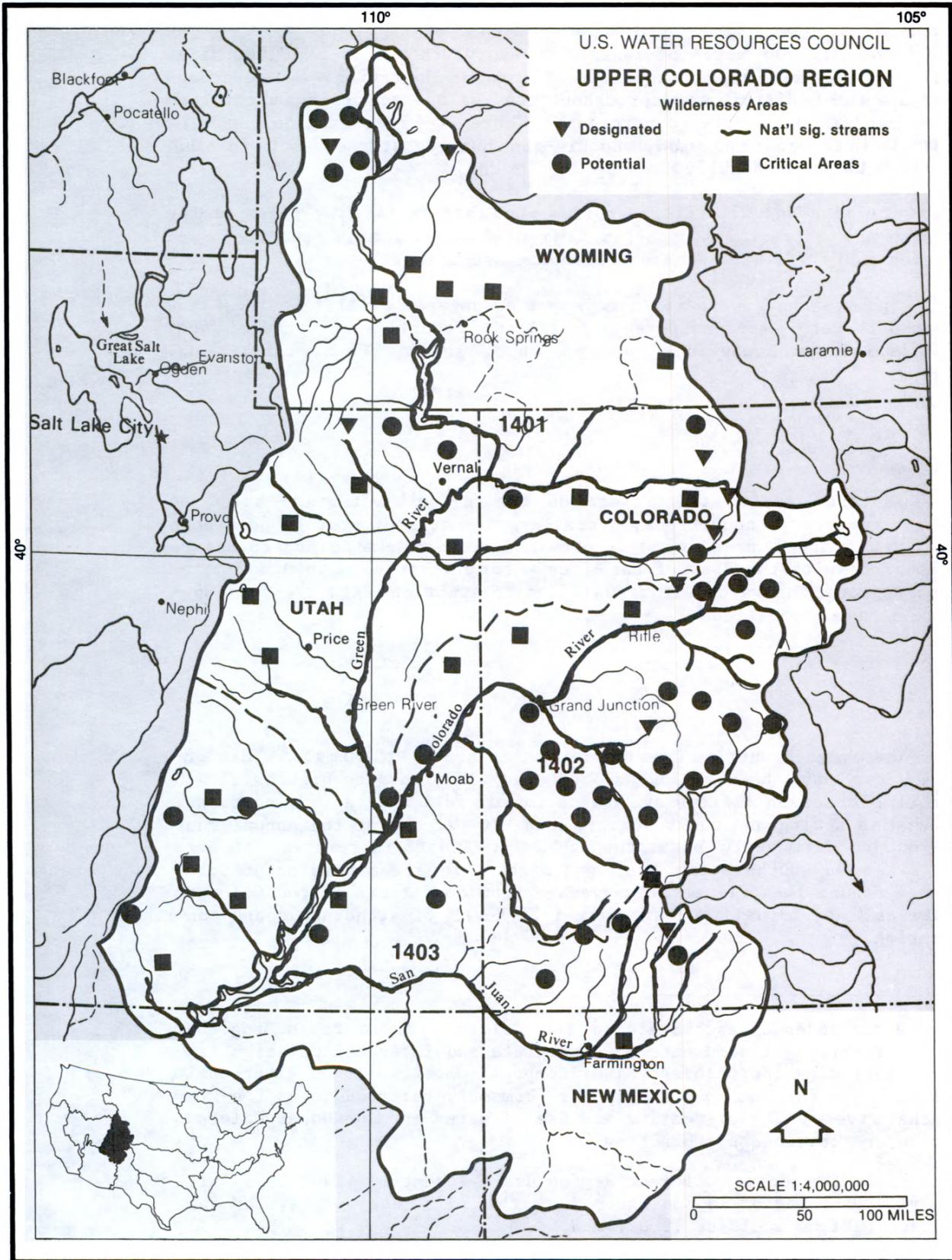


Figure 14-3. Environmental Resources

Over 322,000 acres of lakes and reservoirs and over 17,000 miles of streams provide good to excellent fishing in the region. Mule deer and elk are widely distributed throughout the region, and moose and antelope are found in the northern portions. There are free-ranging herds of buffalo in Colorado and Utah, and big-game hunting attracts more than 1.4 million hunters annually.

The fish and wildlife resources more than satisfy the needs of the region and attract many sportsmen from adjacent regions and from such states as California, Kansas, Oklahoma, and Texas.

In 1975 there were six species of endangered wildlife here: black footed ferret, American peregrine falcon, Kendall warm springs dace, Colorado River squawfish, humpback chub, and the Utah prairie dog.

Water

All the data in this report on the region's water are based on long-term average conditions, since large amounts of storage have been provided to supply present and future intra-region demands and to assure compliance with the "Law of the River"² for deliveries to the Lower Colorado Region. The water withdrawals and consumption data are for long-term average conditions.

Surface Flows

The average outflow from the region is about 10,000 mgd.³ Historical flows have been as low as 5,000 mgd (1934) and as high as 21,400 mgd (1917). Seasonal flows are lowest in late fall and early winter, and highest in spring and early summer. About 70 percent of the annual runoff occurs from early April through July. Runoff in relation to area is lowest in southeastern Utah and highest in the mountains of Colorado. Figure 14-4 illustrates average flow conditions in the Colorado River as they actually occur, with 1975 level of withdrawals and consumption.

²The water codes of each State in the Colorado River Basin, together with several legal documents of interstate and international significance, including the Colorado River Compact, Upper Colorado River Basin Compact, and the Mexican treaty, are commonly referred to as the "Law of the River." The allocation and use of water in the Upper Colorado Region are governed by this "Law."

³States of the Upper Colorado Region use a long-time (1906-1975) virgin flow estimate of 13,386 mgd. With the 1975 level of development, average outflow would be 10,077 mgd.

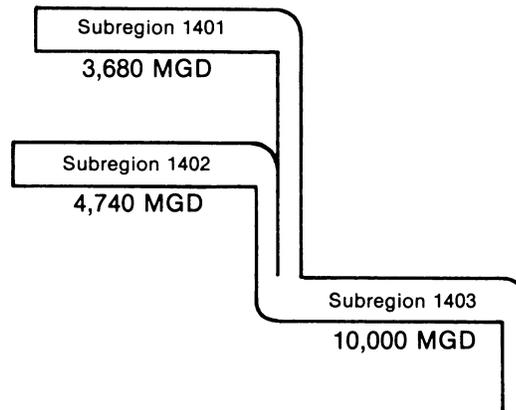


Figure 14-4. Streamflow

Ground Water

The available ground water in storage in the Upper Colorado Region is estimated at about 78 trillion gallons (Figure 14-5). Present use is about 126 mgd. Ground water is available from the alluvium along streams and from the sedimentary rocks that cover two-thirds of the region. Although the water in storage is relatively large, well yields are relatively small ranging from 5 to 50 gallons per minute over a major portion of the region. The quality of ground water varies widely throughout the region, but in general the quality is poor because of the exposure to highly saline rock formations. Isolated areas are somewhat more productive and supply water of good quality.

Under existing conditions, effects of withdrawals are minimal. However, any large-scale withdrawal could, because of the interconnection with surface water resources and brackish ground waters, ultimately decrease streamflow, change the chemical quality of the ground water, and decrease natural discharge from shallow aquifers.

Water Withdrawals

Total water withdrawn from streams and ground water averaged about 6,869 mgd, excluding exports of 805 mgd and reservoir evaporation (Figure 14-6). Irrigation diversions account for 93 percent of the total. Minerals extraction and processing and steam electric, the next largest withdrawals, account for only 1.9 and 1.5 percent, respectively.

Future water withdrawals for irrigation are expected to increase during the next decade and then slightly decrease by 2000 as more efficient irrigation methods are adopted. Withdrawals for domestic use will increase about 19 percent in the next 25 years, while use for minerals and steam electric generation is expected to increase about 169 percent and 95 percent, respectively, in the same period. Total water withdrawals are projected to increase to 7,519 mgd by 2000.

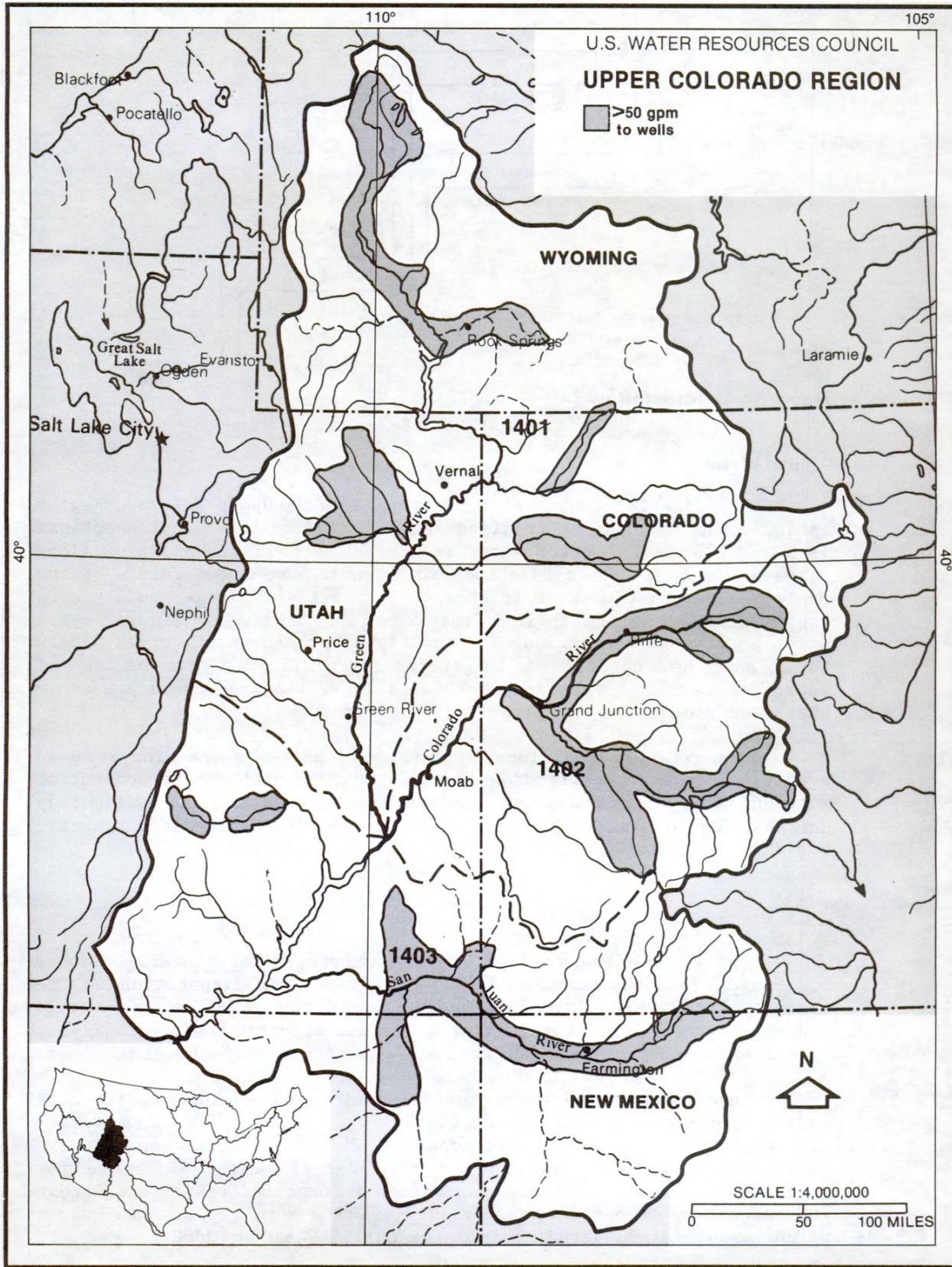
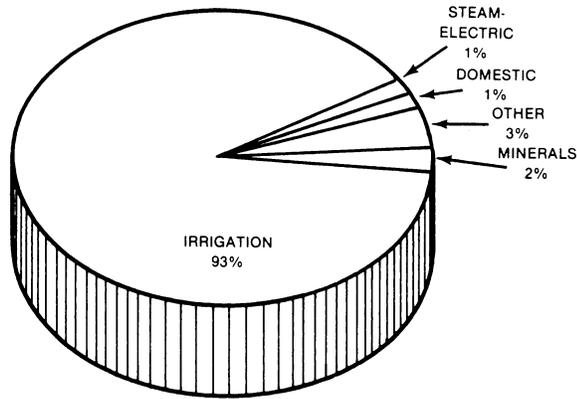


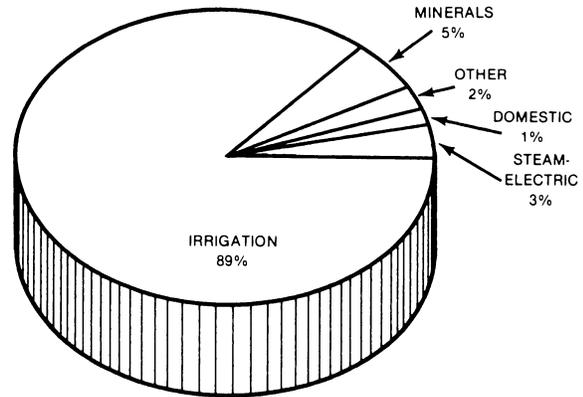
Figure 14-5. Major Aquifers

ANNUAL FRESHWATER WITHDRAWALS



1975

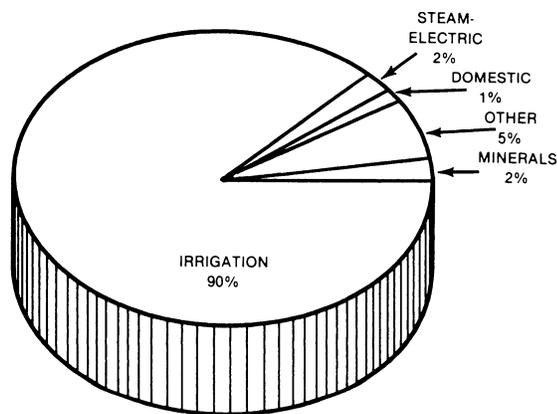
Total Withdrawals — 6,869 MGD



2000

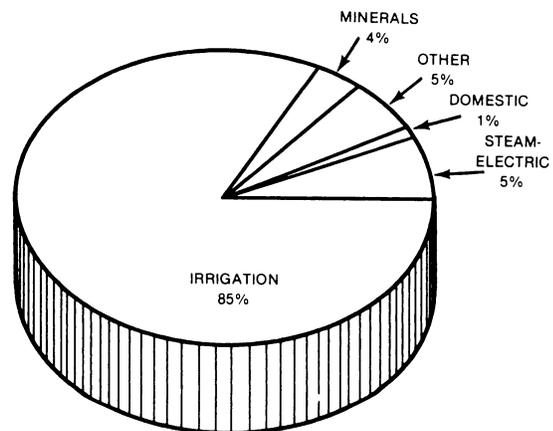
Total Withdrawals — 7,519 MGD

ANNUAL FRESHWATER CONSUMPTION



1975

Total Consumption — 2,440 MGD



2000

Total Consumption — 3,232 MGD

Figure 14-6. Withdrawals and Consumption

Water Consumption

Water depletion, including consumptive uses, and pond and reservoir evaporation, is projected to increase from 3,956 mgd in 1975 to 5,055 mgd in 2000. Export and evaporation account for about 35 to 40 percent of water supply depletions in the region. Water consumption is projected to increase from 2,440 mgd in 1975 to 3,232 mgd by 2000. Water consumed is water that is not returned to the streams. Irrigation accounts for 90 percent of the present (functional use) consumption (55 percent of depletions); domestic, mineral, and steam electric use consume about 4.5 percent of the total. Substantial increases are expected in use of water for minerals and for steam electric as coal is used to help meet the Nation's increasing energy demands. Use in these two categories is projected to increase from 86 mgd in 1975 to about 295 mgd in 2000. Irrigation consumptive use is expected to increase by 547 mgd to provide supplemental water to water-short lands and to supply about 260,000 acres of new land.

Total consumption will increase 32 percent in the next 25 years. Two important water uses in the Upper Colorado Region that deplete streamflow are exports and evaporation from reservoirs. In 1975 exports amounted to 805 mgd, and evaporation from large reservoirs and small ponds totaled 711 mgd. The depletions from exports are projected to increase to 1,095 mgd by 2000. Figure 14-6 illustrates graphically the present and projected consumption of water within the region.

Instream Uses

Many stream uses do not require actual removal of water from the stream. Principal among these in the Upper Colorado Region are fish and wildlife, hydroelectric power, recreation, and waste assimilation. These purposes require minimum levels of quantity and quality for satisfactory use.

In the Upper Colorado Region where the appropriation doctrine applies, these uses generally have a lower priority of use than consumptive uses. Some instream flow requirements have been established for fish and other nonconsumptive purposes with the region by NF estimates. Interest in these uses is growing and many groups are urging State legislatures to modify present water statutes and priorities of use. The Water Resources Council has made estimates of the instream flow requirements for fish and wildlife. The instream flow approximation for this purpose is 7,947 mgd at the outflow point. This is 19 percent more than the 6,700 mgd which will be released according to the interstate compact.

Instream flow requirements at the outflow point from the region to meet downstream commitments are established by the terms of the Colorado River Compact which "provide for the equitable division and apportionment of the use of the waters of the Colorado River System" between the States of the Upper Division and the States of the Lower Division. The Compact "apportioned from the Colorado River System in perpetuity to the Upper Basin and

to the Lower Basin, respectively, the exclusive beneficial consumptive use of 7.5 million acre-feet of water per annum (6,700 mgd), which shall include all water necessary for the supply of any rights which may now exist." Compact terms also state that the Upper Basin States "will not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75 million acre-feet for any period of ten consecutive years reckoned in continuing progressive series" (Article III(c) of the compact also indicates an obligation on the Upper Division States if surplus waters of the system are insufficient to meet U.S. obligations to Mexico and requires that "the burden of such deficiency shall be equally borne by the Upper Basin and the Lower Basin, and whenever necessary the States of the Upper Division shall deliver at Lee Ferry waters to supply one-half of the deficiency so recognized. . . ."

Water Supply and Demand

The Colorado River is one of the most highly controlled rivers in the world. It is approaching that point where little water from the system will ever escape from the basin to the Gulf of California. It is also approaching the time when the river will be unable to supply the offstream demands placed upon it. The Upper Colorado Region produces most of the flow of the river but demands upon it extend into several other regions and into Mexico, based on compacts and international commitments.

Total Upper Colorado Region commitments including intraregion withdrawals, reservoir evaporation, exports to adjacent regions in Arizona, Colorado, New Mexico, Utah, and Wyoming, and deliveries to the Lower Colorado now exceed the "virgin flow" at the outflow point of the region.

Total consumption in the Upper Colorado Region, including intraregion consumptive uses, exports to the four Upper Basin States, and reservoir and farm/stock ponds evaporation now averages 3,956 mgd. Total depletions including consumption, exports, and reservoir evaporation in the region are projected to increase to 5,055 mgd by 2000. This represents 36 percent of the long-term natural streamflow.

When 5,055 mgd are added to the 6,700 mgd outflow required by the compact, about 84 percent of the estimated natural outflow will be committed within the region in an average year. Such commitments cannot be met in many dry years. This does not describe the seasonal water shortages, which have existed on many of the tributaries since the first irrigation projects were started, or the need for long distance transfer of water to supply irrigable land.

If the states are to develop natural resources at the SRF rates and according to other expressed aspirations, severe water shortages will develop in a time frame that directly affects planning and development decisions being made today. Resource development plans are now on the drawing board but are not scheduled for implementation for a decade or two may find that there will be insufficient water to meet their needs

over the useful life of the proposed undertakings. The current emphasis on development of mineral fuels, although far from fully crystallized, underscores the concerns over future water shortages.

Comparative Analysis

Table 14-5 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water use in the Upper Colorado Region.

Because the NF values do not recognize the increased use of domestic water to satisfy the large population increase since 1970, the estimate for present domestic plus commercial use is about 25 mgd less than the SRF estimate. The SRF projects a 55 percent population increase between 1975 and 2000, while the NF projects only a 7 percent increase. The need for domestic water will be determined by the population growth. If the population increases as projected in the SRF, the need for domestic water supplies will almost double to 201 mgd by 2000.

The water required to meet the SRF projected mineral fuels extraction and processing and steam electric generation needs is generally much greater than that shown by the NF projections. The NF did not project a significant development of mineral fuels in this region. The decisions on use of water for these purposes will depend largely upon a national policy on energy use and conservation that is still to be formulated and adopted. If domestic energy production is encouraged through control of oil and natural gas imports, marketplace pricing, and production incentives, the mineral fuels of the region will probably be utilized. Under these circumstances, the SRF estimates of water consumption for oil shale processing, coal gasification, and steam electric generation should be equalled or exceeded by 2000.

Consumptive use for agriculture in 1975 is 12 percent less for the SRF than the NF. The SRF values are those generally accepted by the States of the Upper Colorado River Basin and reflect their best judgment of average depletions under the present level of development in the river system.

The NF projects a full supply for all irrigated land (1,627,000 acres) by 2000. On the other hand, the SRF indicates that only about 60 percent of the water-short lands will be fully supplied since there appears to be no practical way to fully supply some of these lands. The NF projection of new irrigated lands is based on the region's meeting a share of the nation's projected needs for food and fiber. SRF projections are based on presently authorized projects. The NF estimates for public lands and fish and wildlife needs for instream flows further help to explain water supply problems in the region.

The SRF assumes that reservoirs will have to be built to regulate seasonal flows to provide irrigation, municipal needs, electrical plants, and mineral uses with late season water and to maintain instream flow. Therefore, reservoir evaporation is projected to be 25 percent greater in 2000 for the SRF than for the NF.

Table 14-5.--Socioeconomic and volumetric data summary: the Upper Colorado Region

Category	1975		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	344	431	357	523	368	670
Total employment	128	168	140	205	150	280
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	12,440	NE	12,440	NE	12,440	NE
Streamflow at outflow point(s)	10,000	10,077	9,232	8,875	8,901	8,153
Fresh-water withdrawals	6,869	7,949	7,841	9,505	7,519	8,795
Agriculture	6,427	7,639	7,254	8,809	6,706	7,580
Steam electric	103	53	157	172	201	248
Manufacturing	4	<1	2	<1	2	<1
Domestic	70	105	76	159	83	201
Commercial	10	a	10	a	11	a
Minerals	132	120	195	304	355	698
Public lands	103	32	120	61	127	68
Fish hatcheries	20	NE	27	NE	34	NE
Other	0	NE	0	NE	0	NE
Fresh-water consumption	2,440	2,118	3,018	2,890	3,232	3,419
Agriculture	2,221	1,956	2,688	2,479	2,775	2,668
Steam electric	39	50	106	164	151	241
Manufacturing	2	<1	1	<1	2	<1
Domestic	25	39	27	58	29	74
Commercial	3	a	4	a	4	a
Minerals	47	45	72	137	144	376
Public lands	103	27	120	52	127	60
Fish hatcheries	0	NE	0	NE	0	NE
Other	0	NE	0	NE	0	NE
Ground-water withdrawals	126	105	NE	105	NE	105
Exports	805	635	985	866	1,095	1,059
Evaporation	711	662	721	860	728	860
Instream approximation						
Fish and wildlife	7,947	0	7,947	0	7,947	0
Treaties and compacts	6,700	6,698	6,700	6,698	6,700	6,698

NE - Not estimated.

a SRF domestic water use includes commercial and institutional requirements.

Problems

The water supply in the Upper Colorado Region is not sufficient to meet projected needs, adequate instream flows, and the terms of the Colorado River Compact. There are a number of water and related land use problems which are critical enough to require early and continuing attention. These problems affect the lives and environment of the people of the region and adjacent regions.

Problems have been identified by the States, Indian tribes, and Federal representatives participating in this assessment.

Domestic Water Use

In the rural areas of the region and on the four Indian reservations, many inhabitants use poor quality water or haul water long distances to supply minimum needs. The cost of improving individual systems or hauling water leaves these residents with insufficient water to provide some of the amenities normally enjoyed in more populated rural areas.

Some rural domestic systems are not designed to protect against contamination or to provide adequate treatment. In urban areas where significant increases in population have occurred due to construction of steam electric powerplants, coal mining activities, oil exploration and production, and trona mining, the water supply, treatment, and distribution facilities are inadequate to meet present and projected needs.

Sufficient water of adequate quality can be made available in the basin to meet the additional requirements (34.6 mgd) for the SRF projected population increase of 262,000 during the next 25 years if sufficient storage can be provided. At some locations, however, remoteness of the supply will also be an important factor in meeting needs.

The most serious problem in the future domestic water supply picture will be financial. Local financial resources will be inadequate to upgrade rural domestic systems, to expand urban supply, treatment, and distribution facilities, and to provide other necessary community services. State or Federal grants and loans will be needed to assist impacted areas that are called upon to furnish coal, electricity, and oil to help satisfy the Nation's energy demands.

Water for Agriculture

About 45 percent of the approximately 1.4 million acres of presently irrigated area in the region lacks adequate water for optimum crop production in most years. The State-regional objective is to provide supplemental water to 335,000 acres of presently inadequately irrigated land by the year 2000. This will require an additional consumptive use of about 167 mgd.

Over 7 million acres of potentially productive land are available in the region for expansion of irrigated agriculture. The SRF projects expansion of irrigation by at least 334,000 new acres by the year 2000. A large part of this acreage will be developed by already authorized Federal projects if funds are provided for their construction. Water consumption for these new lands will be about 543 mgd.

Providing water for supplemental irrigation and for new lands will help stabilize rural communities and will improve socioeconomic conditions on the Indian reservations. Since this is one of the most important State-regional objectives, the States and the Indian tribes strongly support funding of the authorized Federal projects. Since water is legally available, the problems involve financing, impacts on instream flows, and water quality. Local financial resources are inadequate to provide full irrigation supplies and Federal or State programs must provide funds to meet the State-regional objectives.

Water for Mineral Extraction and Energy Conservation

Some of the largest reserves of mineral fuels (coal, oil shale, tar sands, and uranium) in the Nation are located in this region. The State/Regional objective of using these resources to improve the socioeconomic situation is in keeping with a national policy of less reliance on foreign energy resources. A significant part of the reserves of mineral fuels is located on public lands. Their use will, in a large sense, be controlled by Federal leasing and development policies. If domestic production is encouraged through control of oil and natural gas imports, marketplace pricing, and production incentives, then growth will take place rapidly.

Mineral fuels extraction and use, including use for steam electric generation in the region, are estimated to require an additional 522 mgd (SRF) of water consumption by year 2000. About 100,000 acres of land will be required for access roads, milling sites, and surface mining by 2000. While the use of land and water is rather great, the values created in terms of products are substantially greater than for alternative uses.

Environmental degradation is a problem with mineral fuels use. Water and air quality impairment and aquatic plant and wildlife degradation are potential adverse effects. Strict enforcement of minimum standards will be required to protect the region from unreasonable losses.

In the final analysis, problems growing out of use of mineral fuels will be influenced by a national policy on energy and conservation that is still to be formulated and adopted.

Controlling Water Quality

Salinity concentrations at major points in the Upper Colorado River and its tributaries above Lake Powell are generally less than 500 mg/l, and the water is usable for all purposes. However, from the headwaters to the outflow point at Lee Ferry, salinity increases as a result of

natural causes and man's activities. Natural causes account for about 60 percent of the salinity concentration in the river, while man's actions account for about 40 percent.

Natural salinity increases from diffuse pickup of mineral salts by surface runoff, ground-water inflow, springs, other point sources, and use of water by riparian vegetation. The concern related to high levels of salinity in the Lower Colorado Region will affect management decisions in this region. Man's use of the region's waters has increased the salinity of the remaining flow of the Colorado River through salt loading and salt concentration. Evaporation from reservoirs, streams, and canals, evapotranspiration by crops, and exports causes increased concentration.

Sediment enters streams from erosion on national resource lands, private lands, and construction sites. Sediment impairs fish and wildlife habitat and riparian vegetation and reduces stream, reservoir, and natural lake capacity.

Over 30 million acres are affected by erosion. Improved management, seeding, vegetative control, watershed treatment, stabilization work, and farming practices would correct problems on more than 50 percent of these lands.

Authorized programs of the Department of Agriculture and the Department of the Interior are intended to reduce salinity and sediment. If these programs are adequately funded over the next 25 years, salinity in the stream system can be kept at manageable levels, and sediment inflow to streams and resulting losses can be substantially reduced.

Although not presently considered a severe or critical problem, other pollutants enter streams from industrial sources and urban and rural communities. If the mineral fuels available in the region are developed as projected in the SRF, pollution control will involve the expenditure of substantial sums of money and will require a unified effort of local, State, and Federal agencies. Local technical and financial resources may be insufficient to handle the problems.

Protecting Unusual and Unique Natural Areas

There are many archeological resources, historic sites, unique and interesting natural areas, and streams having special qualities. A significant number of these resources are now protected. Those being preserved and protected are located in national forests, parks, and monuments and in State parks and tribal parks.

Approximately 1.6 million acres are being studied under the Wilderness Act, and the Departments of Agriculture and Interior have identified significant acreages for research, natural areas and natural landmarks. The States and Indian tribes are also evaluating natural and historic sites.

Only a small handful of archeological sites are now protected, although hundreds of sites are known. Many of the sites are located on the Indian reservations. Preservation, protection, and evaluation of these sites are important because of their value as archeological history, but funds are inadequate to mount a full-scale examination of their importance.

Historic sites are being studied and identified, and many are listed in the National Register of Historic Places.

More than 2,700 miles of streams have been identified as having special qualities that make them prime candidates for study as wild and scenic rivers. The stream segments considered from a State-regional viewpoint to have special qualities deserving further study total about 1,000 miles.

The added emphasis on use of the mineral resources of the region to supply energy to the Nation and increased recreation use by residents of adjacent regions will place additional pressures on water and related land resources and will create conflicts regarding protection and preservation of archeological and historic sites, unique and unusual natural areas, and undeveloped streams. As resource developments are proposed and studied, the alternative uses of the related water and land resources must carefully be evaluated, and a course of development and preservation must be charted consistent with the national interest, State/Regional objectives, and the wishes of the majority of the basin's residents.

Providing Access and Facilities for Water-Oriented Recreation

The abundance of water surface areas reservoirs, natural lakes, and streams exceeds the recreation needs of the region's population. Many of the streams and lakes attract recreationists from the large population centers adjacent to the region, and, in fact, are popular vacation spots for people all over the Nation.

On streams where white water rafting and boating are popular, the National Park Service and Bureau of Land Management impose seasonal and daily use limits to minimize sanitation problems and to protect camp sites and shore areas. Control of use at some of the smaller reservoirs and lakes may also be required in the future.

At the larger water bodies (Lake Powell, Flaming Gorge, Granby, Blue Mesa, and Navajo reservoirs), additional access, sanitation, and launching facilities and other accommodations will be needed by the year 2000.

Fish and Wildlife

Fish and wildlife resources are of outstanding importance. This region, with its limited population and extensive public lands, has escaped many of the pressures placed on these resources in many other regions of the United States.

The consumptive use of fish and wildlife may be near the maximum permissible levels in parts of the region. In addition, the nonconsumptive use of fish and wildlife is highly valued by people who vacation in the region. This adds immeasurably to the region's recreation-based economy. It is the desire of the States to maintain fish and wildlife resources at or above present levels consistent with the balanced development of the water and related land resources. It is not likely that this can be accomplished under present programs and policies and with increasing demands for water by sportsmen from within and outside the region.

Special problems will surface over the next decade and continue indefinitely. Public demands on fish and wildlife will exceed the capacity of the habitat to produce. Habitat lost through the expansion of irrigated agriculture, mineral development, and urbanization and their attendant water demands will cause fish and wildlife losses that may not be retrievable.

Conflicts

The basic conflict over water use will develop between the consumers of water (agriculture, domestic, industrial, mining, and steam electric) who withdraw large quantities from the streams and the instream users (fish, recreation, wildlife, hydropower, etc.) who do not withdraw water.

Protection of stream segments and related lands for environmental quality, under present statutory authorities, may prevent development of storage facilities to regulate streamflows for instream uses, for consumptive uses, and for export from the region. In order to achieve water conservation and improved water quality (primarily salinity control), adverse impacts will occur to the artificially created wetlands in irrigated areas. Reservation of water for Federal lands and for Indian uses may conflict with water rights already established under State law.

Consumptive use of water without appropriate compensating measures will likely prevent maintenance of optimum instream flows for fish and other aquatic life. The Continental transfer of water to large growing population centers outside the region in eastern Colorado, western Utah, Wyoming, and New Mexico will create conflicts with projected in-basin (in-region) users over an insufficient water supply.

Institutional and legal constraints established over a hundred or more years control many facets of water and related land use. A continuing dialogue among the present and future users of the finite water resources of the region will be highly important to resolve conflicts and attain the State/Regional goal of balanced economic growth and protection of the environment.

Individual Problem Areas

With the help of a work group of Federal, State, and Indian representatives, the regional sponsor identified six areas where critical problems associated with water and related lands exist or will probably develop in the next 25 years. For each of these areas, the problems have been described and evaluated. The problem areas are as follows:

1. Green River - Wyoming
2. Yampa-Whate River - Colorado, Wyoming
3. Uinta Basin, Price, San Rafael - Utah
4. Colorado, Gunnison, Dolores - Colorado
5. San Juan River - Colorado, New Mexico
6. Canyon Lands - Utah

Figure 14-7a shows the location of these areas. Summary sheets describing each area, its problems, and their effects follow the map. Water quantity problems are identified in problem areas 1, 2, 3, 4, 5, and 6; severe existing water quantity and quality problems are identified in all six areas, and the problems are projected to worsen.

A tabulation of the type of problems found in each area is illustrated in Figure 14-7b. This illustration also shows the problems identified for each subregion.

1. Green River—Wyoming

Description

This problem area includes the Green River drainage in Wyoming and the Great Divide Basin, a closed basin adjacent to the Continental Divide. The area contains about 20,600 square miles. The mountainous areas to the east, north, and west drop steeply to the high rolling plateau section to the south. This portion of the region produces about 11 percent of the region's surface flow. Ground water is limited and is of poor quality in most of the area.

Approximately 52,000 people live in the area. The largest community in the area, Rock Springs, has a population of 17,700 (SRF). There are large reserves of trona (soda ash), coal, and oil shale in the area. Uranium, oil, and gas are also found, but reserves are not large.

Water Issues

Some rural domestic water supplies are inadequate and of poor quality. These water supplies are not adequately treated nor protected from contamination. In fact, domestic water supplies of growing communities serving the coal and trona mining operations have been inadequate to meet increased demands. About 150,000 acres of irrigated land are short of water in most years.

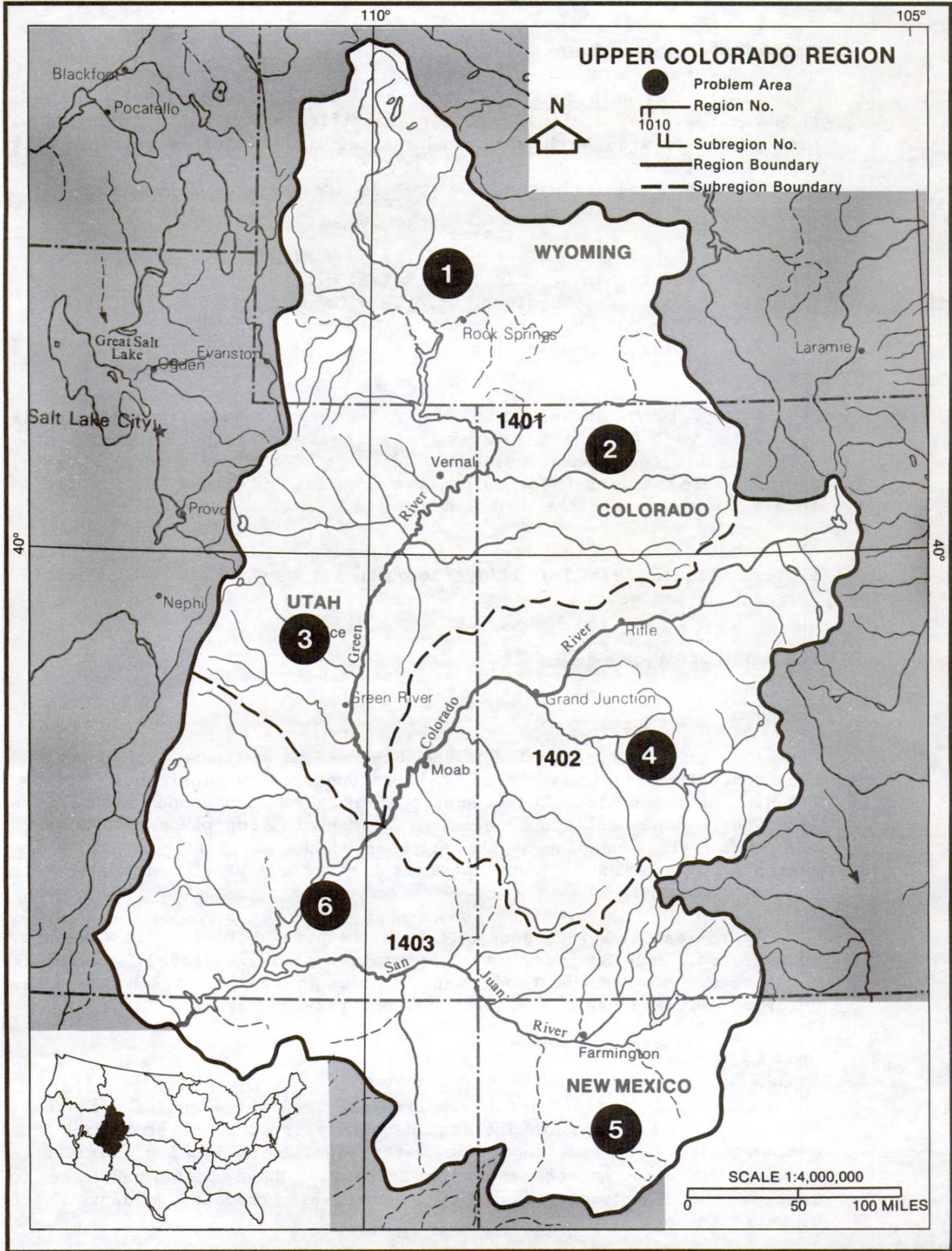


Figure 14-7a. Problem Map

UPPER COLORADO REGION (14)

PROBLEM MATRIX

Problem area		Problem issues												
		O= Identified by Federal Agency Representatives				X= Identified by State-Regional Representative								
No. on map	Name	Water quantity				Water quality				Related lands			Other	
		Fresh surface	Ground	Marine and estuarine	Surface/depth	Fresh surface	Ground	Marine and estuarine	Surface/depth	Flooding	Drainage	Erosion and sedimentation		Dredge and fill
Subregion 1401	Green-White-Yampa	O	O			O	O			O			O	
Area 1	Green River, Wyoming	X				X							X	X
Area 2	Yampa-White River – Colorado, Wyoming	X				X							X	X
Area 3	Uinta Basin, Price, San Rafael, Utah	X				X						X	X	X
Subregion 1402	Colorado-Gunnison	O	O			O	O			O			O	
Area 4	Colorado, Gunnison, Dolores – Colorado	X				X							X	X
Subregion 1403	Colorado-San Juan	O	O			O	O			O			O	O
Area 5	San Juan River – Colorado, New Mexico	X				X						X	X	X
Area 6	Canyon Lands, Utah	X				X						X	X	X

Figure 14-7b. Problem Matrix

Large quantities of water will be consumed when expanded use is made of coal resources for steam electric generation and when oil shale is mined and processed to help meet the Nation's energy needs. Further withdrawals and consumption will degrade water quality, and salt concentrations will increase in the water leaving the problem area.

Related Land Issues

Increased population growth in the problem area and increased use from large population centers will exert pressure on the fish and wildlife and recreational resources. Erosion of private and public lands and sedimentation will reduce the capacity of streams and reservoirs and adversely affect aquatic life.

Institution and Financial Issues

The competition between consumptive users of water and instream users will grow in proportion to the demand for withdrawal for consumption. Rights to the use of water on Federal lands have not been quantified, thus creating uncertainties in planning and implementation. Preservation of stream segments under the Wild and Scenic Rivers Act could prevent optimum use of water supplies. Such multipurpose use is considered more important by State and local interests than single-purpose presentation.

If projected development of water and related lands and mineral fuels takes place, local financial resources will be inadequate to provide regulatory, conveyance, treatment, and distribution systems for domestic and irrigation supplies.

Adverse Effects

If the problems listed above are not resolved, economic and environmental losses will continue. Rural areas will remain depressed. Rural and urban domestic water supply systems will not provide water of adequate quantity and quality. The fish and wildlife and recreational resources will deteriorate. Increased consumptive use will increase salt concentrations, and water resources development will increase salt loading in water leaving the region and adversely affect water users in the California and Lower Colorado Regions and in Mexico.

2. Yampa—White River—Colorado, Wyoming

Description

The problem area includes the Yampa River drainage area in Colorado and Wyoming and the White River drainage area in Colorado. The Rocky Mountains form the eastern boundary, and the streams flow through narrow valleys and canyons to enter the Green River near the Colorado-Utah border.

This portion of the region produces about 12 percent of the region's surface flow. Ground-water supplies are limited, but some productive aquifers are found in the stream valleys. Approximately 23,000 people live in the area. Major communities are Craig and Steamboat Springs, which have populations of 5,400 and 4,021, respectively. There are large reserves of coal and oil shale in the area.

Water Issues

Some rural domestic systems are not adequately protected from contamination. In the larger communities, where large population increases have occurred recently, local governments have had difficulty upgrading and expanding water supply systems. About 45,000 acres of irrigated land need supplemental supplies in the late growing season. Large amounts of water will be required when coal and oil shale reserves are mined and processed for steam electric power and oil. Additional withdrawals will affect aquatic life and instream uses and increase the salt concentration in the water leaving the area.

Related Land Issues

Increased population growth in the area and increased use from large population centers east of the area will exert pressure on fish and wildlife and recreational resources. Erosion from private and public lands fills streams and reservoirs with sediment and adversely affects aquatic life.

Institutional and Financial Issues

The future use of water, mineral fuels, and related lands largely depends on a national energy policy that would encourage or discourage use of coal and oil shale, since much of these resources are in Federal ownership.

The conflict between consumptive uses of water and nonconsumptive instream use will increase as withdrawal and consumption increase. Rights to use of water on Federal lands have not been quantified, thus creating uncertainties in planning and implementation. Some development could be prevented by limiting uses of streams and land under Wild and Scenic Rivers and Wilderness Acts.

Local financial resources will be inadequate to develop water supplies for domestic use and irrigation, provide recreational facilities, and protect fish and wildlife, if projected development of water, lands, and mineral fuels takes place.

Adverse Effects

If the problems identified are not dealt with, economic and environmental losses will occur in the region. Rural areas will experience high

unemployment, and outmigration will continue. Rural and urban domestic water supply systems will not provide water of adequate quantity and quality. Fish and wildlife resources will decrease by 10 percent without adequate preservation, enhancement, and management programs.

3. Uinta Basin, Price, San Rafael—Utah

Description

The problem area includes the Uinta Basin, the Price River, and San Rafael River drainages in Utah. The area extends from the Uinta Mountains on the north to canyon lands in southeastern Utah. The western boundary is the Wasatch Mountains, and the eastern boundary in the Utah-Colorado border.

This portion of the region produces about 13 percent of the region's surface flow. Ground-water supplies are limited, but waters of good quality are found in some of the porous sandstone formations.

Approximately 62,000 people live in the area. Price, and Vernal, Utah, are the two largest communities. The Uinta and Ouray Indian Reservation is located in the Uinta Basin. The Indian population numbers about 1,650.

There are large reserves of coal, oil shale, and oil-impregnated sandstone and lesser reserves of oil and natural gas in the problem area.

Water Issues

Central domestic water systems are lacking in some parts of the area, and domestic water must be hauled to many farmsteads. Some rural domestic systems supply water of poor chemical quality and are not adequately protected from contamination. Communities affected by large population increases have had difficulty upgrading and expanding water supply facilities. About 105,000 acres of irrigated land lack adequate late season water supplies. Additional lands should be irrigated on the Indian reservation to improve the socioeconomic standing of Indians. High concentrations of salt are found in the lower reaches of the Duchesne, Price, and San Rafael Rivers. New uses and increased exports will increase these concentrations and have adverse effects downstream in the Colorado River.

Large quantities of water will be required as additional steam electric powerplants are constructed to use coal. Oil shale development and exports will also deplete instream water supplies. These additional withdrawals will adversely affect aquatic life and instream uses.

Related Land Issues

Erosion from public and private lands contributes to the sediment and salt load in the Colorado River. Unusual and unique land areas, streams,

lakes, flora, and fish and wildlife will be affected by increased population, increased recreational use, and the development of mineral resources. Wildlife habitat will be lost through mineral development and expansion of agriculture.

Institutional and Financial Issues

A national energy policy that is still to be established will largely determine the future use of water-related lands and mineral fuels, since a large part of the coal and oil shale is federally owned. Conflicts between consumers of water and nonconsumptive instream uses will intensify as withdrawal and consumption increase. Rights to use of water for Indians and on Federal lands have not been fully quantified.

Local financial resources are inadequate to develop water supplies for domestic and irrigation needs and to provide other essential community services. Providing recreational facilities, protecting scenic resources, and protecting and managing fish and wildlife resources as development takes place and the population increases will require more financial input than is generated at the local level of government.

Adverse Effects

An increase in the use of water and other natural resources of the area can be expected to improve its socioeconomic conditions. If the problems identified above are not dealt with, social, economic, and environmental losses will occur in the State and region. Inhabitants of rural areas and of the Indian reservation will experience low income and high unemployment, and outmigration will continue. If mineral fuels are left undeveloped, little opportunity will exist for improvement of socioeconomic conditions in the problem area.

Increased consumption and water resources development will increase salt loading in water leaving the region and adversely affect water uses in the California and Lower Colorado Regions and in Mexico.

4. Colorado, Gunnison, Dolores—Colorado

Description

This problem area encompasses 21,900 square miles extending from the Rocky Mountains of central Colorado to the Colorado-Utah border and includes the main stem of the Colorado, Gunnison, and Dolores drainage areas. It is characterized by high, forested mountains and narrow stream valleys. The population in 1975 was about 162,000. Principal cities are Grand Junction, Montrose, Glenwood Springs, Delta, and Gunnison, Colorado.

This portion of the region produces about 46 percent of the region's surface water. The area is rich in natural resources, including coal, oil shale, oil, natural gas, uranium, molybdenum, vanadium, zinc, lead, copper, silver, and gold. Ground-water supplies are limited, but waters of good quality are found in the stream valley sediments of the Colorado and Gunnison Rivers. The area is very popular for summer recreation and winter sports, and large numbers of people from outside the region come here.

Water Issues

Communities affected by large increases in population have had difficulty finding sufficient funding to upgrade and expand water supply facilities. Some rural farmsteads still haul water to meet minimum domestic needs. Some rural domestic systems supply water of poor chemical quality, and some of these systems are not adequately protected from contamination. About 150,000 acres of irrigated land lack a full-season water supply.

Point and diffuse sources contribute to the salt load in the Colorado River; new consumptive uses and the expansion of exports will increase concentrations in the flows leaving the region. Large withdrawals of water for irrigation, steam electric generation, oil shale development, exports, and other uses will deplete instream water supplies. These additional withdrawals and consumption will affect aquatic life and instream uses.

Related Land Issues

Erosion from public and private lands contributes sediment and salt to the streams, reducing channel and reservoir capacities and increasing the salt load in streams leaving the area. Population increases and pressures from population centers outside the region are exerting extraordinary pressure on natural areas, recreation areas and fish and wildlife resources. Wildlife habitat will be lost in some areas through expansion of agriculture and mineral development.

Institutional and Financial Issues

The national energy policy will largely determine the future use of water and related lands since a large part of the mineral fuels is federally owned. Rights to use water on Federal lands have not been quantified. Conflicts between consumers of water and nonconsumptive instream uses will intensify as withdrawals and consumption increase.

Local financial resources are inadequate to develop water supplies for future domestic and irrigation needs and provide other essential community services. Providing recreational facilities, protecting scenic and natural areas, and protecting and managing fish and wildlife resources as mineral development and expansion of agriculture take place will require more financial resources than local governments can generate.

Adverse Effects

Although increased use of water and other resources of the area can be expected to improve socioeconomic conditions, if the problems identified above are not resolved there will be social, economic, and environmental losses in the State and region. If irrigation supplies are not increased, rural areas will continue to experience high unemployment and outmigration. Leaving the mineral fuels undeveloped provides no opportunity for socioeconomic growth in the problem area. Increased consumptive use and water resources development will increase salt loading in water leaving the region and adversely affect water users in the Lower Colorado and California Regions and in Mexico.

5. San Juan River—Colorado, New Mexico

Description

This problem area encompasses 11,050 square miles in southwestern Colorado and northwestern New Mexico. It extends from the Continental Divide on the east to the Four-Corners area 125 miles to the west. The area is characterized by high, forested mountains, narrow valleys, and high deserts.

About 107,000 people live in the area. The principal communities are Durango and Cortez, Colorado, and Farmington and Shiprock, New Mexico. Three Indian reservations, Southern Ute, Ute Mountain, and Navajo, are located wholly or partly within the area.

This area produces about 14 percent of the region's surface flow. Ground-water supplies are limited, and water is of good quality only in the stream valley sediments. The mountains and forests are popular recreation areas.

Water Issues

On the Indian reservations, water of unsuitable quality is often used for domestic purposes. Some rural domestic water systems are not adequately protected from contamination. In the communities where large population increases have occurred in recent years, local governments have had difficulty upgrading and expanding domestic water systems. About 66,000 acres of irrigated land are inadequately supplied in the late growing season. Additional lands on Indian reservations need water to upgrade the Indians' economic status. Additional withdrawals and consumptive use will increase salt concentrations in the remaining flows in the San Juan River. Aquatic life and instream uses will be adversely affected by large withdrawals for steam electric generation, coal gasification, irrigation, and other uses.

Related Land Issues

Population increases and pressures from population centers outside the region will exert pressures on water-oriented recreation facilities, natural areas, and fish and wildlife resources. Wildlife habitat will be lost through expansion of agriculture and use of coal for gasification and steam electric generation. Erosion from private and public lands contributes sediment and salt to the San Juan River and reduces channel and reservoir capacities and increases the salt load in the Colorado River.

Institutional and Financial Issues

The national energy policy will largely determine the future use of water and related lands since most of the coal in the area is in Federal or Indian ownership. Rights to use of water on Federal lands and the three Indian reservations have not been fully quantified, which creates uncertainty in planning and implementation. Conflicts between consumers of water and nonconsumptive instream uses will intensify as withdrawals and consumption increase.

Local financial resources are inadequate to develop water supplies for future domestic and irrigation needs and provide other essential community services. Providing water-oriented recreational facilities, protecting scenic and unusual areas and streams, and protecting and managing fish and wildlife resources as mineral development and expansion of agriculture evolve will require more financial resources than can be generated by local governments.

Adverse Effects

If the problems are not solved, social, economic, and environmental losses will occur. If agriculture is not expanded and supplemental water for present irrigated lands developed, rural residents and Indians will continue to experience high unemployment, and outmigration will increase. Leaving the land, recreational potential, and coal undeveloped provides no opportunity for growth in the area. Increased consumptive use and water resources development will increase salt loading in water leaving the area and affect water users in the Lower Colorado and California Regions and in Mexico.

6. Canyon Lands—Utah**Description**

This area encompasses 19,600 square miles in southeastern Utah. The area takes its name from typical terrain, which consists of deeply eroded canyons, escarpments, natural arches, bridges, and other unusual rock formations. There are four national monuments, two national parks, and one national recreation area in the problem area.

The problem area is one of the least populated in the Nation, with only 19,700 people. The largest community in the area, Blanding, has a population of only 2,570. A portion of the Navajo Indian Reservation is situated south of the San Juan River. This area produces less than 3 percent of the surface flow of the region. Ground-water supplies are also very limited, and yields of wells are small.

The national recreation area, parks, and monuments are popular and attract tourists from adjacent regions and throughout the Nation. Other natural resources are coal, uranium, oil-impregnated sandstone, and oil. Although coal reserves are rather large (17.5 billion tons), they remain undeveloped because of the remoteness of the area.

Water Issues

Water is a very limited resource in the area except in portions of the Colorado and San Juan Rivers that are in deep canyons. The Indians and many farmers and ranchers haul potable water long distances to meet minimum domestic needs. If coal is developed and projected increases in population occur, existing water supplies and domestic water systems will be inadequate. New communities may be built near coal mines. About 15,400 acres of irrigated land need supplemental water. New agricultural lands need to be developed on the Navajo Indian Reservation by providing irrigation water. Water will have to be conveyed long distances from Lake Powell or from the Colorado River if coal is used for steam electric generation and coal gasification.

Related Land Issues

Increased visitation from large population centers in nearby regions will exert pressure on water-oriented recreation facilities, natural areas, and fish and wildlife resources. Wildlife habitat will be lost when coal reserves are developed and new communities established. Erosion on private and public lands contributes sediment and salt to the river system, reducing channel and reservoir capacity, and increasing the salt load in the Colorado River.

Institutional and Financial Issues

National energy policy will largely determine the future use of water and related lands since most of the mineral fuel reserves in the area are on Federal lands. Rights to the use of water on Federal lands and the Navajo Indian Reservation have not been fully quantified. This creates considerable uncertainty in planning and implementation. If mineral development occurs, local financial resources will be inadequate to provide domestic water for an expanding population or to provide water-oriented recreation facilities, protect scenic areas and streams, and protect and manage fish and wildlife resources.

Adverse Effects

Leaving the recreational potential and mineral fuels undeveloped will provide no opportunity for growth in the area. Unemployment will rise, and outmigration will continue. If development takes place, water withdrawals and consumptive use will increase, and salt concentrations in water leaving the region will affect water users in downstream regions.

Summary

The Upper Colorado Region can provide water and land to meet the needs of an expanding economy and maintain a quality environment for the next quarter of a century if adequate water storage and effective management are provided. Beyond that time period, water supplies may be insufficient to satisfy the demands of an expanding economy.

This is a semiarid region with low precipitation, cold winters, and warm to hot, dry summers. The growing season varies from 60 days in the high mountain valleys to about 180 days in the lower elevations. Irrigation is required in much of the region to sustain crop production and the livelihood of many residents. Natural resources include large reserves of mineral fuels (coal, oil shale, tar sands, and uranium), trona and other minerals, land, unique and unusual scenery, forests, fish and wildlife.

The region is rural in character. Farming communities are small, and the few urban areas are oriented to agriculture and mining. The growth of the economy is dependent on the use of the region's mineral fuels to meet the expanding energy needs of the region and the Nation.

The Colorado River and its tributaries are the life blood of the region. A number of reservoirs have been constructed to regulate the erratic streamflows and provide water for irrigation, municipal, industrial, and other uses and to meet compact commitments to the Lower Colorado Region. Water is withdrawn for these uses; 93 percent is taken for irrigation. About 36 percent of the withdrawn water, excluding exports, is consumed. Consumption of water is projected to increase about 32 percent by 2000. Serious water shortages exist now, and by the year 2000 about 84 percent of the region's natural streamflow will be committed to depletions and interstate compact requirements in an average year. Water quality standards will require control of polluting discharges, but with increased consumption of water, salinity levels will increase at several localities, including the outflow point of the region.

There are severe problems associated with water and related land use. The failure to solve problems will probably have the greatest impact locally, but there will also be serious State, regional, and inter-regional ramifications. The most serious problems are associated with providing water for domestic, agricultural, and mineral extraction and processing, controlling erosion, and protecting the environment. The resolution of conflicts over use of water through better planning and management will require special attention.

Economic growth will require the consumption of large quantities of water for expanding agriculture, stabilizing rural communities, and developing mineral fuels. Expansion will require more domestic water and will increase the need for recreational opportunities, including picnicking, camping, boating, skiing, sightseeing, hunting, and fishing. Local financial resources will be inadequate to provide for this expansion, and programs will be required to assist local governments in dealing with the projected

growth. The protection of the essentially unspoiled natural environment conflicts with the plans for development and use of the water and related natural resources. Preservation of the present environment will not be possible if the region's resources are used to meet State-regional goals and national needs. A continuing dialogue among those who favor economic growth and those who opt for no environmental change will be highly important to the resolution of conflict and attainment of the State-regional goal of balanced economic growth and protection of the environment. This goal is the desire of most of the region's residents.

Conclusions and Recommendations

Finding a solution to the emerging problems associated with water and related resources in the Upper Colorado Region is essential to the well-being of the region's population and the Nation. Solution of the region's problems requires careful, multiobjective, multidisciplinary planning and engineering. Such planning must necessarily involve environmental, institutional, and legal factors as well as the technical aspects. Strong Federal, State, and public and private local input and cooperation are indispensable in developing and implementing the resulting plans.

Federal Role

For most of the high priority problems, the Federal Government has assumed responsibility for helping solve the problems. Beginning with the passage of the Water Quality Act of 1965, the Federal Government has been involved in water quality problems of the Colorado River. A number of conferences, hearings, and studies have been conducted, and the States have adopted numeric standards for three key stations on the river, pursuant to the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The Colorado River Basin Salinity Control Act of 1974 (Public Law 93-320) enables the Federal Government to proceed with controls to protect and enhance the quality of water in the Colorado River. The Federal input involves construction and operation of authorized control units, the investigation of 12 other water quality improvement projects, reformulation of previously authorized Federal water projects, and other studies to cope with the river's high salinity. The Bureau of Reclamation, the Soil Conservation Service, and the Environmental Protection Agency are all involved and can, with adequate funding, deal with the problems under existing authorities. Further study is needed in cooperation with the States of the Upper Colorado Region to determine the desirability of establishing uniform and compatible water quality standards for the Upper Colorado River Basin.

To provide water for agricultural, industrial, and domestic purposes, 10 Federal water projects have been authorized for construction by the Bureau of Reclamation. Other proposed developments are under investigation by this same agency. The authorized projects and investigations should be funded at a reasonable level to meet emerging needs.

The Soil Conservation Service should assist the States and private land owners in developing plans to reduce erosion and improve irrigation water management. The Bureau of Land Management and the Forest Service should develop plans and institute programs to curb erosion on Federal lands and reduce sediment inflow to streams and reservoirs.

While flooding is not a major problem at present, the Corps of Engineers and the Soil Conservation Service should, within their authorities under law, plan and work with States and local entities to reduce possible future flood damage through nonstructural and structural meas-

ures. The Bureau of Outdoor Recreation, the Forest Service, the National Park Service, and the Bureau of Land Management, under existing statutes and in cooperation with the States, should complete studies of wilderness areas, streams having special qualities, natural areas, and historic sites to assure preservation and protection of the unique and unusual lands, streams, and scenery of the region.

The Bureau of Indian Affairs should direct more effort to provide adequate domestic water of suitable quality for the Indians on the four Indian Reservations in the region.

Planning

Many comprehensive water and related land studies have been conducted in the region over the last three decades, and information is available for most water-related problems. No regional or river basin (Level B) planning appears to be needed for at least the next decade.

Planning in the near future by Federal and State agencies should be directed toward implementation studies for solution of the critical water problems in the region. All such studies should use the "multiple objective approach" and involve the local public interests.

Data Research

Special data needs in the region are related to inconsistencies in the water supply and use base. Research is needed in techniques to conserve water and reduce salinity.

Institutional Arrangements

Water rights for Federal lands and Indians have not been fully quantified or legalized, creating uncertainty as to available supplies for community development, agriculture, coal production and gasification, steam electric generation, and oil shale conversion. Court suits have been filed by Indian tribes, and the outcome could have far-reaching effects on the development of the water and related resources of the region. Active participation by Federal and State agencies is required to solve the Federal and Indian water rights questions.

Private and local financial resources are inadequate to meet investment demands to provide water for projected domestic needs, agricultural use, water quality control, recreation facilities, fish and wildlife conservation, and for environmental quality protection. The Federal-State grant, loan, and cost sharing programs should be reexamined and modified to provide better programs for improvement of rural communities in the Nation.

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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.