Upper Colorado Region

Comprehensive Framework Study

Main Report

Upper Colorado Region State-Federal Inter-Agency Group / Pacific Southwest Inter-Agency Committee / Water Resources Council
June 1971

This report was prepared by the
UPPER COLORADO STAFF AND WORK GROUP CHAIRMEN
of the
UPPER COLORADO REGION STATE-FEDERAL INTER-AGENCY GROUP
for the
PACIFIC SOUTHWEST INTER-AGENCY COMMITTEE
WATER RESOURCES COUNCIL

Clyde D. Gessel, Chairman	Bureau of Reclamation
Robert H. Hagen	Water Quality Office
Lyle E. Hollenbeck	Bureau of Outdoor Recreation
Robert W. Scott	Bureau of Sport Fisheries and Wildlife
Paul S. Shafer	Bureau of Reclamation
Homer C. Stewart	Bureau of Mines
John D. Hedlund	Soil Conservation Service
Fred O. Case	Soil Conservation Service
M. Glade Pincock	Economic Research Service
Richard J. Vasquez	Corps of Engineers
Arnold W. Zimmerman	Corps of Engineers
Robert H. Griffin	Federal Power Commission
George W. Hanley	Federal Power Commission
Paul L. Billhymer	Upper Colorado River Commission
Robert E. Farrer	State of Arizona
Thomas C. Clark	State of Arizona
Laren D. Morrill	State of Colorado
David P. Hale	State of New Mexico
James G. Christensen	State of Utah
Floyd A. Bishop	State of Wyoming
Peter J. Hutchison	State of Wyoming

Additional Task Force Members

Earl M. Bay, Bureau of Reclamation; Lee J. McQuivey, Corps of Engineers; Loren L. Swick, State of Colorado

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

MAIN REPORT

JUNE 1971

This report of the Upper Colorado Region State-Federal Inter-agency Group was prepared at field level and presents a framework program for the development and management of the water and related land resources of the Upper Colorado Region. This report is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected states, and by the Water Resources Council prior to its transmittal to the Congress for its consideration.

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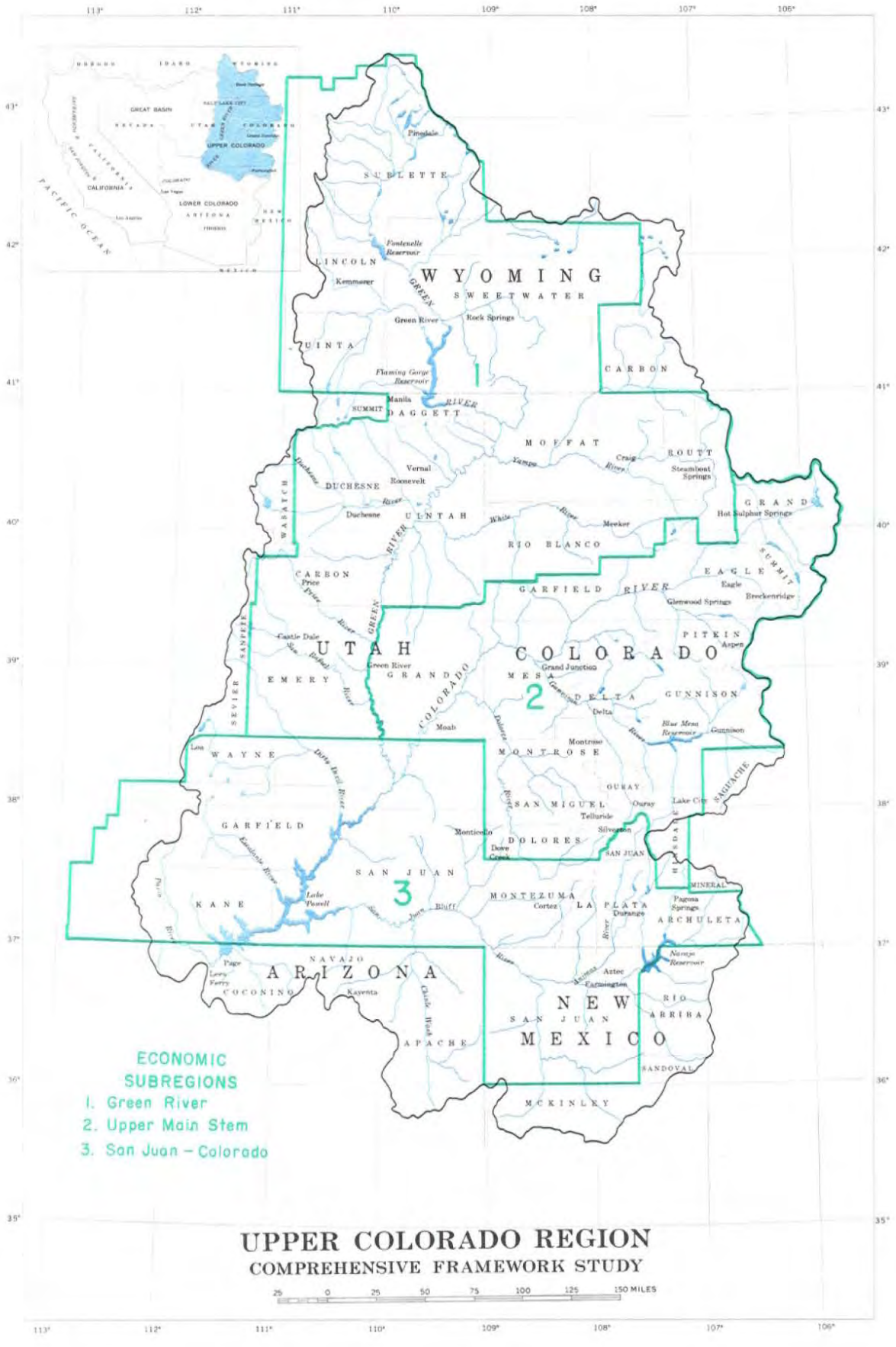


UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

SUMMARY

This report summarizes the results of comprehensive investigations for the formulation of proposed plans to provide a broad guide to the best use, or combination of uses, of water and related land resources to meet foreseeable needs. It provides appraisals of natural resources and their geographic distribution, makes projections of future requirements, defines problems and needs, and presents a framework program and alternatives thereto to serve as a general guide for resource development and conservation for the years 1980, 2000, and 2020.

The Upper Colorado Region comprises the drainage of the Colorado River above Lee Ferry, Arizona, and the Great Divide Basin in south-central Wyoming. The region includes parts of Arizona, Colorado, New Mexico, Utah, and Wyoming and totals 113,496 square miles in area. Nearly two-thirds of the land is in public ownership.

The region is and probably will remain largely an exporter of raw and partially processed materials and other resources, including water and an importer of finished products. A majority of the available water is now committed to downstream delivery and transmountain diversion.

Agriculture is livestock oriented, with beef cattle being the major product. They are produced on the range- and irrigated-farm base and mostly marketed outside the region. About 87 percent of the projected production of electrical energy will be exported. The bulk of mineral development will be for petroleum, uranium, coal, molybdenum, and trona production. The 1965 population of 366,000 is projected to almost double by 2020. This includes the hydrologic portion of Arizona.

Outstanding opportunities are available for year-round recreational activities. A great number of visitors from adjoining regions and throughout the United States enjoy the fishing, hunting, skiing, camping, and other outdoor activities within the region.

The 1965 level of water and related land utilization, management, and development was used as the base year for planning. The total water supply, which assumes no depletions by man's activities, averages 14.87 million acre-feet annually based upon the period 1914-65. On-site depletions plus the evaporation from reservoirs on the main stem of the Colorado River for 1965 normalized conditions were 3.45 million acre-feet. Irrigation and associated depletions accounted for 62 percent of the 1965 use, main-stem reservoir evaporation 19 percent, export to adjacent regions 15 percent, and the remaining 4 percent was used for all other purposes.

The Office of Business Economics and Economic Research Service (OBERS) March 1968, projections were modified to better fit the situation in the

region. These modified projections are designated as the regionally interpreted OBERS projections (RI OBERS) and are the basis for the framework plan. This plan is described in detail, then is followed by alternative plans that reflect emphasis on different uses for the available water supplies and resources. The alternative plans are identified as:

1. States' alternative to the framework plan (6.55 million acre-foot) level of development,

2. States' alternative at the 8.16 million acre-foot level of development, and

3. States' alternative for water supply physically available at site in the region (9.44 million acre-feet).

Comparisons of the framework plan and alternate levels of development are shown in the table on the following page.

Program costs borne by the Federal Government for the framework plan would total about $3 billion for the 55 years for installation; annual OM&R (operation, maintenance, and replacement) costs would increase to about $48 million by 2020. Non-Federal entity costs would total $10 billion for installation by 2020, with OM&R costs increasing to over $646 million annually, particularly for thermal-electric power and recreation.

Time frame	Water development	Associated development	Total development
		Installation cost in $1,000	
1966-1980	1,190,300	2,700,840	3,891,140
1981-2000	1,074,350	5,982,310	7,056,660
2001-2020	658,780	1,397,680	2,056,460
1966-2020	2,923,430	10,080,830	13,004,260

All proposed levels of development meet the requirements of OBERS projections and use the available resources of the region in varying degrees. It appears that the commitments of the Colorado River Compact can be met, and except for local shortages during low streamflows, on-site demands can be met for the 6.55 MAF development level. At the two higher levels, augmentation will be required.

Land and mineral resources exist in sufficient quantity to meet all projected levels of development. With minor exceptions, hunting and fishing needs will be met.

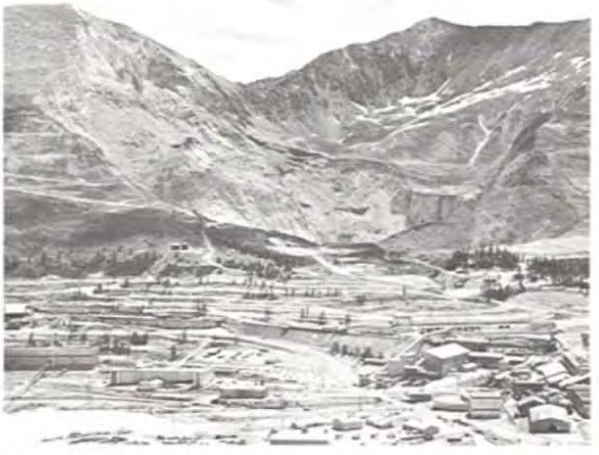
Comparison of framework plan and alternatives
for water and selected related requirements,
Upper Colorado Region

	Unit	1965 base	Framework plan in 2020	States' alternatives: 6.5 million acre-feet in 2020	States' alternatives: 8.16 million acre-feet in 2020	States' alternatives: Water available at site in 2020
On-site Depletions						
Irrigation	1,000 ac.-ft.	2,128	3,294	3,297	3,658	4,089
Export	1,000 ac.-ft.	551	1,653	1,455	2,203	2,817
Other uses	1,000 ac.-ft.	132	941	1,136	1,642	1,878
Less import	1,000 ac.-ft.	(-)3	(-)3	(-)3	(-)3	(-)3
Subtotal		2,808	5,885	5,885	7,500	8,781
Main-stem reservoir evaporation	1,000 ac.-ft.	643	660	660	660	660
Total		3,451	6,545	6,545	8,160	9,441
Agricultural Activity						
Irrigated land	1,000 acres	1,622	2,122	2,118	2,354	2,579
Dry cropland	1,000 acres	603	503	503	503	503
Range grazing production	1,000 AUM's	6,368	7,665	7,665	7,665	8,392
Timber production	Mil. cu. ft.	48	340	340	340	340
Industrial Activity						
Electric power						
Thermal	Megawatts	1,335	42,081	42,591	47,591	50,391
Hydro	Megawatts	1,300	1,300	1,300	1,300	1,300
Minerals						
Shale oil	Mil. bbl./day	0	0	1.5	4	4
Coal byproducts	Equivalent mil. bbl./day	0	0	0.2	0.8	1.6
Potash	Tons/day	0	0	4,100	4,100	4,100
Fish and Wildlife - Recreation						
Fish and wildlife						
Sport hunting	1,000 man-days	1,268	2,374	2,634	2,955	3,072
Sport fishing	1,000 man-days	3,547	8,667	9,221	9,691	10,094
Recreation	Mil. rec.-days	56	225	225	225	225
Watershed Management and Flood Control						
Watershed management						
Sediment yield reduction	Ac.-ft./yr.		2,764	2,764	2,764	2,764
Flood control						
Flood damage reduction	1,000 dollars		6,744	7,063	7,754	
Economic Activity (Economic Boundaries)						
Population	1,000's	337	660	746	901	
Employment	1,000's	111	251	285	343	
Gross regional product	Mil. dollars	1,142	10,470	11,712	13,906	
Personal income	Mil. dollars	730	7,572	8,570	10,529	

SOURCE OF WATER

STORAGE FOR FLOOD CONTROL,
RECREATION, POWER,

IRRIGATION,



MUNICIPAL AND INDUSTRIAL

Water is an important resource of the Upper Colorado Region. Water from the melting snow is stored in multiple-purpose reservoirs for flood control, recreation, power, irrigation, and municipal and industrial use.

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PART I

INTRODUCTION

Authorization, Purpose, and Scope

The Upper Colorado Region is one of the major river basins in the United States included in a nationwide program to provide comprehensive river basin plans for the development, use, and management of water and related land resources. This program stemmed from recommendations of the Senate Select Committee on National Water Resources; and planning concepts are embodied in Senate Document No. 97, 87th Congress, Second Session. The overall program was presented by the President in the Fiscal Year 1963 budget. The Upper Colorado Region study was approved by Congress, and funds were provided to start this activity in Fiscal Year 1967.

The States of Arizona, Colorado, New Mexico, Utah, and Wyoming and the Upper Colorado River Commission participated with the various Federal agencies in this investigation under authority provided by the appropriate state legislature.

The basic objective in the formulation of the framework plan and alternatives is to provide a broad guide to the best use, or combination of uses, of water and related land resources in each region to meet foreseeable short- and long-term needs. In studies to achieve this basic objective, consideration was given to: (a) the timely development and management of these resources as essential aids to the economic development and growth of a region; (b) the preservation of resources, in appropriate instances, to insure that they will be available for their best use as needed; and (c) the well-being of all of the people as the overriding determinant in such planning.

The purpose of this report is to present condensations of the findings of the supporting appendices; the description of the region; the present (1965) status of water and related land resource development; availability of water, land, and other resources; and regional needs and demands. Also, the report presents a comprehensive framework plan and possible alternative plans, a comparison of proposed plans, conclusions reached, and recommendations for future action.

The studies made for this report are preliminary, or reconnaissance, in scope. All geographic areas within the region and all purposes served by the conservation, development, and use of water and related land resources were considered. Available data pertinent to the study that have been collected, developed, and cataloged over the years by local, State, and Federal agencies were utilized. The studies considered only

intraregional water and related land resources use except for those interregional water uses established by prior compacts and agreements.

Guidelines

General guidelines for framework studies were prepared by the Water Resources Council and Pacific Southwest Inter-Agency Committee. For example, the following guidelines, all formulated in the early stages of this study, became prevailing considerations and were complied with during the course of the study.

1. All interregional diversions will be recognized and the expected transfers of water included as a loss to the transferring-out region and available for use in the transferring-in region.

2. The distribution of water between regions will be made in accordance with existing compacts and legal agreements.

3. Available water allocated under compacts, agreements, or laws but not presently in beneficial use by the allottee will be available for future beneficial use of the allottee (state or other organizational unit). This study will rely on appropriate state laws or policies for determination of priorities of use among competing areas and uses.

4. The ocean should be considered available and plans for its use as a water resource could be included. Availability to the Upper Colorado Region would be limited by exchange with other regions.

5. Consideration of water quality will provide sufficient latitude to permit future growth and full development of water use, provided the condition of the water does not reflect failure to apply corrective measures which are physically and economically feasible. These water quality considerations shall not inhibit application in any way of existing interstate compacts or court decrees or intrastate appropriation of water.

6. Importation of water from outside the Pacific Southwest will not be investigated except for presently authorized projects.

7. The relationships of wild and scenic rivers to land use, watershed management, water development, and other functions will be considered.

8. Maintenance of environmental quality will be given high priority in planning for the future.

9. Only general consideration will be given to cost-repayment capacity relationships for selection of a plan of water and land development. The plan will be based essentially upon the reasoned judgment of competent planners.

Cooperating Agencies

This report is a cooperative effort of the following States and Federal agencies.

State of Arizona
State of Colorado
State of New Mexico
State of Utah
State of Wyoming
Upper Colorado River Commission
Department of Agriculture
- Agricultural Research Service
- Forest Service
- Economic Research Service
- Rural Electrification Administration
- Soil Conservation Service

Department of the Army
- Corps of Engineers

Department of Commerce
- Economic Development Administration
- National Weather Service

Department of the Interior
- Bureau of Reclamation
- Bureau of Outdoor Recreation
- Bureau of Sport Fisheries and Wildlife
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Geological Survey
- National Park Service

Environmental Protection Agency
- Water Quality Office

Department of Labor
- Bureau of Employment Security

Department of Transportation
- Federal Highway Administration

Federal Power Commission
Department of Health, Education, and Welfare
- Public Health Service

Coordination and Administration

The Water Resources Planning Act (P.L. 89-80, July 22, 1965) established the Water Resources Council. The President transferred the functions and committee organization of the Inter-Agency Committee on Water Resources to the Water Resources Council on April 10, 1966. By letter of

October 10, 1966, the Water Resources Council requested the Pacific Southwest Inter-Agency Committee (PSIAC) to take leadership and coordinate the comprehensive studies in the Pacific Southwest, including the Upper Colorado Region. PSIAC accepted this responsibility by letter of November 21, 1966. An organization meeting to begin the Upper Colorado Region study was held on January 31, 1967. The Upper Colorado River Commission was subsequently designated as the chair agency.

State and Federal agency coordination during the study phase of this report consisted of correlation and consolidation of basic information, analyses of present and future water and related land use problems, and formulation of the framework plan and alternatives. Each participating agency provided basic data, analyses, and leadership in its special field. Detailed coordination was accomplished through the use of work groups and task forces.

PART II

DESCRIPTION OF REGION

Location and Size

The Upper Colorado Region comprises the drainage basin of the Colorado River above Lee Ferry, Arizona, and the Great Divide Basin in south-central Wyoming. The region is on the west side of the Continental Divide and includes parts of Arizona, Colorado, New Mexico, Utah, and Wyoming. It encompasses an area of 113,496 square miles, including 109,580 square miles in the Upper Colorado River drainage and 3,916 square miles in the Great Divide Basin of Wyoming. The region is bounded on the east and north by mountains forming the Continental Divide and on the west by the Wasatch Mountains. On the south it opens to the Lower Colorado Region at Lee Ferry in northern Arizona.

For the purpose of analyzing problems and selecting a framework plan, the region was divided into three hydrologic subregions comprising the natural drainage basins of the Colorado River and its two principal tributaries, the Green and San Juan Rivers. These areas are generally independent of each other, especially with regard to water and related land use. Total area of the region by states and subregions is shown below. The subregions are delineated on the frontispiece map and are discussed in the following sections.

Area by states and subregions
(Unit--square miles)

Subregion	Arizona	Colorado	New Mexico	Utah	Wyoming	Total
Green River		10,574		17,066	1/21,020	48,660
Upper Main Stem		22,168		4,024		26,192
San Juan-Colorado	6,927	5,800	9,740	16,177		38,644
Total	6,927	38,542	9,740	37,267	21,020	113,496

1/ Includes Great Divide Basin of 3,916 square miles.

Green River Subregion

The Green River Subregion is located in southwestern Wyoming, northwestern Colorado, and northeastern Utah. It has an area of about 48,660 square miles or about 43 percent of the entire region, and comprises the entire drainage basin of the Green River and the Great Divide Basin. Principal tributaries of the Green River are Blacks Fork and Hams Fork in southwestern Wyoming, Yampa, and White Rivers on the western slope of the Continental Divide in northwestern Colorado, and the Price, Duchesne,

and San Rafael Rivers in eastern Utah. These streams are fed by numerous headwater lakes. The Great Divide Basin has only one stream with perennial flow, a few perennial lakes, and numerous intermittent or dry lakes and streams. It does not contribute to the water resources of the region except for a small amount of internal use.

The largest towns in the subregion are Rock Springs and Green River in Wyoming, Vernal and Price in Utah, and Craig, Steamboat Springs, and Meeker in Colorado.

The subregion is well served with transportation facilities. Interstate 80 crosses the plains of southern Wyoming and U.S. 40 crosses the northern Colorado and Utah parts of the subregion. In addition, Interstate 70 passes through the southern part of the subregion in Utah. A network of state highways and local roads connect towns of the area. The main line of the Union Pacific Railroad crosses southern Wyoming. The main line of the Denver & Rio Grande Western Railroad passes through Price in Utah, and a branch line serves Steamboat Springs and Craig in Colorado.

Mineral development is the major industry of the Green River Subregion. Oil and natural gas are of primary importance. Also of major importance are coal, gilsonite, asphalt, and trona (soda ash). Vast reserves of oil shale are present and offer potential for large future industrial developments.

Agriculture ranks near mineral production in importance to the local economy. Agricultural development is centered around livestock production, primarily beef cattle and sheep. Because of a short growing season, crop production is limited largely to small grain, hay, and pasture. These crops are used as winter livestock feed and complement the vast areas of public grazing lands administered by the Forest Service and Bureau of Land Management.

Forestry and timber-based industries are a significant segment of the local economy. Nine million acres of the subregion are forest or woodlands and have a direct effect on the local economy. Many of the rural communities are dependent on the forests for their livelihood through the lumber and wood industries, management and protection of the forests, or forest recreation.

Recreation is increasingly important to the economy. Large numbers of vacationers are attracted by the Flaming Gorge National Recreation Area and the Dinosaur National Monument, as well as by several national forests and other public lands with outstanding recreational opportunities. Also popular as recreation spots are numerous state parks, private developments, and winter sports areas.

Upper Main Stem Subregion

The Upper Main Stem Subregion is the area drained by the Colorado River and its tributaries above the mouth of Green River. Principal tributaries are the Roaring Fork, Gunnison, and Dolores Rivers. The subregion has an area of 26,192 square miles, with about 85 percent of the area in Colorado and the remainder in Utah.

Grand Junction, Montrose, and Glenwood Springs are the principal towns of the subregion in Colorado. Moab is the only major community in the Utah portion.

Interstate 70 and the main line of the Denver & Rio Grande Western Railroad traverse the subregion and provide the principal transportation routes. A network of state highways and secondary roads also extends through the area.

Mineral development is the predominant industry of the subregion. The area is the Nation's chief source of molybdenum and is a major source of vanadium, uranium, lead, zinc, coal, and gilsonite. Although gold and silver were the basis for early settlement, production of these metals is now of secondary importance. Like the Green River Subregion, the Upper Main Stem Subregion contains vast reserves of oil shale which offer potentialities for large future industrial developments.

In the Upper Main Stem Subregion, as in the Green River Subregion, agriculture centers around livestock production and production of livestock feeds on irrigated lands to complement the large areas of rangeland. There is somewhat more diversification of crops in the Upper Main Stem Subregion, however, with some major land areas devoted to sugar beets, beans, potatoes, table vegetables, and fruit. This diversification is made possible by climatic and topographic conditions which create favorable air drainage and minimize frost damage.

The subregion contains numerous recreational areas of national significance. These include several national forests, the Rocky Mountain National Park and a part of the Canyonlands National Park, the Shadow Mountain and Curecanti National Recreation Areas, and the Black Canyon of the Gunnison, Colorado, and Arches National Monuments. Also the area contains such noted resort areas as Aspen and Vail as well as many popular smaller resorts on both public and private land.

San Juan-Colorado Subregion

The San Juan-Colorado Subregion is the area drained by the Colorado River and its tributaries between the mouth of the Green River and Lee Ferry, Arizona. The largest of the tributary streams is the San Juan River which heads on the western slope of the Continental Divide

in southwestern Colorado. Three small tributaries are Dirty Devil, Escalante, and Paria Rivers which drain a portion of the eastern slope of the Wasatch Plateau in Utah. The subregion includes portions of Utah, New Mexico, Arizona, and Colorado. It has a total area of about 38,644 square miles, 34 percent of the Upper Colorado Region.

The largest towns of the subregion are Durango and Cortez in Colorado, Monticello and Blanding in Utah, and Farmington in New Mexico. Page at Glen Canyon Dam is the only community of significant size in the Arizona portion of the subregion. Most of the remaining Arizona portion is in the Navajo Indian Reservation.

The subregion is served by U.S. Highways 84, 89, 160, 164, 550, and 666 and by an extensive system of state highways and secondary roads.

Mining and agriculture form the economic base for the San Juan-Colorado Subregion. The agricultural development is similar to that of the Upper Main Stem Subregion with most of the cropland devoted to livestock feeds but with production of diversified market crops on lands with favorable air drainage. The main market crops are fruit, vegetables, and dry beans. Oil, natural gas, and coal are the most important minerals produced. There is also a significant production of vanadium and uranium. Gold, silver, and associated minerals are produced, but their importance has declined considerably from the boom production of the early settlement days.

Recreation and associated industries contribute substantially to the local and region economy. The San Juan Mountains, known as the "American Alps," are renowned for their scenic beauty and recreational opportunities and attract vacationers from throughout the country. The subregion also is noted for its national forest and for its national parks and monuments, many of which preserve prehistoric Indian ruins. It contains Bryce Canyon and Mesa Verde National Parks and the major part of Canyonlands National Park. Also, it includes nine national monuments--Yucca House, Navajo, Capitol Reef, Rainbow Bridge, Canyon de Chelly, Natural Bridges, Hovenweep, Aztec Ruins, and Chaco Canyon. Also notable in the subregion are the Glen Canyon National Recreation Area and the "Four Corners," the only point in the United States where four states join. Many recreational facilities are provided on the public domain and by state, local, and private developments.

Economic subregions

In addition to the three hydrologic subregions described above, the region was divided into three economic subregions for use in economic analyses. These subregions are similar to the hydrologic subregions but are defined by county lines rather than by river drainage. This simplified the collection of statistical data for the economic analyses which

are available by counties. The differences in boundaries necessarily cause some variations in the statistical data for the economic and hydrologic subregions, but these are generally small.

History

The prehistory of the region spans the first 11,000 years and it is anticipated that earlier evidences of the presence of man may be found. The Lithic Stage commenced about 9,000 B.C. and is characterized by finely chipped Clovis Fluted projectile points, the well-known Folsom points, and the delicately flaked leaf-shaped Eden and Angostura points. Man subsisted on big game hunting during this period. The Archaic Stage, which dates from about 2,000 B.C., followed. Artifacts indicate man had adapted to a hunting and plant-gathering subsistence in a harsh desert and semiarid environment. During the Archaic Stage, man began to specialize into regionally identifiable cultural groupings out of which the later period and better-known Anasazi and Fremont cultures emerged. The Anasazi culture, which ranges from the fifth to the 14th century, A.D., is known for impressive achievements in architecture, ceramics, and horticulture and had a highly developed religious system.

There is a discontinuity between the prehistoric cultures and the Indian populations existing at the time the first European explorers entered the Region. Navajos, situated in the southern portion of the region, are latecomers who arrived during the last 500 years.

In 1869 Major John Wesley Powell explored 500 miles of the Colorado River system from Green River, Wyoming, to the mouth of the Virgin River within the present area of Lake Mead. Powell's studies and recommendations were the first and for many years the most significant in shaping policy and legislation for adapting the arid lands of the West to agriculture.

One of the first permanent settlements was the fort built by Antoine Robidou in 1832 near the confluence of the Uinta and Duchesne Rivers in the Green River Subregion. John Robertson established a trading post on Blacks Fork about 1834 and induced Jim Bridger to settle nearby along the immigrant trail to Oregon and later to California. Fort Bridger became an important resupply point for the Mormon pioneers in 1847 and succeeding years and for California-bound travelers following the gold discovery of 1849.

Gold attracted early prospectors and miners to the region. It was discovered near Breckenridge, Colorado, in 1859, and numerous placer mines quickly flourished. Other gold and silver strikes followed. During the next few years there was considerable development throughout the Colorado part of the region and the population increased rapidly.

Settlement was confined at first to mining camps in the upper reaches of the rivers and to limited agricultural areas that developed to supply the nearby camps and the travelers on the overland trails to the West. With the decline of mining enterprises, agriculture became the basic industry of the region. Many miners, disappointed in their search for gold and silver, turned to stockraising and the growing of crops as a means of livelihood. Towns and cities were developed mainly near farms and mines and at important railroad points. Statehood was achieved by Colorado in 1876, Wyoming in 1890, Utah in 1896, and New Mexico and Arizona in 1912.

Development

The Mormon pioneers early established the pattern of small agricultural communities along river valleys where the more favorable farming land could be cultivated and irrigated and where livestock could be grazed on nearby forest and rangelands. The livestock industry soon became an important sector of the agricultural economy and remains today as a major industry in most of the region.

It was soon found that irrigation was essential to successful crop production in most parts of the region. The rate of irrigation development was slow, however, because of difficult construction methods and generally low crop values. By 1900 most of the readily available sources of irrigation water had been developed by private individuals and small irrigation companies. Shortly after the turn of the century the first Federal reclamation projects were undertaken in the region and these have been the nuclei around which today's larger farming communities and trading centers have evolved. There are now numerous Federal projects throughout the region, many of which provide stability to former private developments by providing supplemental water and eliminating water supply shortages during periods of deficient streamflows.

The early history of the region has its roots in the mining industry. As has already been mentioned, the discovery of gold and other precious metals led to an influx of prospectors and miners and the establishment of numerous early settlements. Mining activity and commercial requirements of the booming populations associated with the industry attracted the early railroad development. Even the construction of the Union Pacific was partially based on the influences of gold and silver discoveries in California and Nevada in the mid-1800's. Similar discoveries in the Colorado Rockies and the desperate need for transportation to the mining camps led to the construction of a great network of railroads, mostly narrow gage to cope with the mountain conditions. These in turn produced a demand for wood for railroad ties and bridge timbers and for fuel. Coal replaced wood as a domestic and industrial fuel source and led to the coal mining industries of Colorado, Utah, and Wyoming.

In the late 1800's and early 1900's the growing populations, both within the region and in the adjacent metropolitan areas, provided an expanding coal market for heating and industrial uses. For a time coal production was of major economic importance. After World War II the substitution of gas for coal as a fuel and the adoption of diesel power on the railroads caused a major decline in coal mining. Towns such as Rock Springs in Wyoming, Price and nearby mining towns in Utah, and similar areas scattered through the Colorado part of the region suffered heavy economic displacements and loss of employment that led to distress that only now is beginning to moderate. The decline in coal production was precipitous and many mines, even whole camps and towns, were closed and abandoned. The trend has been reversed in recent years as demands increase for coal for the generation of thermoelectric power. Soaring demands for electric power have recently led to the development of strip-mining techniques and the construction of mine-mouth powerplants. These have resulted in increased coal production but with only little recovery of coal mining employment.

Mining of molybdenum in western Colorado was started during World War I. Production grew rapidly and now about half of the free world's production is obtained from the area.

Uranium-vanadium deposits have been mined sporadically since about the turn of the century. Exploration and mining boomed during and following World War II with the development of atomic fission and the demands for atomic energy. At that time the Government was essentially the only customer, and exploration and production were slowed when supplies exceeded the demands. Since 1965 a new boom has been taking place to meet the needs of power producers who have been ordering increasing numbers of nuclear-fueled generators. While surface outcroppings were well explored in the earlier boom, extensive drilling is now being undertaken by larger companies. Radioactive mineral deposits in the region are among the greatest known in the world today.

Production of oil and gas in the region dates from the early 1900's. Petroleum booms came with the discovery of the Rangely field in western Colorado in the 1940's and the Greater Aneth field in southeastern Utah in the late 1950's. Activity in exploration has tapered off in recent years with the drilling of many unsuccessful wildcat wells.

Timber harvesting began with the early settlers who produced lumber for home and business construction, rail ties, mine props, fuel wood, and poles. During the period 1868-1905 several million railroad ties were cut for the Union Pacific Railroad. The accessibility and abundance of this forest product were major factors in the completion of the transcontinental railroad and its subsequent expansion to the early settlements of the region. In recent years, with new methods of utilization and processing, uses for the local timber resources have been greatly expanded and timber has become of major importance to the local economy.

The wood is now used in the manufacture of a variety of products such as plywood, mouldings, specialty paneling, treated posts and poles, excelsior, boxes, pulp chips, and matches.

Impetus to hydroelectric power generation was given by the mineral industry. The first hydroelectric development was at Aspen, Colorado, in 1885. In 1891 the Ames Plant, located in the upper portion of the Dolores drainage in Colorado, was among the first hydroelectric plants to transmit alternating current at high voltage. As the region became settled and the need for electricity grew, several small hydroelectric plants were built. As of December 1965, 16 of these small plants, with a total installed capacity of about 76,000 kilowatts, were operating in the region.

It was not until the 1950's that steam-electric power production had significant growth. In 1950 only six small steam-electric plants with an installed capacity of about 56,000 kilowatts were operated by utilities. By 1960 five additional steam-electric plants had been built, bringing the capacity to about 400,000 kilowatts. In the 5 years preceding December 1965, the installed capacity was increased by 233 percent to 1,335,000 kilowatts as large steam-electric units were built at the Four Corners (New Mexico), Hayden (Colorado), and Naughton (Wyoming) plants. These plants were located primarily to take advantage of the availability of low-cost coal. Most of their output is exported to load centers outside the region.

It was also in the 1950's that the Colorado River Storage Project and Participating Projects were authorized by the Congress. Primarily for water conservation, the development was aided financially by the addition of hydroelectric power generating units at several reservoirs constructed under the authorization. By December 1965, 820,500 kilowatts of generating capacity had been installed at the Glen Canyon and Flaming Gorge Powerplants. By December 1968 the capacity had reached 1,128,000 kilowatts with the addition of capacity at the Glen Canyon Powerplant and installation of the Blue Mesa and Fontenelle Powerplants. The Glen Canyon, Flaming Gorge, and Blue Mesa Plants are parts of the Colorado River Storage Project in Arizona, Utah, and Colorado, respectively, while the Fontenelle Plant is part of the Seedskadee Participating Project in Wyoming. By 1968 plants of the storage project and participating projects comprised about 93 percent of the total hydroelectric power capacity then operating in the region. At the present time most of the power generated at federally owned plants is exported from the region. These exports will continue until load growth in the region itself makes power generated there salable.

The region has attracted many nonresidents to enjoy hunting, fishing, and other recreational opportunities. These visitors have made a major contribution to the region's economy.

Climate

The climate in the Upper Colorado Region is semiarid to arid and consists generally of four seasons. Wide variations in precipitation, temperature, and wind movement result primarily from varied topography and to a lesser extent from the rather wide range in latitude.

Average annual precipitation ranges from less than 6 inches in the lowest valleys to more than 50 inches in the higher mountains while that in most valleys and agricultural areas varies from 10 to 20 inches a year. (See map following page 14 .) Precipitation from late October through mid-April consists primarily of snow, particularly at higher elevations. Snow accumulations occasionally exceed 100 inches at the higher elevations and do not completely melt until late summer.

Temperatures vary widely with extremes being recorded from -60° F. at Taylor Park, Colorado, to 115° F. at Lees Ferry, Arizona. Mean monthly temperatures are lowest in January and highest in July and generally show about 50° F. seasonal difference. The average frost-free period or consecutive period with temperatures above 32° F. varies from 20 days or less at elevations above 8,500 feet to more than 180 days at elevations below 5,000 feet. The growing season is slightly longer than the frost-free period for the grass and alfalfa crops which predominate on the higher elevation lands.

Winds over the region move generally from west to east, but the wind movement is greatly modified by local topographical influences. Average annual wind velocity varies from about 8 to 14 miles an hour while strong winds associated with local thunderstorms have reached velocities of 80 to 90 miles per hour.

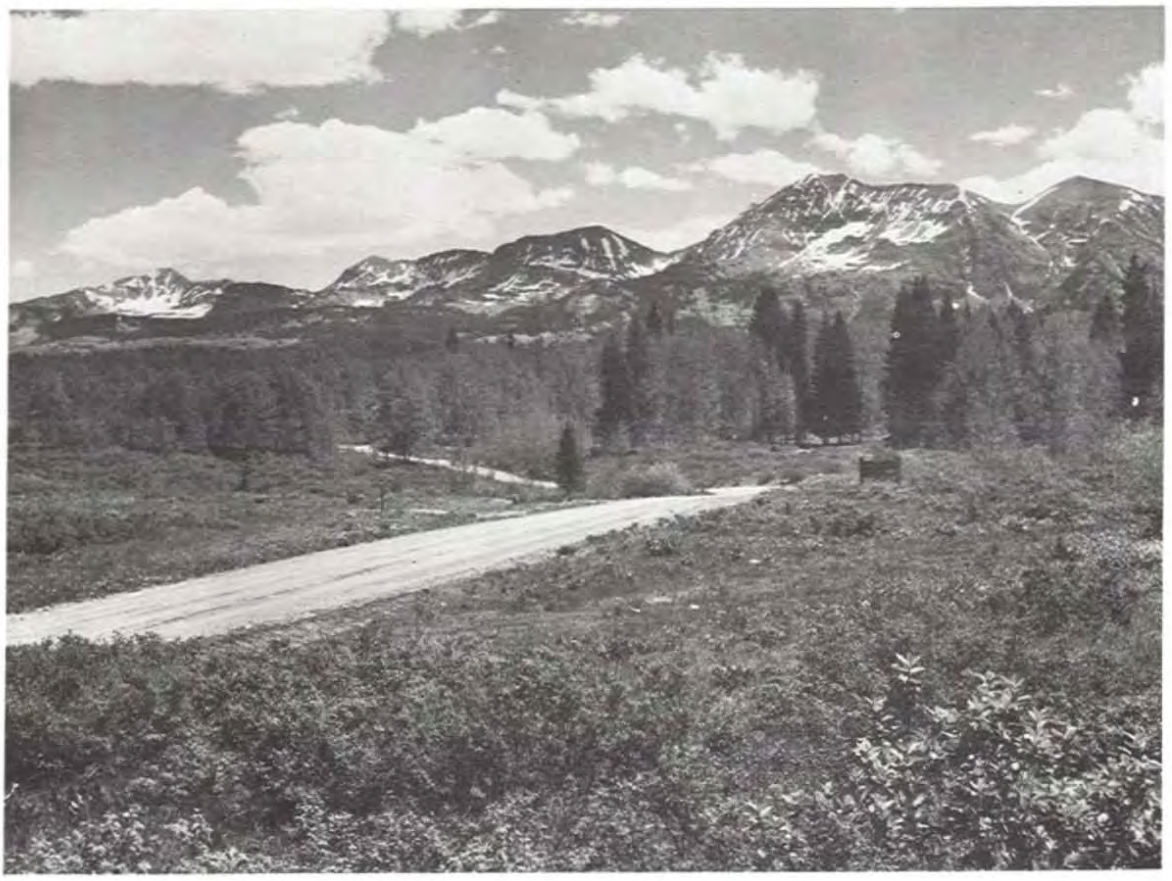
Annual evaporation from lakes and reservoirs is estimated to range from less than 30 inches at higher elevations to about 60 inches in the lower valleys.

Geology and Topography

The region is comprised of highly dissected mountainous plateaus, typified by deep canyons, river valleys, rolling ridges, and flat-topped mesas. It is rimmed on the east, north, and west by high mountains. Elevation varies from 3,100 feet at Lee Ferry, Arizona, to more than 14,000 feet at some of the higher mountain peaks.

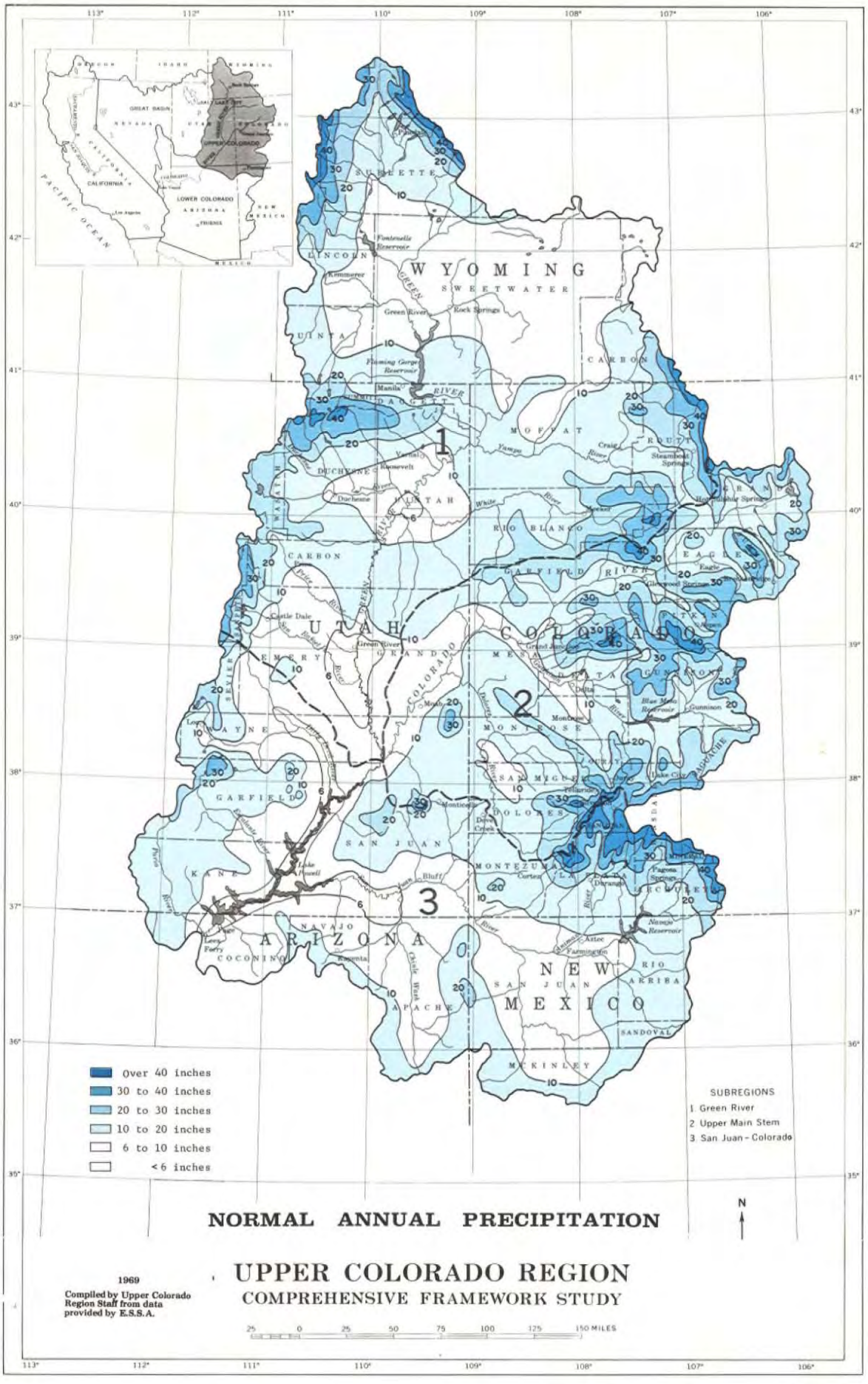
The Colorado Rocky Mountains--including the San Juan Mountains on the south end of the region--are impressive from both a scenic and geologic viewpoint, as are many other mountain ranges in the region. Sparsely vegetated plains predominate at lower elevations. Above 8,000

feet the mountains and plateaus are, for the most part, heavily forested; however, the timberline ends at about 11,500 feet and above that elevation alpine and barren areas occur.

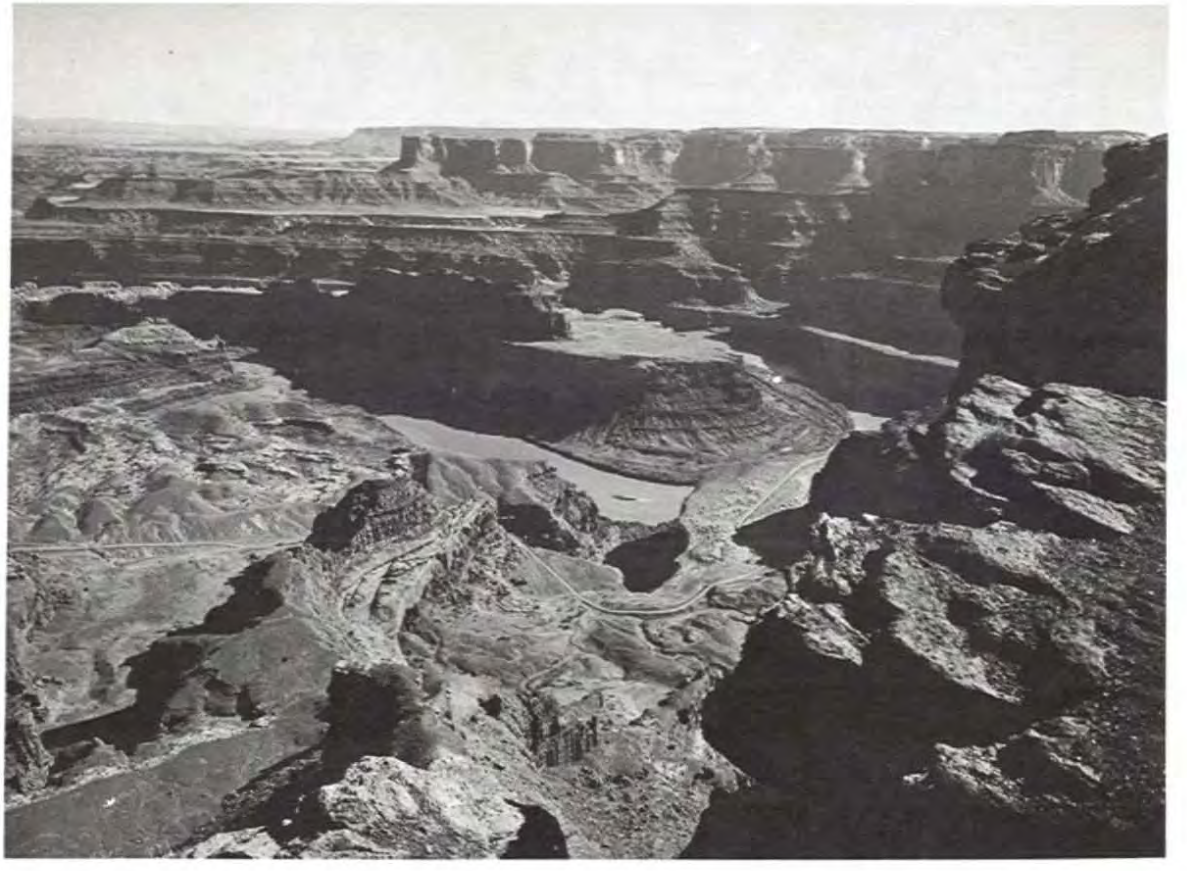


Panoramic view of Kebler Pass in high mountains of Colorado.

The Upper Main Stem and San Juan-Colorado Subregions are predominantly characterized by severely eroded sedimentary rocks. This peculiar topography of high, flat-topped plateaus and mesas separated by narrow, nearly vertical-walled canyons is referred to as the Colorado Plateaus Province. Stream erosion as the principal weathering agent has produced cuts where various rock layers of all ages are exposed. These dramatic erosional features, together with the brilliant colors of the formations, have been the basis for designating several national monuments.


Over 40 inches
30 to 40 inches
20 to 30 inches
10 to 20 inches
6 to 10 inches
< 6 inches
SUBREGIONS
1 Green River
2 Upper Main Stem
3 San Juan - Colorado
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
N
NORMAL ANNUAL PRECIPITATION
1969
Compiled by Upper Colorado Region Staff from data provided by E.S.S.A.
UPPER COLORADO REGION
COMPREHENSIVE FRAMEWORK STUDY
25 0 25 50 75 100 125 150 MILES

GPO 852 - 764



Panoramic view of canyonlands cut by Colorado River.

The Green River Subregion is underlain mostly by sedimentary rocks of the Tertiary and Mesozoic ages. These rocks contain vast deposits of coal, oil, and oil shale. The topography of the Green River Subregion, except in the Uinta Mountains, is more gentle than that of the Upper Main Stem and San Juan-Colorado Subregion. Rolling plains with shallow stream valleys are the rule.

In hundreds of square miles of the region there is no soil cover and bare sandstone and shale are exposed to the elements. Associated with the outcrops are large acreages of shallow soils that are less than a foot deep. Shallow soils are extensive at lower elevations but are several feet deep along stream valleys, on old pediment surfaces, and on uplands mantled by wind-deposited or loessial soils.

Resources

The water and land resources of the region are discussed in the following paragraphs.

Water

An average of about 95 million acre-feet of water a year is provided by precipitation in the Upper Colorado Region. About 80 million acre-feet of this is returned to the atmosphere by evapotranspiration. The remaining 15 million acre-feet is the streamflow and ground water recharge. Approximately 75 percent of the runoff in the region is produced from only about 14,200 square miles or 13 percent of the region. An additional 10 percent of the runoff comes from 9,500 square miles or about 9 percent of the region. The remaining 15 percent comes from about 78 percent of the watershed.

Snowpack in the high mountains of Colorado is a major source of water for the region.

Because of variations in precipitation, streamflows fluctuate widely from year to year and season to season. For the 1914-65 period undepleted streamflows have been estimated at an average of about 15 million acre-feet annually at Lee Ferry, the dividing point between the Upper and Lower Colorado River Basins with a range of from about 24 million acre-feet in 1917 to about 6 million acre-feet in 1934. About 70 percent of the annual runoff occurs during the April to July snowmelt period. After the snowmelt, flows dwindle rapidly and remain at relatively low base flows the remainder of the year.

Melting snow from high mountains provides water in Ruby Anthracite Creek in Colorado.

Extensive ground water reservoirs are located in consolidated rocks and alluvium throughout the region. The ground water is interrelated with surface runoff. During periods of high runoff water moves from the stream channels into adjacent aquifers as ground water recharge. Conversely, during low flow periods, ground water returns to stream channels and augments the streamflow. Although large quantities of ground water underlie the region, development has been limited to about 133,000 acre-feet a year under 1965 conditions. Most of the ground water withdrawn is used for municipal and industrial purposes.

In addition to state laws which provide for intrastate control of water, use of water in the Colorado River system is governed principally by three documents--the Colorado River Compact signed in 1922, the Mexican Water Treaty signed in 1944, and the Upper Colorado River Basin Compact signed in 1948.

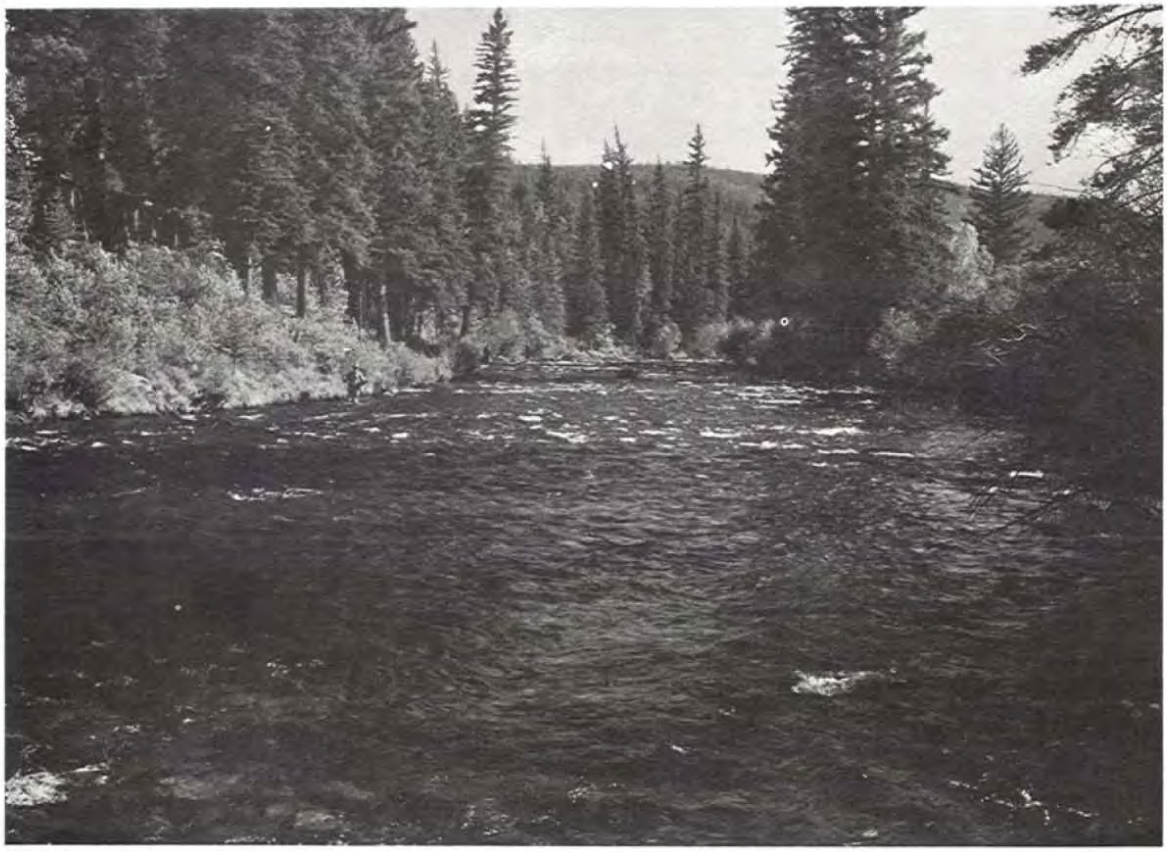
Among other provisions, the Colorado River Compact apportions to each of the Upper and Lower Colorado River Basins in perpetuity the exclusive beneficial consumptive use of 7,500,000 acre-feet of water of the Colorado

River system per annum. It further establishes the obligation of Colorado, New Mexico, Utah, and Wyoming, designated States of the upper division, not to cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75 million acre-feet for any period of 10 consecutive years.

The Mexican Water Treaty defines the rights of Mexico to the use of water from the Colorado River system. It guarantees the delivery of 1,500,000 acre-feet of Colorado River water annually from the United States to Mexico.

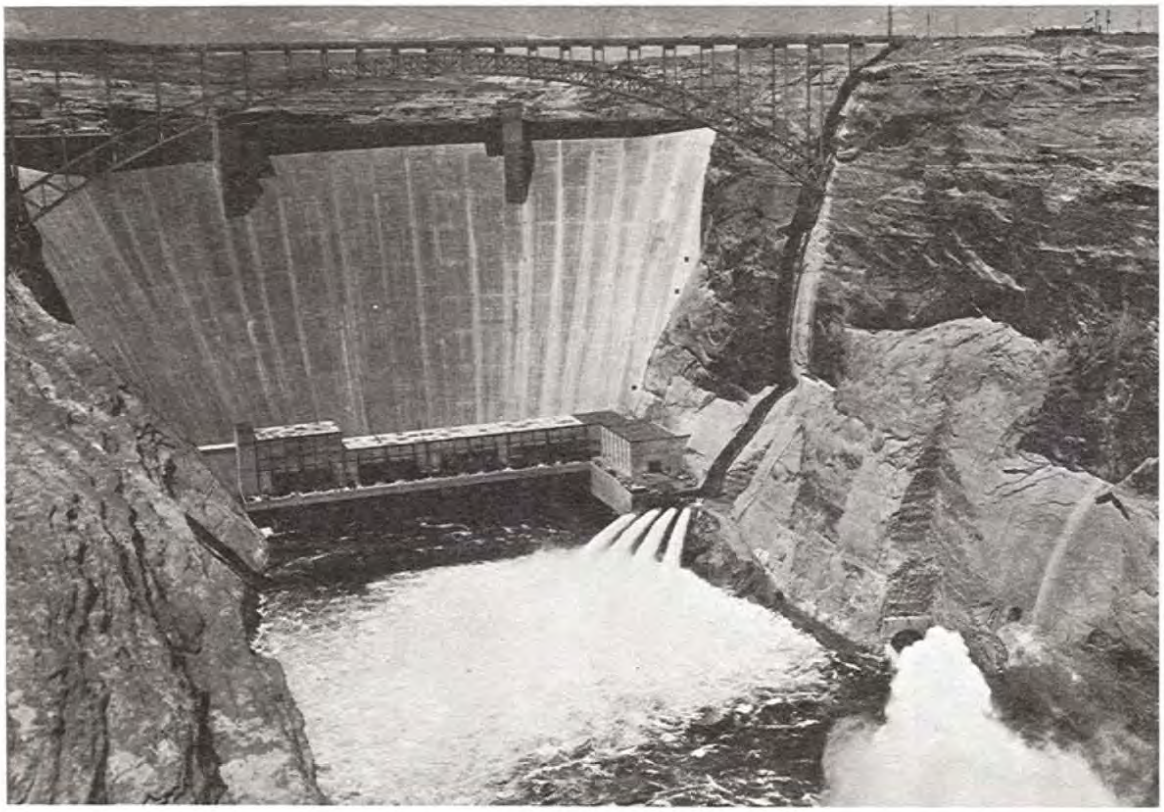
By the Upper Colorado River Basin Compact the use of water apportioned to the Upper Basin is divided among the Upper Basin States and principles are established to govern deliveries of water to meet the Lee Ferry flow obligations. By the compact, Arizona is granted the consumptive use of 50,000 acre-feet of water a year and the other States are each apportioned a percentage of the remaining consumptive use as follows: Colorado 51.75 percent, New Mexico 11.25 percent, Utah 23 percent, and Wyoming 14 percent.

The quality of surface water generally is very good in the Upper Colorado Region and except in a few areas is satisfactory for irrigation, livestock watering, recreation, and for municipal and industrial purposes. The average concentration of dissolved solids is generally less than 100 mg./l. in streams near the mountains. The weighted average concentration does not exceed 500 mg./l. in most main streams and their principal tributaries except in some lower reaches where concentrations occasionally may be as high as 3,000 mg./l. Water in the lower reaches of the main streams is classified as very hard. The quality of ground water varies widely but overall it is not as good as that of the surface water.



A reservoir upstream regulates streamflow and provides clear water of excellent quality for downstream use.

Suspended sediment concentrations and loads vary widely throughout the region. The sediment load is normally light in the upper reaches of the major streams but increases in the middle and lower reaches. Sediment concentrations have historically been detrimental to consumptive uses of water as well as to cold water fisheries and recreation. Prior to the construction of Colorado River Storage Project reservoirs, the average annual suspended sediment concentration measured on a long-term basis was about 6,000 p.p.m. at Lees Ferry. Since the closure of Glen Canyon Dam, average annual weighted concentrations at Lees Ferry have been reduced to less than 100 p.p.m.



Clear water being released from Glen Canyon Dam.

Biological quality of surface water, characterized by nutrients, dissolved oxygen, and bacteria concentrations, is considered very good, except for some localized problems. Drainage from abandoned and active mines is estimated to eliminate some 120 miles of stream fisheries.

Land

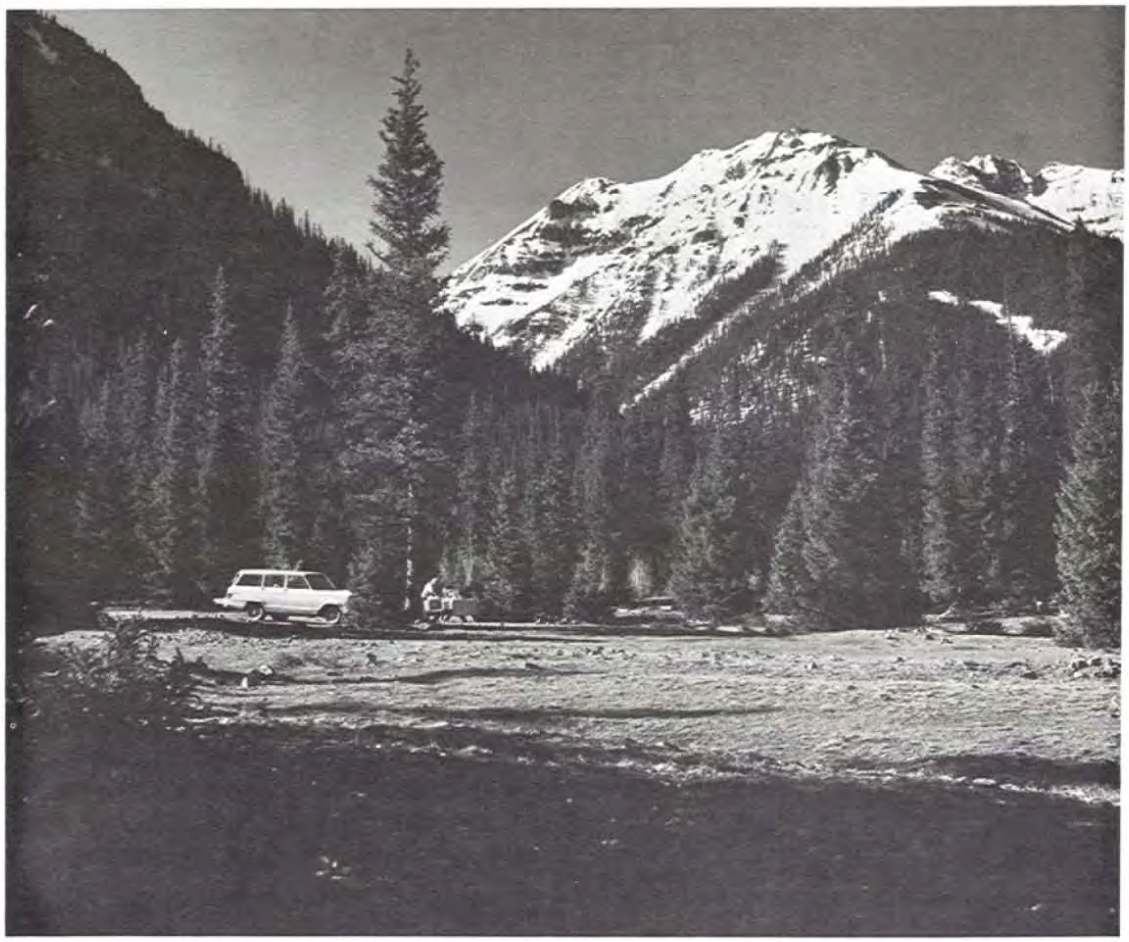
The Upper Colorado Region includes 72,639,000 acres, of which 72,234,000 acres are land areas and 405,000 acres are water bodies of more than 40 acres. Of the 72,234,000 acres of land, approximately 2,225,000 acres are cropped, 23,987,000 acres are in forests and woodlands, and the remaining 46,022,000 acres are in grass and browse rangelands, barren areas, and urban and built-up areas. Of the cropped land 1,622,000 acres are irrigated and 603,000 acres are dry cropland. The areas of alpine mountain peaks and barren and inaccessible land are extensive while the urban and built-up areas constitute less than 1 percent of the area.

Nearly two-thirds of the land area is in public ownership under Federal and State administration. The remainder is privately owned, with slightly more than half of this in ownership by corporations and

individuals, and the remainder in Indian tribal or individual ownerships held in trust by the Bureau of Indian Affairs.

Most of the lands of the region are managed under a multiple-use concept in order that the largest possible amounts of goods and services may be produced from the resource base. Conservation, including preservation of unique resources, is practiced to protect the resource base from deterioration in the course of development and production. Resource uses of the region include crop production, domestic livestock grazing, outdoor recreation, mineral production, timber production, and the preservation of wilderness and other public values. In addition, land is used as the site for industrial development and other occupancy.

Forests cover approximately one-third of the land area and contribute significantly to the regional economy through water production, recreational use, ranching operations, and an expanding forest products industry.



Typical forest scene in high mountains of the region.

Extensive outdoor recreational use is made of both public and private lands year-round. Recreational areas available to the public include the national forests, national parks and monuments, wilderness or primitive areas, and public domain lands as well as many state, local, and private developments.

The People

The Upper Colorado Region is sparsely populated. In 1965 the population of the economic subregions was about 337,000 and the average density was about three persons per square mile compared with a national average of 64.

On the basis of estimates for 1965 only two communities of the region have populations of more than 20,000--Grand Junction, Colorado, with 22,400 and Farmington, New Mexico, with 21,000. The next largest towns are Durango, Colorado, with a population of 11,200 and Rock Springs, Wyoming, with 10,300. All of the other communities have populations of less than 10,000. Only about 37 percent of the residents live in towns with populations of more than 2,500 inhabitants and the remainder are in rural areas.

In 1960 males outnumbered females in every age group except 20 to 39. Forty-eight percent of the people were age 20 to 64. At the extremes of the range were 44 percent of the population under 19 years of age with 8 percent of the population 65 and older.

Educational attainment of the people age 25 and over compared quite favorably with that of their counterparts in the Nation at large. In each subregion for both 1950 and 1960 the median number of school years completed by both males and females exceeded the national levels of accomplishment.

Approximately 69,000 Apache, Navajo, and Ute Indians reside in the region.

PART III

PRESENT STATUS OF DEVELOPMENT (1965)

This part summarizes the 1965 base year level of water and related land utilization, management, and development. The principal uses of water and land are presented and the major economic activity discussed.

The agricultural base in the region is primarily a cow-calf and sheep enterprise utilizing 1.5 million acres of irrigated and dryland feed crops and 60 million acres of Federal and private grazing land. Also marketed are cash crops from 50,000 acres, such as fruit, sugar beets, Moravian malting barley, and vegetables. Dry beans and wheat are also grown as cash crops on 301,000 acres of both dry and irrigated farms. Presently 124,000 acres of irrigated land are idle and 185,000 acres of dry cropland are not cropped annually.

Industrial development in the basin represents a substantial part of local economic activity. Remote location, limited supply of labor, and unavailability of capital resources have affected growth. Petroleum, molybdenum, coal, uranium, and trona dominate present production and value in the mineral industry. Thermal-electric power generation utilizing local coal resources has an installed capacity of 1,335 megawatts. Timber products harvested in 1965 amounted to 53 million cubic feet, of which about half, or 311 million board feet, was sawtimber.

The region is part of one of America's outstanding recreation and tourist areas in a quality environment setting. Abundant fishing and hunting exist for both residents and nonresidents.

Main-stem storage development provides 33 million acre-feet of storage regulation to meet outflow requirements from the region and allow for regional development. These facilities include 1,300 megawatts of installed capacity for hydroelectric power and have a large potential for water-based recreation.

1965 Water Development

The total water supply, which assumes no depletion by man's activities, averages 14.87 million acre-feet annually based upon the period 1914-65. On-site depletion and evaporation from reservoirs on the main stem of the Colorado River for long-term average or normalized conditions were 3.45 million acre-feet. The chart following page 24 depicts the 1965 normalized flow and depletions. Tables 1 and 2, page 24, show a breakdown of the depletion by subregion and states for the various uses.

Table 1 - Water uses by states, 1965, Upper Colorado Region

Type of use	On-site depletions in acre-feet					
	Arizona	Colorado	New Mexico	Utah	Wyoming	Total
Municipal and industrial	1,500	15,900	2,400	5,000	2,600	27,400
Electric power (thermal)		3,200	15,300	1,300	3,400	23,200
Minerals	-	16,900	1,600	9,400	5,800	33,700
Fish and wildlife	600	2,700	400	7,900	100	11,700
Recreation	-	700	100	300	200	1,300
Stock-pond evaporation and livestock use	1,100	20,700	2,400	6,200	4,500	34,900
Subtotal	3,200	60,100	22,200	30,100	16,600	132,200
Irrigation						
Consumptive use	4,400	991,300	76,000	404,400	221,200	1,697,300
Incidental use	500	198,700	15,000	81,000	20,400	315,600
Reservoir evaporation	2,000	27,100	31,700	30,200	23,900	114,900
Total irrigation	6,900	1,217,100	122,700	515,600	265,500	2,127,800
Export						
Diversions		417,100		109,500		526,600
Reservoir evaporation		12,300		11,400		23,700
Less water import				(2,600)		(2,600)
Subtotal of all above	10,100	1,706,600	144,900	664,000	282,100	2,807,700
Main-stem reservoir evaporation						643,000
Region total						3,450,700

Table 2 - Water uses by subregions, 1965, Upper Colorado Region

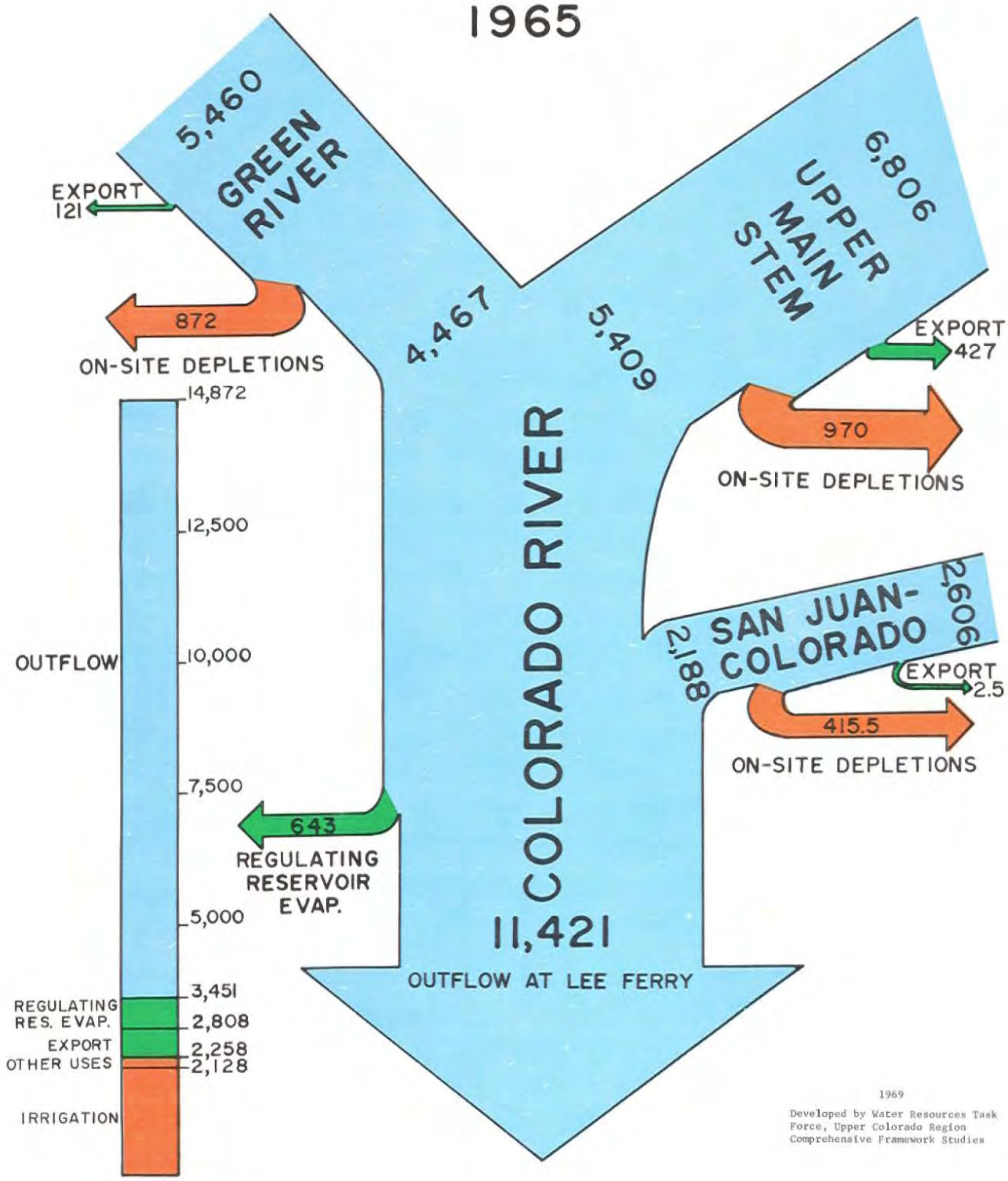
Type of use	On-site depletions in acre-feet			
	Green River	Upper Main Stem	San Juan-Colorado	Region total
Municipal and industrial	7,900	12,300	7,200	27,400
Electric power (thermal)	6,300	1,600	15,300	23,200
Minerals	17,200	11,900	4,600	33,700
Fish and wildlife	8,000	1,300	2,400	11,700
Recreation	500	500	300	1,300
Stock-pond evaporation and livestock use	13,300	11,200	10,400	34,900
Subtotal	53,200	38,800	40,200	132,200
Irrigation				
Consumptive use	662,400	747,400	287,500	1,697,300
Incidental use	113,600	167,300	34,700	315,600
Reservoir evaporation	42,400	16,900	55,600	114,900
Total irrigation	818,400	931,600	377,800	2,127,800
Export				
Diversions	109,500	414,600	2,500	526,600
Reservoir evaporation	11,400	12,300		23,700
Less water import			(2,600)	(2,600)
Subtotal of all above	992,500	1,397,300	417,900	2,807,700
Main-stem reservoir evaporation	67,000		576,000	643,000
Region total	1,059,500	1,397,300	993,900	3,450,700

UPPER COLORADO REGION

WATER SUPPLY (1914-1965),

ON-SITE DEPLETIONS & OUTFLOW FOR 1965

(In Thousands of Acre Feet)



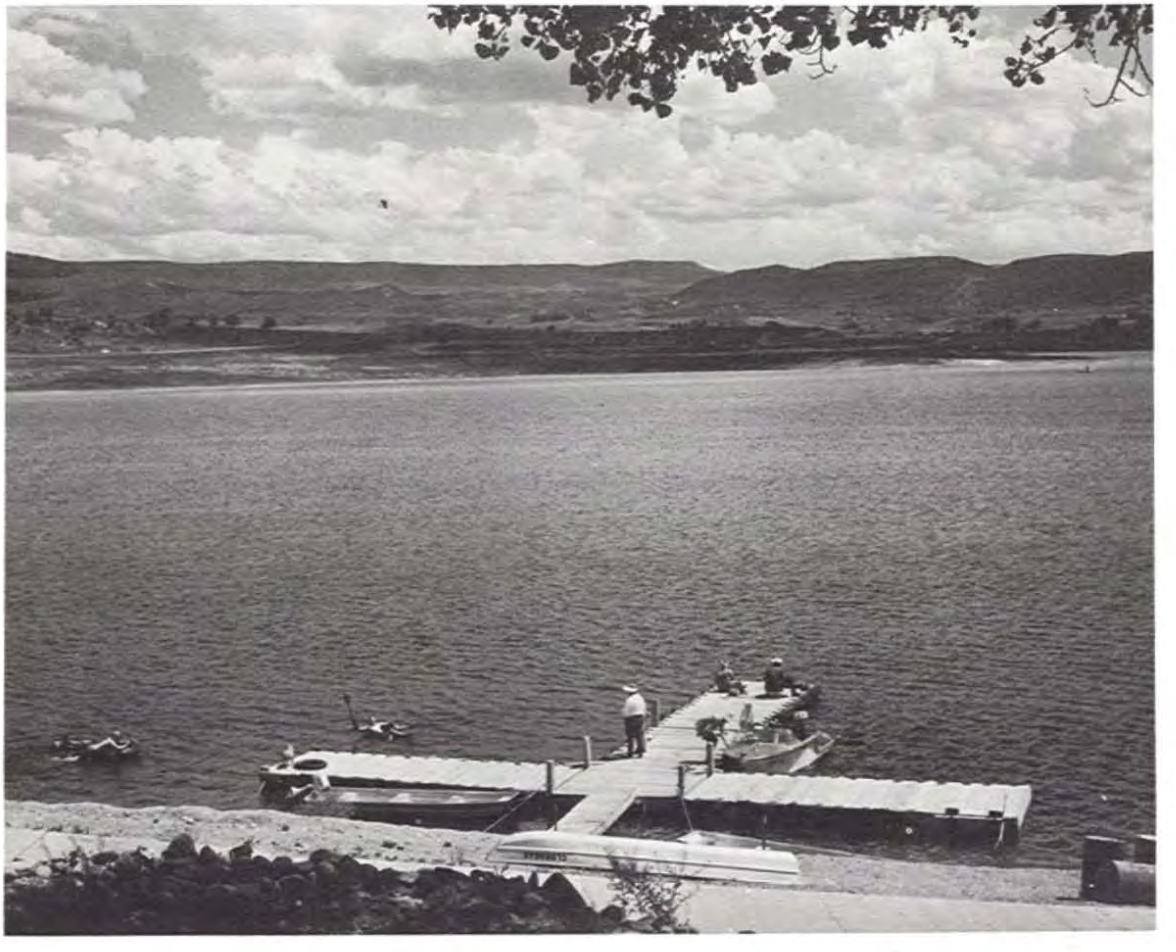
1969

Developed by Water Resources Task Force, Upper Colorado Region Comprehensive Framework Studies

Irrigation and associated depletions accounted for about 62 percent of the 1965 use, main-stem reservoir evaporation accounted for about 19 percent, exportation to adjacent regions 15 percent, and the remaining 4 percent was used for all other purposes.

Water is exported by transmountain diversion to the Great Basin Region in Utah and to the Platte and Arkansas Rivers and Rio Grande in Colorado. A very small import from the Great Basin existed in 1965.

Active reservoir capacity totaled about 29.7 million acre-feet (MAF) in 1965, including main-stem storage of 25.2 MAF which regulates flow to the Lower Colorado. About 4.5 MAF of storage was used primarily for conservation purposes associated with irrigation. Other uses include municipal and industrial water supply, recreation, fish and wildlife, and flood control.



Crawford--a multipurpose reservoir for the Smith Fork Project in western Colorado.

Quality of water at the upper reaches near mountain divides is excellent; downstream the quality is degraded as the result of hydrologic, geologic, and man-made influences. The average total dissolved solids of the Colorado River at Lees Ferry, Arizona, was 586 parts per million for 1941 to 1966, adjusted to present conditions of development.

Some problems occur because of existing waterborne diseases, improper treatment of water and solid waste, radiological hazards, mosquitoes, and air pollution.

Flood control measures in operation consisted of flood control storage of about 1.2 million acre-feet and multiple-use land treatment measures on 1.8 million acres of watershed area. Substantial additional beneficial effects accrue from other reservoirs not operated specifically for flood control.

1965 Land Ownership and Use

About two-thirds of the land was owned or administered by Federal and state governments, as illustrated by the chart entitled "Land Ownership and Administrative Status, 1965."

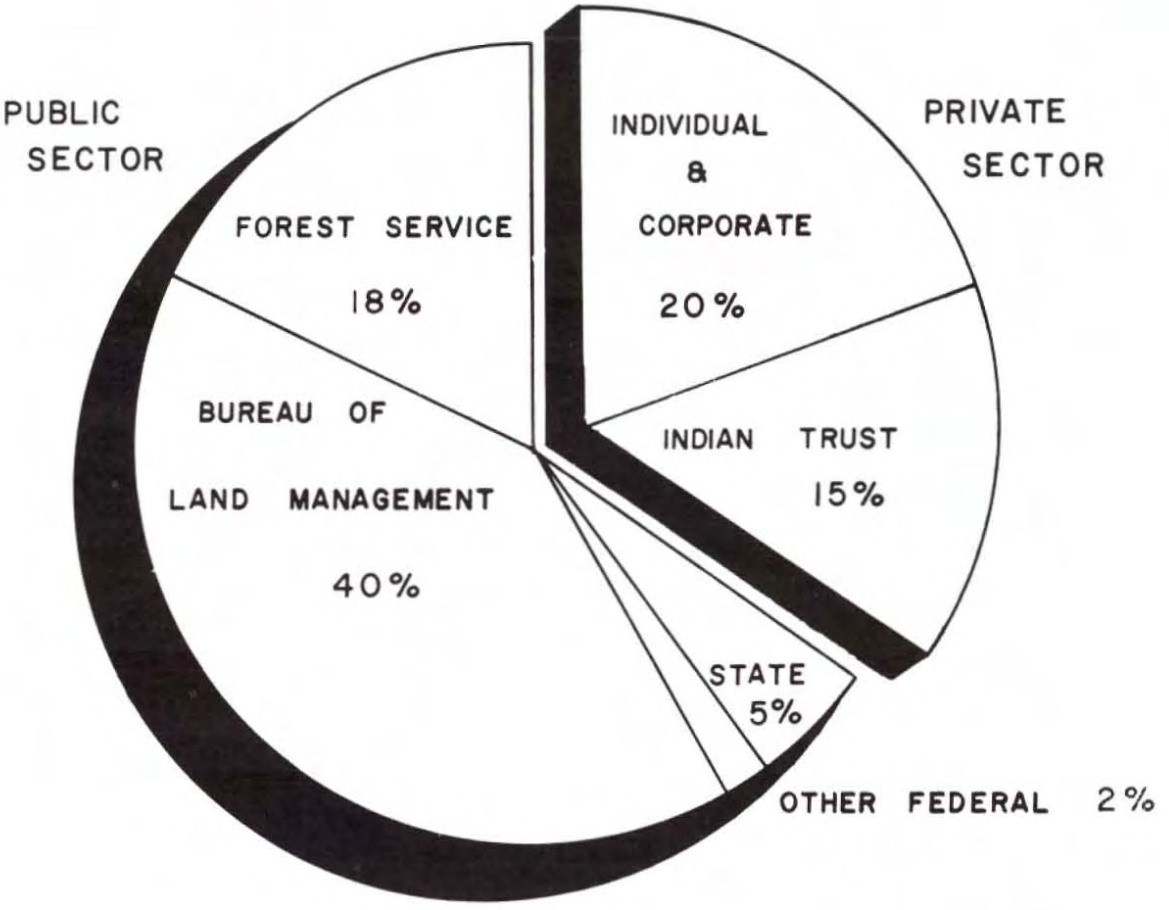
There are 72.6 million acres, or 113,496 square miles, in the region. Multiple land use in 1965, with concurrent uses on some land, was as follows.

Multiple land uses--1,000 acres

Cropland and pasture		Wilderness, natural, historic, and cultural	2,636
Irrigated	1,622		
Dry	603		
Livestock grazing	60,442	Developed mineral production	37
Timber production[1/]	9,419	Developed fish and wildlife	299
Urban and industrial	331	Military	114
Transportation and utilities	598	Classified watersheds	258
Developed recreation	71	Water area (40 acres or more)	405

1/ Economic subregions--other figures hydrologic subregions.

LAND OWNERSHIP AND ADMINISTRATIVE STATUS, 1965, UPPER COLORADO REGION



Hay, grass and legume mixtures, alfalfa, small grain, and irrigated pasture for feeding of livestock were produced on almost 88 percent of the irrigated lands. Cash crops such as malting barley, wheat, orchards, sugar beets, and truck crops were raised on 4.6 percent of the available irrigated land. In the average year 7.7 percent of the land remains idle.

Total lands under irrigation including idle for the five states are as follows:

Irrigated acreage

State	Green River	Upper Main Stem	San Juan-Colorado	Region
Arizona	--	--	10,900	10,900
Colorado	117,400	609,900	186,700	914,000
New Mexico	--	--	52,900	52,900
Utah	283,800	8,500	40,300	332,600
Wyoming	311,100	--	--	311,100
Total	712,300	618,400	290,800	1,621,500

Alfalfa grass being cut and chopped for livestock feed on this farm in Silt Project, Colorado.

On dry cropland, hay and cropland pastures use 19 percent of the land; feed grains and wheat use 30 percent; and dry beans and miscellaneous crops use 20 percent. Fallowed, temporarily idle, or conservation use accounts for 29 percent, and marginal land retired to grasses uses the remaining 2 percent.

Livestock grazing takes place on 84 percent of the land area. The 60.4 million acres of range provide seasonal forage for the majority of the region's 850,000 cattle and calves and the 1,300,000 sheep and lambs. Forage production was 6.3 million AUM's in 1965, an AUM being the forage required to feed one cow and one calf for 1 month. Grazing use depends upon the irrigated land base for winter feed in this livestock-oriented region.

Sheep are being moved from summer rangeland to home ranch for winter feeding.

Of 27.4 million acres of forest land, 9.4 million acres are commercial timberland containing 56.8 billion cubic feet of sawtimber. In 1965, 53.0 million cubic feet of timber were removed, about half of which, or 311 million board feet, was sawtimber. Of the timber harvested 98 percent was softwood.

The greatest urban and industrial uses were near such cities as Grand Junction, Colorado, and Farmington, New Mexico.

Practically all public lands and most of the private lands were used for recreation. Developed land areas of 71,000 acres include campgrounds, picnic areas, etc. Of the 516,000 water-surface acres in the region, 337,000 acres are available and suitable for developed recreation.

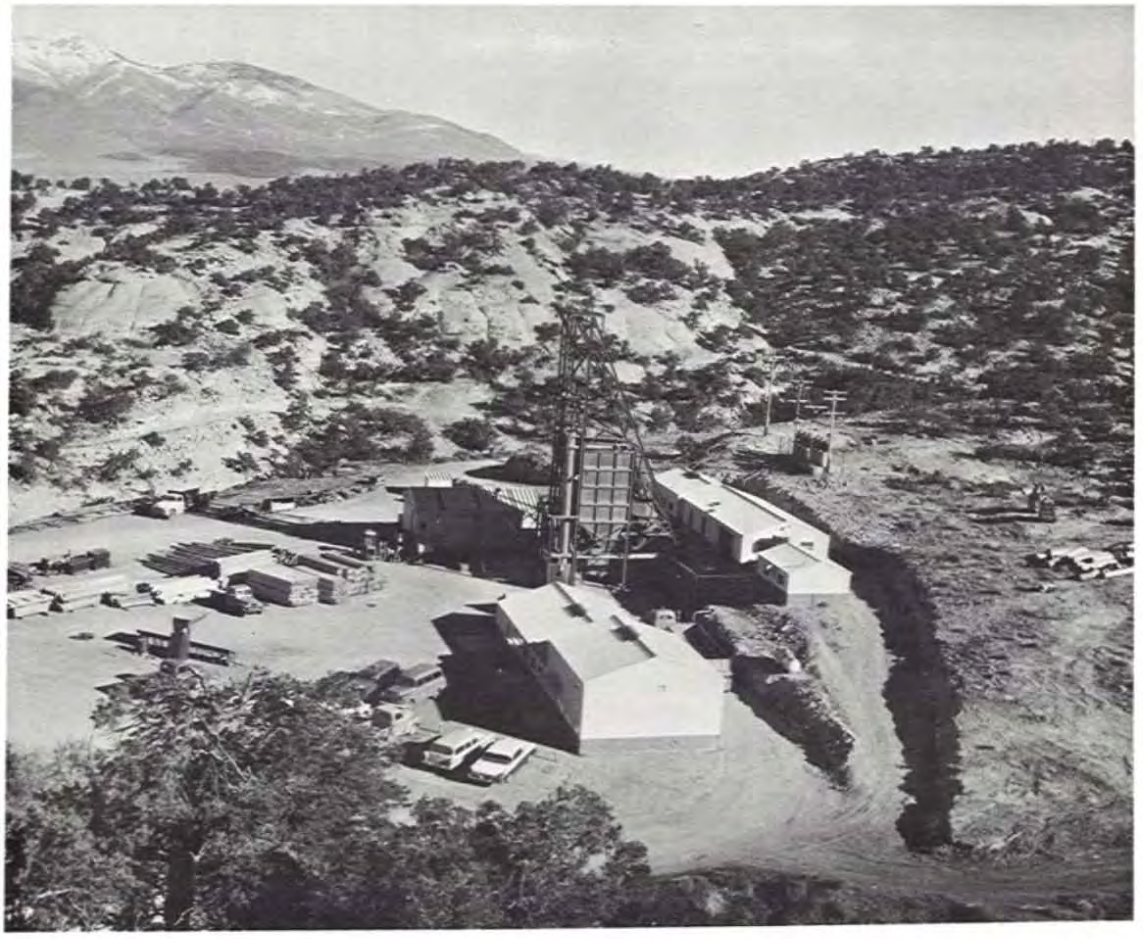
Wilderness and primitive areas, practically all part of the National Wilderness System created in 1964, can be used for fish and wildlife, recreation, grazing, watershed, scientific study, and other compatible uses.

Boating and fishing are popular forms of recreation on reservoirs in the region.

The region provides habitat for significant populations of wildlife and fish, including rare, endangered, or unique species. Nearly 400,000 acres of water provide fishing and to a lesser extent waterfowl hunting.

Military uses include military camps, firing ranges, and mineral reserves. Classified watersheds are those areas specifically treated for such uses as urban water supplies to keep the runoff pure or protect areas below the watersheds.

Developed mineral lands used for access roads, strip mining, oil wells, and mill-site and mine-shaft buildings total 37,000 acres. However, over 2 million undeveloped acres are open for mineral filing and development, with some restrictions as to alternative uses.



Surface plant of a typical medium-sized uranium mine in the Four Corners area.

Economic Activity

This section summarizes the historical and 1965 base economic data, including population, employment, income, and industrial activity.

Population

The estimated population for 1965 was 337,000 (for the economic subregions). Population changes by economic subregions from 1940 to 1965 are indicated below. Thus the population increased 24 percent from 1940 to 1965 but from 1960 to 1965 decreased slightly less than 1 percent. The overall growth rate from 1940 to 1965 was about half the national rate and about a fifth of the rate for the 11 western states. The population trends vary widely by subregions. In the Green River Economic Subregion the population was about the same in 1960 as in 1940, following an increase from 1940 to 1950 and then a decline from 1950 to 1960. Population in the Upper Main Stem Economic Subregion has trended steadily upward from 1940 to 1965. In the San Juan-Colorado Economic Subregion population declined slightly from 1940 to 1950 and then spurted up 74 percent from 1950 to 1960. There was a slight decline from 1960 to 1965.

Population

Economic Subregion[1]	Year			
	1940	1950	1960	1965 (Est.)
Green River	103,199	110,460	102,917	100,579
Upper Main Stem	105,099	109,060	128,079	136,725
San Juan-Colorado	63,237	61,634	107,045	99,625
Total	271,535	281,154	338,041	336,929

1/ The population for 1965 was 366,029 in the hydrologic region.

Employment

The regional employment in 1965 totaled 111,390, or 33.1 percent of the population, as compared with employment totals of 79,181, 95,717, and 111,642 recorded in the census years 1940, 1950, and 1960, respectively (Table 3). While there was relatively little change in the total employment over the 1960-65 period, many of the individual industries during the period experienced significant shifts in their relative positions. Government, services, trade, and finance-insurance-real estate had substantial increases in their percentage share of the region's total employment. Nominal increases or declines were experienced by the remaining industry categories.

Although the region is historically an agricultural and mining area, by 1965 wholesale and retail trade, services, public utilities, and government accounted for over half the total employment.

Agricultural industry employment dropped from 38.2 percent of the total in 1940 to 11.5 percent in 1965, primarily due to enormous increases in efficiency through farm consolidations, mechanization, and other technological innovations.

Table 3 - Population, employment, and participation rate, 1940-1965
Upper Colorado Region

	1940	1950	1960	1965
Population	271,535	281,154	338,041	336,929
Total employment	79,181	95,717	111,642	111,390
Participation rate (employment/ population)	0.292	0.340	0.330	0.331
Employment by Industry				
Agriculture, forestry, and fisheries	30,280	26,832	15,679	12,793
Mining	10,399	12,956	15,735	13,495
Contract construction	4,097	6,496	9,560	7,795
Manufacturing				
Food and kindred products	767	890	1,481	1,482
Lumber and wood products	800	1,100	1,318	1,970
Printing and publishing	439	634	928	824
Other and miscellaneous	1,432	1,315	2,366	1,887
Transportation, communication, and other public utilities	5,718	9,588	9,926	9,884
Wholesale and retail trade	9,949	14,907	21,375	22,631
Finance, insurance, and real estate	851	1,454	2,813	3,216
Services				
Lodging and personal	2,627	3,358	4,736	5,719
Business and repair	1,594	2,590	2,700	2,666
Entertainment and recreation	565	759	889	1,500
Private households	1,693	1,377	2,343	2,338
Medical, educational, and other professional services	5,305	7,627	14,198	16,650
Government	2,665	3,834	5,595	6,540

Mining employment increased 2 percent annually until 1960, principally due to increased oil, gas, and uranium activity. The last 5 years employment decreased because of increased productivity per man-hour and general curtailment of uranium operations.

A surprising percentage of the total employment is the wholesale and retail trade; however, the increased employment is due primarily to the large number of part-time and family workers employed by trade establishments. The relative importance of services has increased persistently at the annual rate of 3.6 percent.

Personal income

Personal income represents a composite of all wage and salary payments, proprietors' income, property income, and transfer payments received by residents of an area during a specific time period, computed prior to the deduction of income and other direct personal taxes but after deduction of individual contributions to government retirement and social insurance programs. The bulk of the personal income received is derived from the sale of productive services, i.e., wage and salary payments, proprietors' income, and property income.

Estimates of real personal income (1965 dollars) for the region, both total and per capita, are tabulated below for selected years between 1940 and 1965. As a whole, total personal income increased from approximately $260 million in 1940 to about $730 million in 1965.

Personal income,1/ 1940-65
Upper Colorado Region

	Green River Subregion	Upper Main Stem Subregion	San Juan-Colorado Subregion	Upper Colorado Region
1940				
Total ($1,000)	104,146	108,627	47,602	260,375
Per capita	1,007	1,027	750	956
1950				
Total ($1,000)	164,564	154,826	76,650	396,040
Per capita	1,484	1,419	1,237	1,405
1959				
Total ($1,000)	192,671	230,787	181,797	605,255
Per capita	1,922	1,848	1,479	1,839
1965				
Total ($1,000)	213,104	333,522	183,372	729,998
Per capita	2,119	2,439	1,841	2,167

1/ 1965 dollars.

For 1965, per capita income lagged behind the national average ($2,760) in all but four counties: Hinsdale, Eagle, Summit, and Pitkin, Colorado. Between 1960 and 1965, per capita income in Eagle, Pitkin, and Summit Counties experienced the largest percentage growth, increasing by 78 percent, 72 percent, and 68 percent, respectively. This significant growth can be attributed to the major developments in winter recreation occurring in the area between 1960 and 1965. Conversely, many counties experienced a decline in per capita income in the 1960-65 period.

Industrial activity

The present economy of the Upper Colorado Region is largely resource oriented. This orientation is not restricted entirely to agriculture, forestry, and mining but includes the region's recreational endowment and the associated contribution to basic income. Industrial output levels of total gross output by major groups are shown below for each subregion.

Total gross output by industry
Upper Colorado Region, 1965
(Unit--million dollars)

	Green River Subregion	Upper Main Stem Subregion	San Juan-Colorado Subregion
Producing industries			
Agriculture	46.2	57.4	22.6
Forestry	2.3	3.3	2.8
Mining	214.9	122.2	183.6
Manufacturing	18.8	57.6	30.2
Noncommodity-producing industries	259.2	347.3	254.5
Total	541.4	587.8	493.7

In 1965 primary industries, defined as agriculture, forestry, and mining, accounted for 43 percent in the Green River Subregion, 31 percent in the Upper Main Stem Subregion, and 42 percent of total processing sector output in the San Juan-Colorado Subregion. The mineral industry overshadows all other activity among the primary industries in all of the subregions. In the San Juan-Colorado Subregion 88 percent of primary industry output results from minerals, the Green River Subregion follows closely with 82 percent, and the Upper Main Stem Subregion is somewhat lower, with mineral production accounting for about two-thirds of primary industry output.

The manufacturing industries, although increasing in importance to the economic base, represent a small part of total regional economic activity. In the Upper Main Stem manufacturing represents 10 percent of

the total activity, in the San Juan-Colorado 6 percent, and in the Green River about 4 percent. Also, manufacturing activity in the present economy relates largely to the processing of agricultural and forestry products.

Noncommodity-producing industries contribute the greatest share to total regional economic activity. These business sectors account for 59 percent of total processing sector output in the Upper Main Stem Subregion, 51 percent in the San Juan-Colorado Subregion, and 48 percent in the Green River Subregion.

Aerial view of FMC Corporation's sodium carbonate mine and plant, about 20 miles west of Green River, Wyoming.

It is within the noncommodity group that the major effects of outdoor recreation and tourism are reflected. Nonresident recreation expenditures for goods and services represent new money brought into the region.

Value added, made up of wages and salaries, profits, and other income; Federal, state, and local taxes; and depreciation, totaled $469 million in the Upper Main Stem Subregion, $350.6 million in the Green River Subregion, and $322.7 million in the San Juan Colorado Subregion for the year 1965.

Value added for selected major industry groups
(Unit--million dollars)

	Green River Subregion	Upper Main Stem Subregion	San Juan-Colorado Subregion
Producing industries			
Agriculture	29.5	32.0	15.8
Forestry	2.0	2.9	2.4
Mining	101.3	47.9	72.3
Manufacturing	5.6	19.5	9.5
Noncommodity-producing industries	92.6	171.8	111.7

To complete the measurement of regional accounts in terms of broad categories of the economy, the gross regional product was estimated for 1965 and is tabulated below. In accordance with methods used for estimating national accounts, gross regional product (GRP) is the sum of four major expenditure components: (1) personal consumptive expenditures, (2) government purchases of goods and services, (3) gross private investment, and (4) net export of goods and services.

Gross regional product, 1965,
Upper Colorado Region
(Unit--million dollars)

Green River Subregion	350.6
Upper Main Stem Subregion	469.0
San Juan-Colorado Subregion	322.7
Region	1,142.3

The value of imports for each subregion is as follows: Green River Subregion $494.9 million, Upper Main Stem Subregion $382.8 million, and the San Juan-Colorado Subregion $444.1 million.

PART IV

RESOURCE AVAILABILITY

Water

In order to ascertain the amount of water remaining over and above present (1965) uses, reconstruction of present modified flows was accomplished in each of the three subregions for the study period 1914 to 1965, the premise being that the general hydrologic conditions of that period might reasonably be expected to reoccur in the future.

The 1914-65 study period was selected as the longest period for which reliable records were generally available in the region. The procedure is one of adding to the historic annual flows at the outflow points of each subregion past annual depletions, the result being virgin or undepleted annual outflows. Then, assuming that all present uses were in effect throughout the 1914-65 period, the present (1965) normalized use in the subregion was deducted from the virgin flow, the result being the present (1965) modified flow. In each subregion the studies reflect the use of waters produced locally within the subregion. In other words, the flows of the Green River and the Colorado River at their confluence are not considered a local inflow to the San Juan-Colorado Subregion. The data from the three subregions can thus be summed up to ascertain the respective results at Lee Ferry, the outlet of the total region. In the study no attempt has been made to account for changes or differences in natural losses, sometimes referred to as "salvage." A considerable amount of such salvage water, however, is accounted for in the computation of reservoir losses in the Main Stem reservoirs.

Water supply available in 1965,
Upper Colorado Region
(Unit--1,000 acre-feet)

	Green River Subregion	Upper Main Stem Subregion	San Juan-Colorado Subregion	Upper Colorado Region
Virgin water supply (1914-65)	5,460	6,806	2,606	14,872
Level of depletions (1965)	993	1,397	418	2,808
Modified flow (1914-65) (excluding main-stem evaporation)	4,467	5,409	2,188	12,064
Main-stem reservoir evaporation normalized (1965)	67	--	576	643
Residual flow	4,400	5,409	1,612	11,421

The availability of this water for future use is limited by physical conditions including the availability of water at or near proposed uses. Other constraints include institutional regulations which must recognize compacts and water laws, patterns of use which determine the extent of storage regulation required, and economic considerations and impacts.

The maximum recoverable ground water in the upper 100 feet is estimated at 17 million acre-feet; because of poor permeability, an additional 98 million acre-feet is not readily available. Only 132,000 acre-feet was pumped in 1965. Economics and water quality considerations may limit large-scale developments in the future.

Land

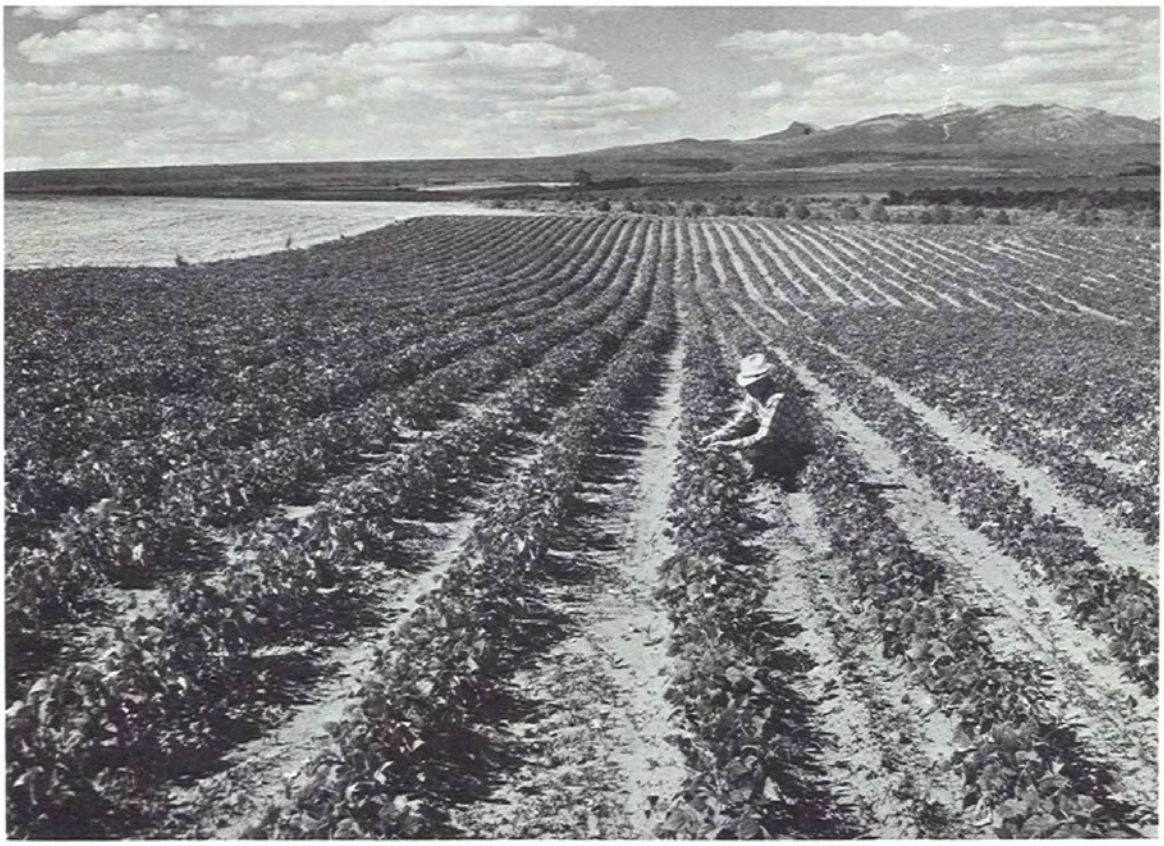
All of the 72.6 million acres (including water surface area) are presently being used for one or more purposes. Lands presently suitable and available for development under the multiple-use concept are (1) grazing lands - 54.6 million acres; (2) commercial timber production - 9.4 million acres; (3) 1.6 million irrigated acres present, plus 7 million acres potentially irrigable without considering water development; (4) dry cropland - 603,000 acres; (5) sufficient amounts, although not fully inventoried, for wilderness, primitive, outstanding national, historic, cultural, and scenic rivers; (6) urban, industrial, transportation, and utilities; (7) developed recreation, fish and wildlife; and (8) developed minerals. About 41 million acres have been identified as key habitat for wildlife. Nearly all public land is available for extensive use as undeveloped recreation and hunting areas.

Other Resources

Agriculture

If an economic water supply can be obtained, potential exists for irrigation of over 7 million acres of new land. About one-third of existing irrigated lands need additional water for best production. Irrigated cropland yields can be increased greatly by providing supplemental water, installing drainage systems, improving irrigation systems, and adopting cultural management practices.

Selected suitable areas totaling 603,000 acres are dry-farmed and will continue as such except for those acreages converted to irrigation. Dry cropland production can be increased by improving cultural management practices such as use of improved varieties, conserving soil moisture, maintaining soil fertility and reducing erosion.

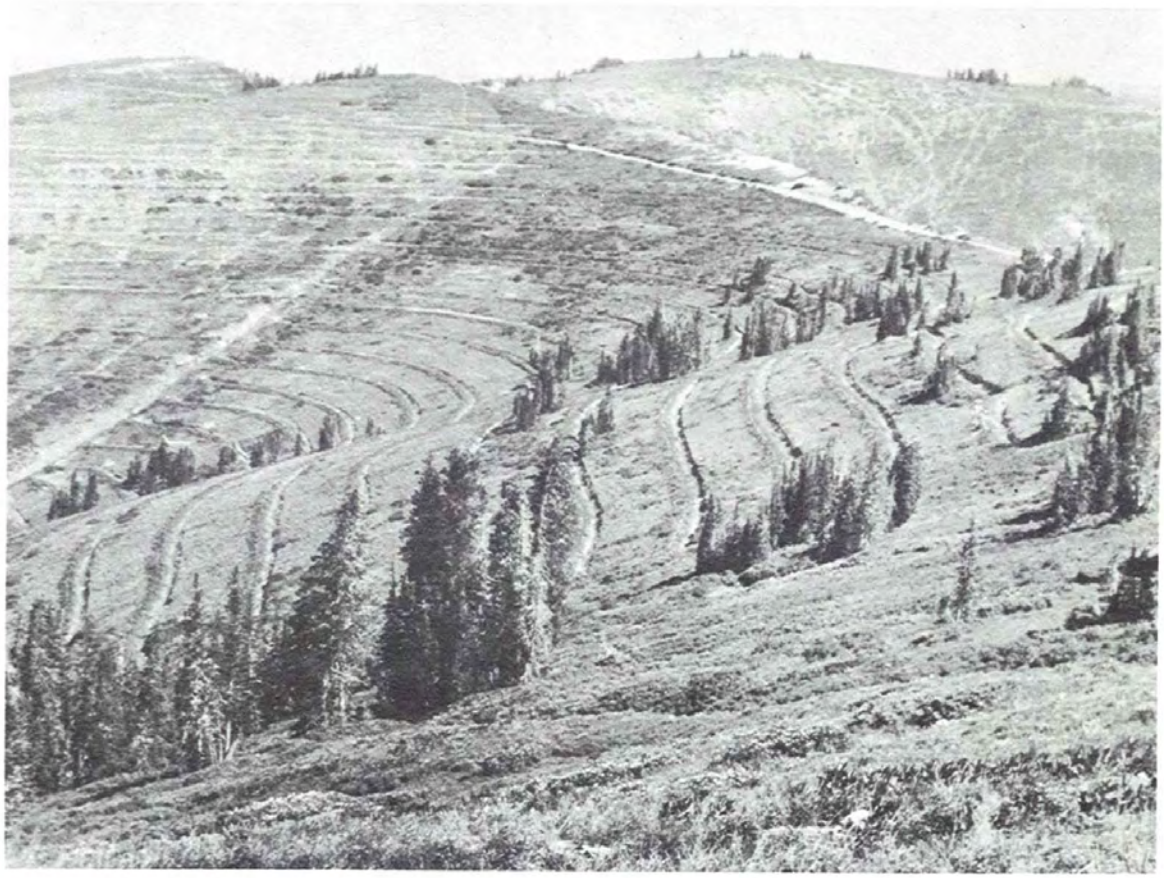


Planned Federal irrigation project will provide dependable water supply for these dry croplands for increased production of diversified crops.

Natural and seeded range and forest and alpine lands are used for grazing. Approximately 54.6 million acres of the 60.4 million acres presently used are suitable and available for future use. The present production of nearly 6 million AUM's can be increased to more than 9 million using only the suitable lands.

Timber

For commercial timber production, 9.4 million acres are suitable and available; an additional 900,000 acres of commercial forest land have been reserved from production. The annual sustained yield potential of timber products is 340 million cubic feet out of the total growing stock of 14.5 billion cubic feet. To meet national timber demands and reach its potential, the harvest can be increased by a vigorous marketing and research program, utilization studies, and intensive timber management. The development of the timber resources must be geared to multiple-use management with full consideration for protection from wildfire and insect-disease attacks.

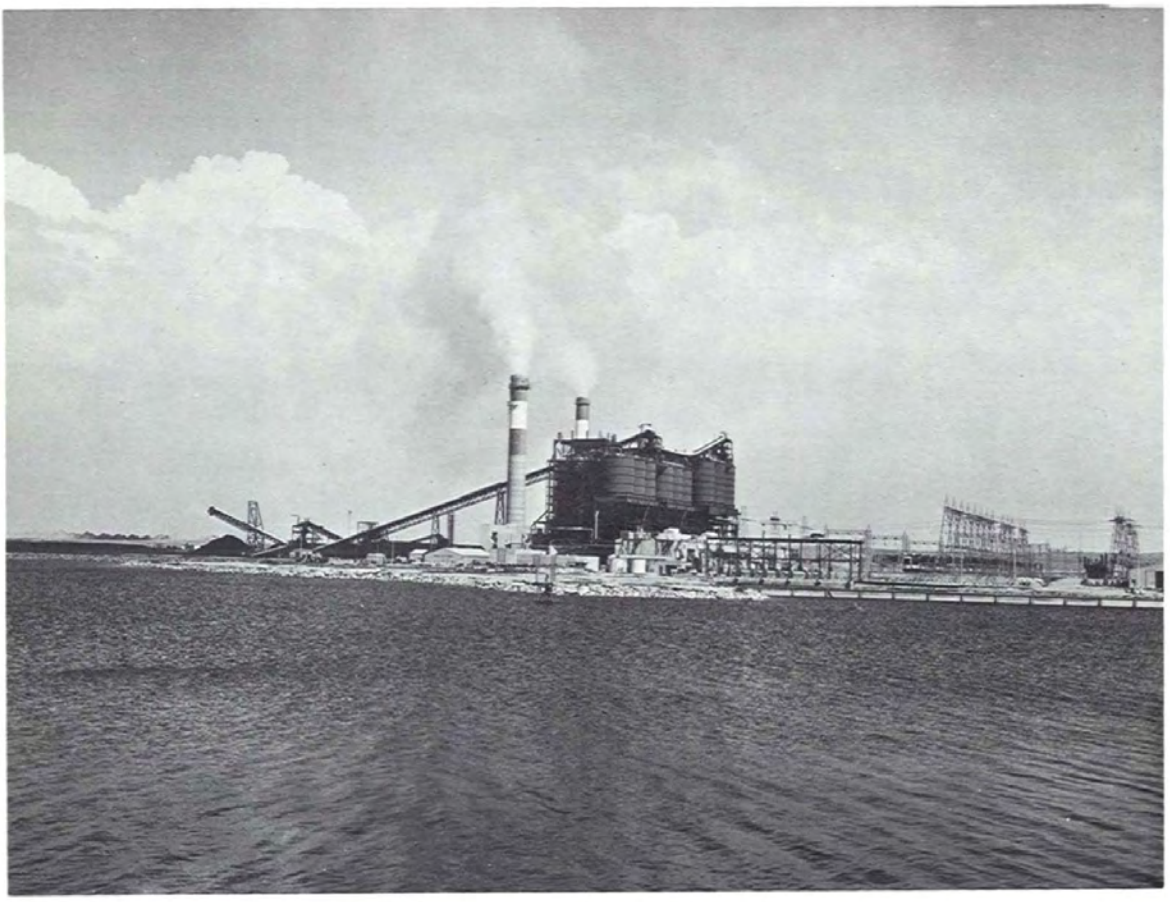


Contour trenching to reduce sediment loss and runoff on steep mountain slopes.

Electric power

The capacity of present hydroelectric plants totals 1,300 megawatts, of which the bulk is at Flaming Gorge, Glen Canyon, and the Curecanti Unit, parts of the Colorado River Storage Project. These plants and others to be constructed as part of the CRSP will probably remain in service beyond 2020. Some small or old plants may be retired from service. Most of the significant hydroelectric sites have been previously studied and these have a potential capacity of 1,800 megawatts.

Thermal-electric capacity now totals 1,335 megawatts. New plants will generate most of the future power production. Raw materials for nuclear fuels as well as very large coal resources for thermal generation are available.

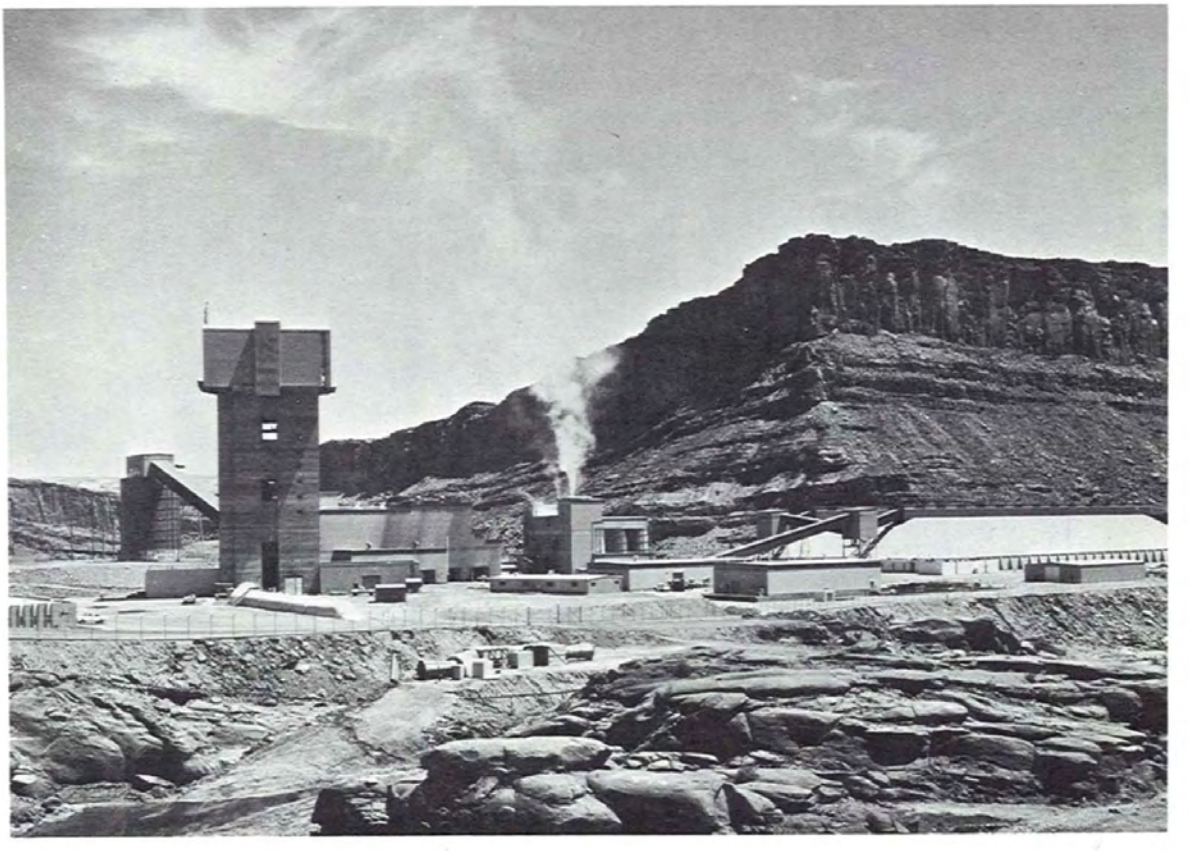


Arizona Public Service Company's Four Corners Powerplant near Farmington, New Mexico.

Minerals

Petroleum, uranium, coal, molybdenum, and trona, produced in significant quantities during the 1947-65 interval, generally are available as reserves or resources in volumes sufficient to meet all foreseeable demands through 2020.

Total estimated crude oil resource is 6.7 billion barrels, of which 845 million barrels are known reserve. Total natural gas resource is 103 trillion cubic feet, of which 10 trillion cubic feet are known reserve. Of the estimated 141 billion tons of coal, 68 percent is bituminous, and practically all the remainder subbituminous. About one-half of all the coal is considered recoverable. Fifty-five percent of the coal is located in the Green River Subregion. The oil shale deposits of the region constitute the largest undeveloped energy source of the United States. They are estimated to have a potential of yielding over 2 trillion barrels of shale oil.



Texas Gulf Sulfur Company's Cane Creek potash mine near Moab, Utah.

There is a wide variety of saline minerals and cement, sand, and gravel resources. Principal mineral resources are shown in Table 4.

Increased production facilities would increase utilization of resources as economic justification and technical capability materialize.

Recreation and fish and wildlife

The region is ideally suited to meet more than local requirements for recreational activity and also fill a portion of the demand from the entire Nation. Resources are generally available to meet most types of recreation needs; however, water surface is not available to meet all projected needs, generated by nonresidents, by 2020.

Generally there are ample resources available to meet fishing and waterfowl hunting needs if minimum flows in streams and reservoir conservation pools are provided. If adequate conservation of the 41 million acres of key wildlife habitat areas is practiced, its capacity may even be improved.

Table 4 - Principal mineral resources, Upper Colorado Region

Resource	Quantity	Location and Remarks
Uranium in sandstone	127,000 tons	Mostly San Juan-Colorado
Uranium in phosphate rock	175,000 tons	Green River, very low grade
Vanadium	240,000 tons	Exploitable within uranium deposits
Thorite	3,900 tons	Upper Main Stem
Helium	41 billion cu. ft.	2/3 Green River, 1/3 San Juan-Colorado
Gilsonite	36 million tons	Green River
Bitumen	15 million barrels	60 percent Green River; 40 percent San Juan-Colorado
Lead	1.5 million tons	Upper Main Stem and San Juan-Colorado
Zinc	2.5 million tons	
Copper	0.25 million tons	Over ½ in Upper Main Stem. Most of remainder in San Juan-Colorado
Silver	555 million ounces	
Placer gold	2 million ounces	
Iron ore	5 million tons	65 percent iron, Upper Main Stem
Molybdenum	8 million tons	Mostly Upper Main Stem, tungsten as byproduct.
Phosphate rock	5,850 million tons	Mostly Green River
Potash	260 million tons	Minable by conventional methods
Pyrite	Multi-million ton deposits	Dolores County, Colorado 50 percent sulfur
Trona	67 billion tons	Source of natural sodium carbonate
Sand and gravel		Widely distributed throughout the region
Crude oil	6.7 billion barrels	Mostly in Green River
Natural gas	103 trillion cu. ft.	Mostly in Green River
Coal	141 billion tons	Widely distributed
Oil shale	2 trillion barrels	8,000 square miles of land in Colorado, Wyoming, and Utah
Rock asphalt	15 billion barrels	Primarily in Utah

Sage grouse and antelope in desert habitat area of Wyoming.

PART V

REGIONAL NEEDS AND DEMANDS

The regional needs and demands are based primarily on the regional interpretation of the projections for the target years 1980, 2000, and 2020, prepared by Office of Business Economics, Department of Commerce, and Economic Research Service, Department of Agriculture (OBERS). Among these projections were population, employment, and the production of agricultural and other commodities to meet demands within the region and to supply a portion of national needs. Several segments of the OBERS projections were adjusted to represent local conditions. These included utilizing available feed and forage crops, timber products, producing minerals and power to meet regional and export needs, accommodating recreation and fish and wildlife needs, and interregional water export.

Problems related to watershed protection, flood control, water quality, pollution control, health factors, maintaining a quality environment, and other needs associated with production, are described.

These projected developments result in requirements for water and associated land resources. Water thus becomes the primary index for development of the regional plans.

Population

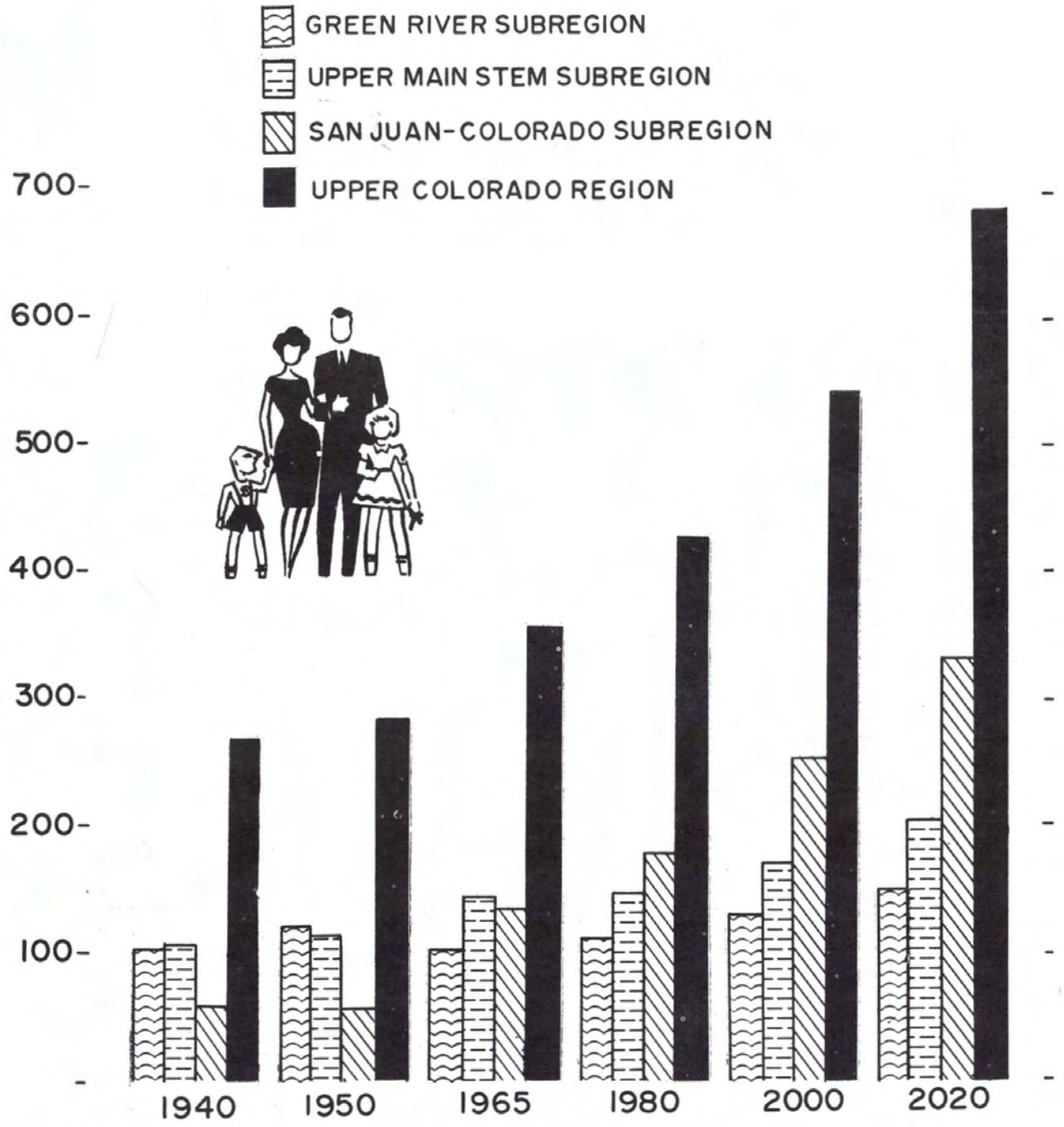
The population of the region is projected to reach 680,000 by 2020, as shown in the following tabulation. This included the 1968 OBE projections with the hydrologic portion of Arizona added because of its impact on the San Juan area.

Subregion and states	1965	1980	2000	2020
March 1968 OBE projections with Arizona portion added (Economic subregions other than Arizona)				
Green River	100,579	107,100	124,400	151,200
Upper Main Stem	136,725	142,900	171,400	204,200
San Juan-Colorado	128,725	176,200	241,900	324,800
Region	366,029	426,200	537,700	680,200
Arizona	29,100	41,700	52,300	64,300
Colorado	186,450	205,400	252,800	313,900
New Mexico	46,600	65,000	95,000	125,000
Utah	65,100	74,500	94,100	124,100
Wyoming	38,779	39,600	43,500	52,900
Region	366,029	426,200	537,700	680,200

UPPER COLORADO REGION

POPULATION

IN THOUSANDS



Projected Requirements

Requirements for food and fiber, industrial commodities, and other goods and services are described under agricultural and industrial projections.

Agricultural projections

Feed crop projections produced on irrigated and dry cropland and rangeland, including hay, field grains, and silage, have been modified--and pasture, range, and native hay added--to utilize available resources to produce livestock and livestock products consistent with 1968 OBERS projections. Timber production reflects the region potential on a sustained yield basis but is not OBERS projections. A summary of projections for these commodities and other food crops is shown below.

Agricultural commodities	Units	1965	1980	2000	2020
Beef	Mil. lbs.	207.3	282.1	375.6	492.9
Pork	Mil. lbs.	2.0	1.5	2.0	2.6
Lamb and mutton	Mil. lbs.	87.7	92.0	122.0	159.9
Wool	Mil. lbs.	12.5	13.1	17.4	22.8
Milk	Mil. lbs.	192.7	348.2	453.6	585.6
Farm chickens	Mil. lbs.	0.5	0.9	1.1	1.4
Eggs	Million	36.0	43.5	57.1	74.3
Feed crops					
Hay	1,000 tons	1,168.1	1,418.3	1,750.9	2,084.4
Feed grain	1,000 bu.	4,417.0	7,167.1	8,350.3	9,281.9
Silage	1,000 tons	490.1	610.0	882.0	1,242.8
Pasture and range	1,000 AUM's	7,737.0	8,681.2	10,594.6	11,745.5
Other crops					
Barley (Moravian)	1,000 bu.	750.0	1,549.0	2,646.0	3,760.0
Wheat	1,000 bu.	3,576.0	5,258.0	5,919.0	6,859.0
Orchard	1,000 tons	80.0	108.0	144.0	181.0
Sugar beets	1,000 tons	172.5	361.0	565.0	825.0
Dry beans	1,000 cwt.	765.0	835.0	929.0	1,026.0
Truck crops	1,000 cwt.	291.0	381.0	500.0	620.0
Potatoes	1,000 cwt.	397.8	463.8	552.0	640.0
Timber	Mil. cu. ft.	53.0	170.4	285.8	340.0

Industrial projections

The principal industrial activity projected is mining and processing of minerals and production of electric power.

Minerals

Projected value of the minerals needed will quadruple to over $2 billion. The bulk of development will be for petroleum, uranium, coal, molybdenum, and trona production. Mineral-fuels interaction, such as how much uranium and oil shale will replace petroleum and coal, is very difficult to predict. Oil shale and other synthetic fuel developments were not projected as needs under regionally interpreted OBERS.

Electric Power

A tremendous increase of electric energy production is required to meet projected local and export needs. Over 80 percent of the energy produced will be exported to the Pacific Northwest, Great Basin, Southern California, Lower Colorado Basin, and east of the Rocky Mountains.

Year	Location of use		Type of generation		
	Local use	Export	Steam	Hydro	Total
	Installed capacity in megawatts				
1980	1/1,300	13,400	13,400	1,300	14,700
2000	1/3,900	39,500	42,100	1,300	43,400
2020	1/7,900	35,500	42,100	1,300	43,400
	Generation in million kilowatt hours				
1980	5,770	97,700	97,570	5,900	103,470
2000	18,200	282,720	295,520	5,400	300,920
2020	36,400	237,320	268,420	5,300	273,720

1/ Includes 20 percent reserve.

Other needs

Associated production and protection needs include land management, watershed management, flood control, irrigation and drainage, recreation, fish and wildlife, and water quality.

Land Management

Improved management and structural practices on grazing lands are required to increase production by 1,300,000 AUM's (animal unit months) by 2020 to meet regionally interpreted OBERS projections, even though 7,100,000 acres less land would be grazed. Proper management and usage will result in the retirement of 5.8 million acres of unsuitable grazing lands. Other uses will require conversion of 1.3 million acres. These

conversions will be required for urban, industrial, transportation, utilities, fish and wildlife, recreation, minerals, irrigation, and reservoir sites.

Much of the dry cropland suffers from lack of dependable moisture, poor soil, or erosion. Proper management practices, or shifting to cover crops, may alleviate some of these problems. About 95,000 acres of the 603,000 present acres are required for irrigation and 5,000 acres will be lost to other uses or inundation by reservoirs.

Watershed Management

Significant upstream watershed problems causing $8.7 million annual damage in 1965 are erosion, flood and sediment, and fire. Damages resulting from upstream watershed problems are those that occur in tributary areas of 250,000 acres (400 square miles) or less. Erosion, the major problem affecting 30.5 million acres, causes $6.7 million annual damages. Upstream flood and sediment damages of $1.4 million affect about 0.4 million acres (these damages are also included in the following flood control section). Fire causes damage of $0.6 million in the region. Average annual damages will increase from $8.7 million to $25.6 million by 2020 if no additional watershed protection programs are instituted after 1965.

Aerial view of flooding of Gunnison River near Delta, Colorado.

Other needs include managing and developing the watershed to permit more multiple use for grazing, recreation, timber production, and fish and wildlife purposes. In addition to the increased land uses it is

essential that the watershed be managed to produce high quality water in sufficient quantities to meet the needs and to insure proper stewardship of the environment.

Rock check dam for control of gully erosion in watershed areas.

Flood Control

Flood control measures are required to reduce the potential for loss of life, human suffering and property damage caused by flood water. Annual flood damages will increase from $2.8 million in 1965 to over $10 million per year by 2020 if no additional flood control programs are undertaken. About one-half of these projected damages are included in upstream damages in the preceding watershed management section. Reduction of damage can be effected through an integrated program of flood forecasting and flood plain management along with structural measures including reservoirs, levees, and channel improvements. Nonstructural flood plain management measures to control development and reduce flood damage from taking place in flood-prone areas are also required. Flood plain studies will be needed in and around urban centers and other potential development areas to delineate areas subject to flooding.

Irrigation and Drainage

Additional irrigated land amounting to 500,000 acres must be developed to meet increased production requirements; 87,000 additional acres will be required to replace presently irrigated lands (often the best land) converted to other uses. For increased production on the present land, improved irrigation systems on 911,000 acres, increased water use efficiency, and improved cultural management practices are required. Nearly 600,000 acres need a supplemental water supply.

Abandoned farm shows effects of a water shortage. Storage facilities planned for this area will alleviate this problem.

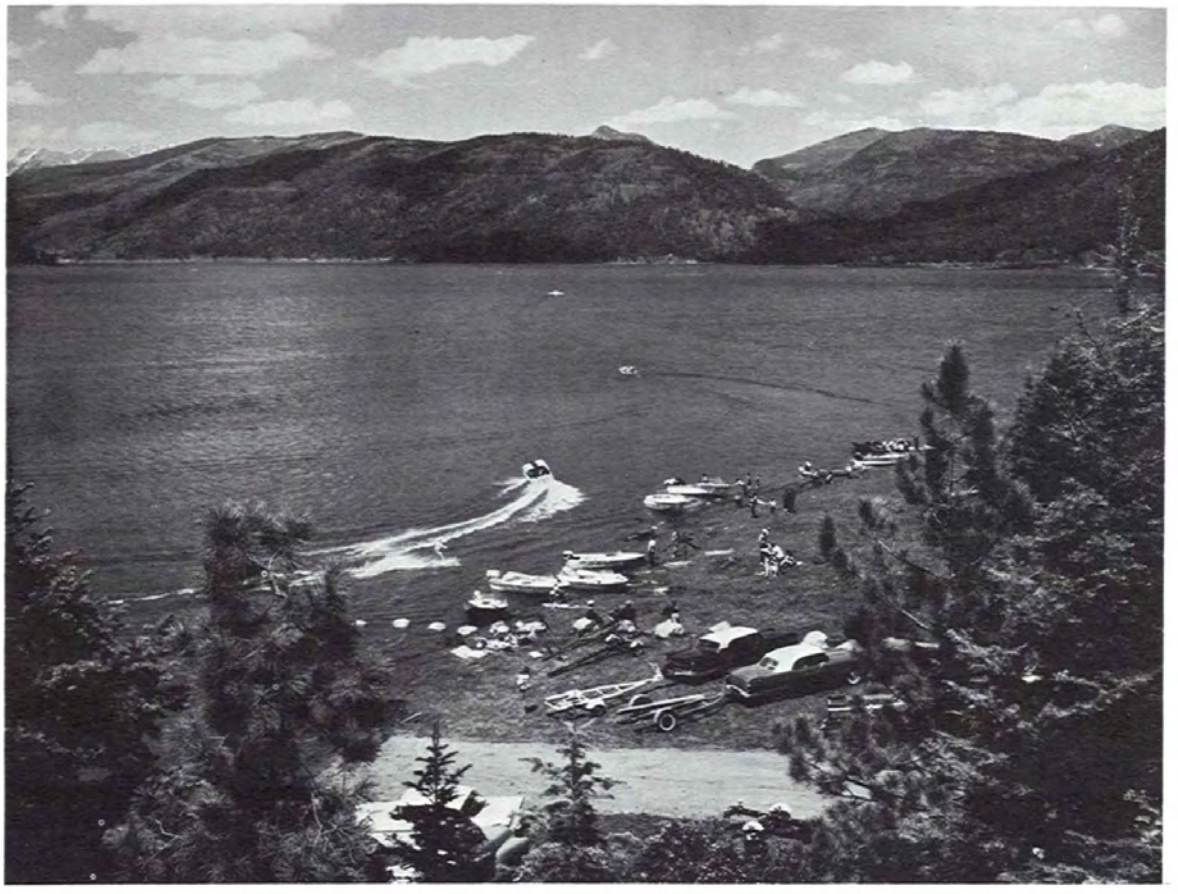
On-farm drainage is needed on 437,000 acres of presently irrigated lands and 176,000 acres of newly developed lands. A total of 5,700 miles of on-farm drains will be needed as well as 1,500 miles of project-type drains.

Open ditch drain newly constructed in irrigated lands in Colorado to relieve waterlogged condition and improve crop production.

Recreation

Partly because of the unique values of the area, total recreation-days, including fishing and hunting, for the region are projected to increase from 60 million in 1965 to 236 million in 2020 as depicted on the figure following page 54. Only about 3 percent of the projected recreation-day use will be generated by residents of the region. A considerable portion of nonresident use originates from the Denver, Colorado Springs, Pueblo, Albuquerque, Salt Lake City, Ogden, and Provo areas.

Within the 2000 to 2020 time frame, 333,000 surface acres of water are required, preferably in small lakes near urban areas, which are more efficient for recreation purposes. Almost a half million additional acres of developed land and over 12 million additional acres of undeveloped land will be needed. It was not possible to project acre needs for wilderness, outstanding natural, and historic areas. Such areas cannot be created when needs arise and should be acquired and protected whenever and wherever they exist.



Man-made lakes provide boating, water skiing, fishing, and camping.

Fish and Wildlife

The scenic beauty and the trout and big-game population make the region one of the finest areas in the nation for hunting and fishing. Hunting and fishing demands are expected to nearly double during the 1965 to 2020 period to meet the inbasin and nonresident needs.

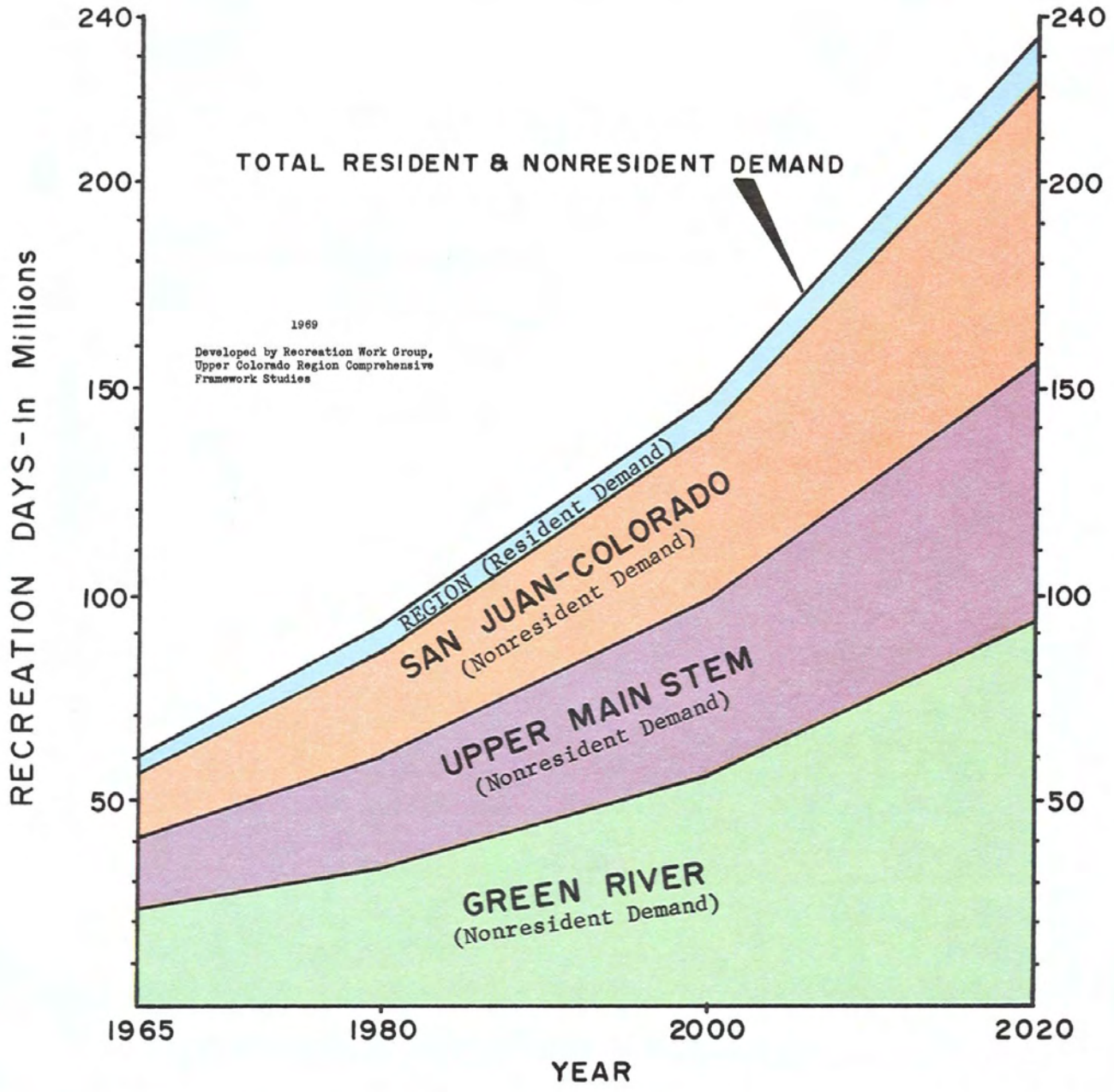
The following tabulation summarizes the projected needs in thousands of man-days by time frames.

	1965	1980	2000	2020
Fishing demands	3,547	4,522	6,502	8,667
Hunting demands	1,268	1,460	1,903	2,374

UPPER COLORADO REGION

RECREATION DEMAND

RECREATION DAYS–Including Hunting & Fishing



GPO 831-456

Fly fishing for rainbow trout in high mountain stream near Crested Butte, Colorado.

Meeting these demands will require 72,000 acres of developed land for fishing impoundments and waterfowl habitat and will require wildlife conservation considerations on over 41 million acres of key habitat area. By 2020, 137,000 acres of additional land will be required to provide winter range needs for big-game animals.

Water Quality, Pollution Control, and Health Factors

Projections indicate an increase in concentrations of dissolved solids of about 61 percent near the mouth of the Green River, 184 percent at the San Juan River near the mouth, and 40 percent in the Colorado River at Lees Ferry due to projected development in the region and water exports. In some areas costly treatment will be required to upgrade mine drainage water for downstream fish, recreation, and municipal and industrial use. Restoration of mining areas would lessen harmful discharge. Inadequately treated municipal and industrial effluents are polluting some streams.

Adequate waste treatment facilities will be required to service present development. Control measures will be required to prevent fertilizers, pesticides, and other pollutants from entering the stream system. Maintenance of minimum flows for water quality, fish and wildlife, recreation, and other uses is desirable in some areas.

Thermal pollution has been minor to date. However, heat output from thermal powerplants is expected to increase 30 times. This tremendous amount of heat must be managed to protect the temperature for fish and for water self-purifications.

There is great need for increased surveillance and emphasis in the areas of domestic water, air pollution, solid waste disposal, radiological pollution, and disease vectors. Particular attention would be given to control of stack emissions from thermal-generating plants and effluent from mineral processing to prevent degradation of the environment.

Restoration of disturbed mining areas and control and stabilization of the tailings piles are necessary to reduce erosion and the contamination of water courses by the radioactive materials and heavy metals transported with the sediments.

Export (Water)

Water export demands by the year 2020 from adjacent regions within compact limitations will result in increased transmountain diversions of 1,102,200 acre-feet by Colorado, New Mexico, Utah, and Wyoming.

Water Requirements

By the year 2020 there would be on-site depletion needs of 6.55 million acre-feet. The largest consumptive use need, which is 50.3 percent of the total in 2020 or 3.29 million acre-feet, is for irrigated crops, associated seeped and phreatophyte areas incident to irrigation and irrigation reservoir evaporation.

Minor water needs in 2020 are in municipal and industrial water supply (1.7 percent), minerals (0.8 percent), augmented fish and wildlife and recreation (1.4 percent), stock-pond evaporation and livestock use (0.9 percent), and thermal-electric power generation (9.6 percent). About 1.65 million acre-feet (or 25.2 percent of the 2020 depletion) would be exported. Main stem regulating reservoir evaporation would account for 10.1 percent or 660,000 acre-feet of depletion. Table 5, and the four figures following page 58, present stream depletions for the five states and three subregions by types of needs for 1980, 2000, and 2020.

Table 5 - Water needs
Regionally interpreted OBERS level of development
Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
				- - 1980 - -					
Municipal and industrial	2,900	22,100	5,900	7,800	4,300	43,000	11,700	16,200	15,100
Electric power (thermal)	34,100	26,700	55,700	50,400	33,200	200,100	72,500	1,800	125,800
Minerals	400	19,500	3,700	10,300	19,000	52,900	31,500	13,700	7,700
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	100	600	100	1,000	200	2,000	800	600	600
Stockpond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	132,700	75,100	99,000	80,300	427,200	181,200	53,900	192,100
Irrigation: consumptive use, incidental and reservoir evaporation	7,000	1,479,000	245,000	588,000	334,000	2,653,000	984,000	1,078,000	591,000
Export		719,000	117,500	190,000	65,000	1,091,500	255,000	716,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,330,700	437,600	874,400	479,300	4,169,100	1,420,200	1,847,900	901,000
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,829,100	1,487,200	1,864,900	1,477,000
				- - 2000 - -					
Municipal and industrial	4,800	34,300	10,600	12,100	5,900	67,700	16,900	24,900	25,900
Electric power (thermal)	34,100	254,600	106,800	86,400	148,700	630,600	393,500	24,200	212,900
Minerals	300	19,900	3,900	10,300	22,100	56,500	32,000	16,700	7,800
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	300	1,000	100	1,600	200	3,200	1,300	900	1,000
Stockpond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	379,100	131,500	141,600	201,500	896,100	511,300	91,700	293,100
Irrigation: consumptive use, incidental and reservoir evaporation	7,600	1,633,000	329,000	605,000	407,000	2,981,600	1,062,000	1,166,000	753,600
Export		883,000	117,500	437,000	150,000	1,587,500	587,000	880,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	2,895,100	578,000	1,181,000	758,500	5,462,600	2,160,300	2,137,700	1,164,600
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						6,122,600	2,227,300	2,154,700	1,740,600
				- - 2020 - -					
Municipal and industrial	7,200	56,000	17,300	20,400	9,200	110,100	26,400	40,400	43,300
Electric power (thermal)	30,100	254,600	106,800	86,400	148,700	626,600	393,500	24,200	208,900
Minerals	300	17,000	2,600	11,400	21,500	52,800	26,400	20,800	5,600
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stockpond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	403,800	137,700	153,700	205,300	941,500	519,100	115,200	307,200
Irrigation: consumptive use, incidental and reservoir evaporation	9,000	1,723,000	411,000	723,000	428,000	3,294,000	1,147,000	1,233,000	914,000
Export		883,000	117,500	467,000	185,000	1,652,500	652,000	880,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,009,800	666,200	1,341,100	818,300	5,885,400	2,318,100	2,228,200	1,339,100
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						6,545,400	2,385,100	2,245,200	1,915,100

Land Requirements

Projections of production requirements and the changes brought about by economic considerations will require a significant difference in land use in the future. Blocks of land will be converted from one use to another. Increased acreages will be required for urban and industrial, irrigated agriculture, recreation, fish and wildlife, and mineral development; a large amount of presently grazed land will be retired, and a decrease will occur in timber and dry cropland. The following tabulation summarizes the projected land needs and the changes from the 1965 condition.

Multiple land needs projected in the framework plan

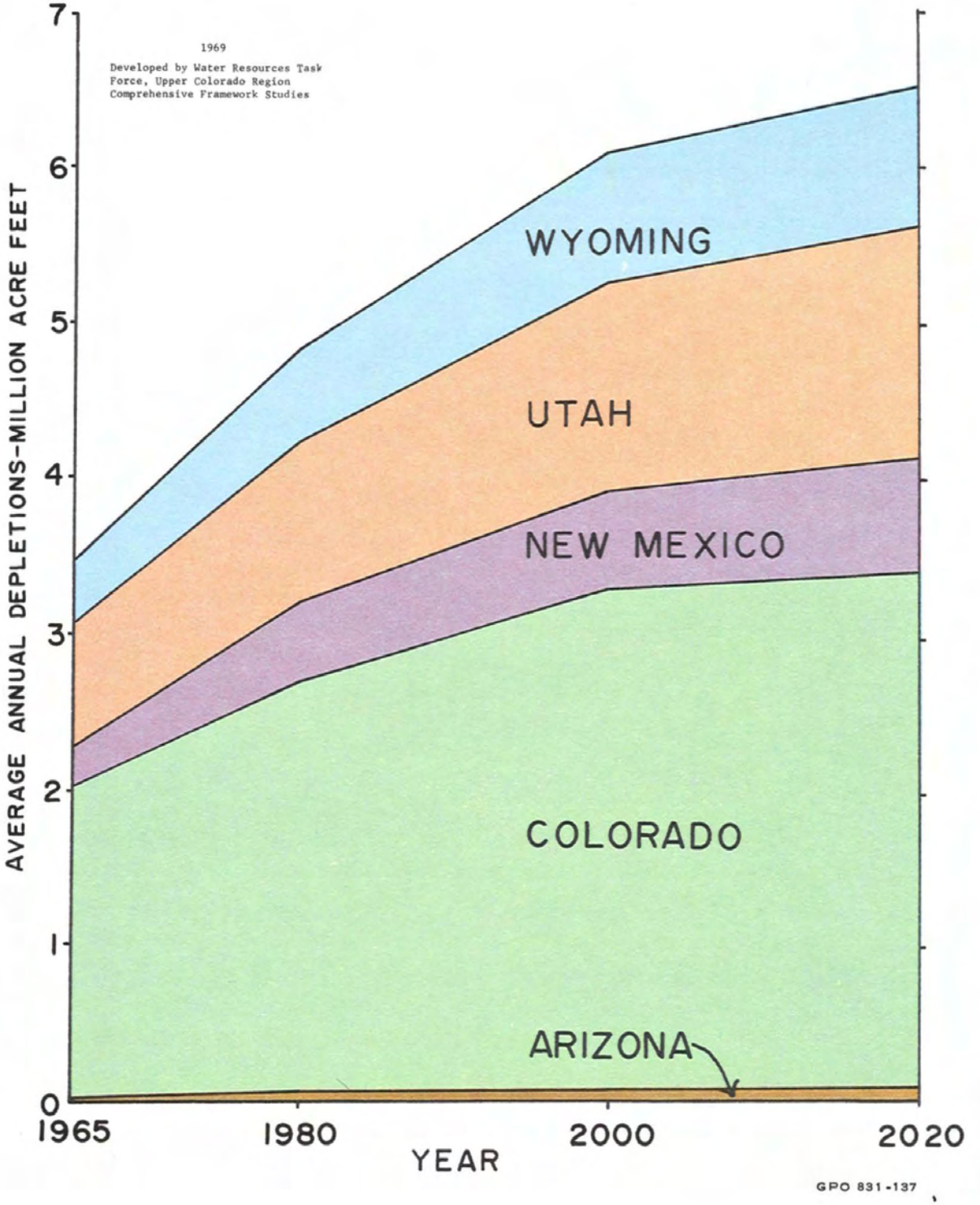
Principal use[1/]	1965	1980	2000	2020	Change 1965 to 2020
			(Thousand acres)		
Cropland and pasture					
Irrigated	1,622	1,794	1,954	2,122	+500
Dry	603	572	532	503	(-)100
Livestock grazing	60,442	55,958	54,691	53,380	(-)7,062
Timber production[2/]	9,419	9,351	9,266	9,194	(-)225
Urban and industrial	331	356	403	471	+140
Transportation and utilities	598	632	703	788	+190
Developed recreation	71	140	273	506	+435
Developed fish and wildlife	299	393	450	508	+209
Wilderness, natural, historic, and cultural	2,636	(not projected)			
Developed mineral production	37	71	103	178	+141
Military	114	114	114	114	0
Classified watersheds	258	262	268	271	+13
Water (area > 40 acres)	405	482	493	514	+109

1/ Multiple uses of the land are made in most categories shown.
2/ Timber production acreage by economic boundary, other figures by hydrologic boundary.

UPPER COLORADO REGION

WATER USE by STATES

For the Regionally Interpreted OBERS
level of development



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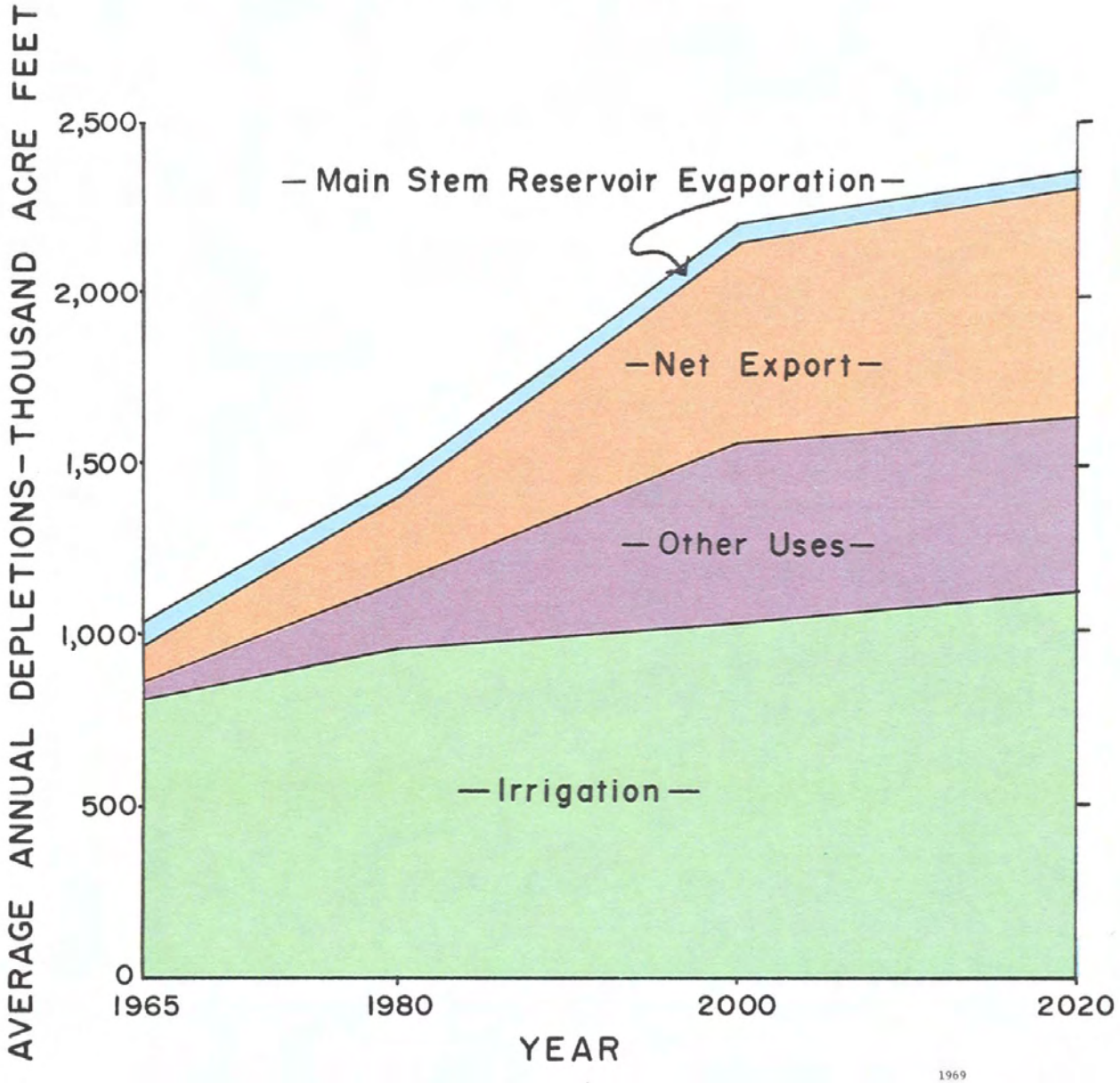
UPPER COLORADO REGION

GREEN RIVER SUBREGION

WATER USE

For the Regionally Interpreted OBERS
level of development



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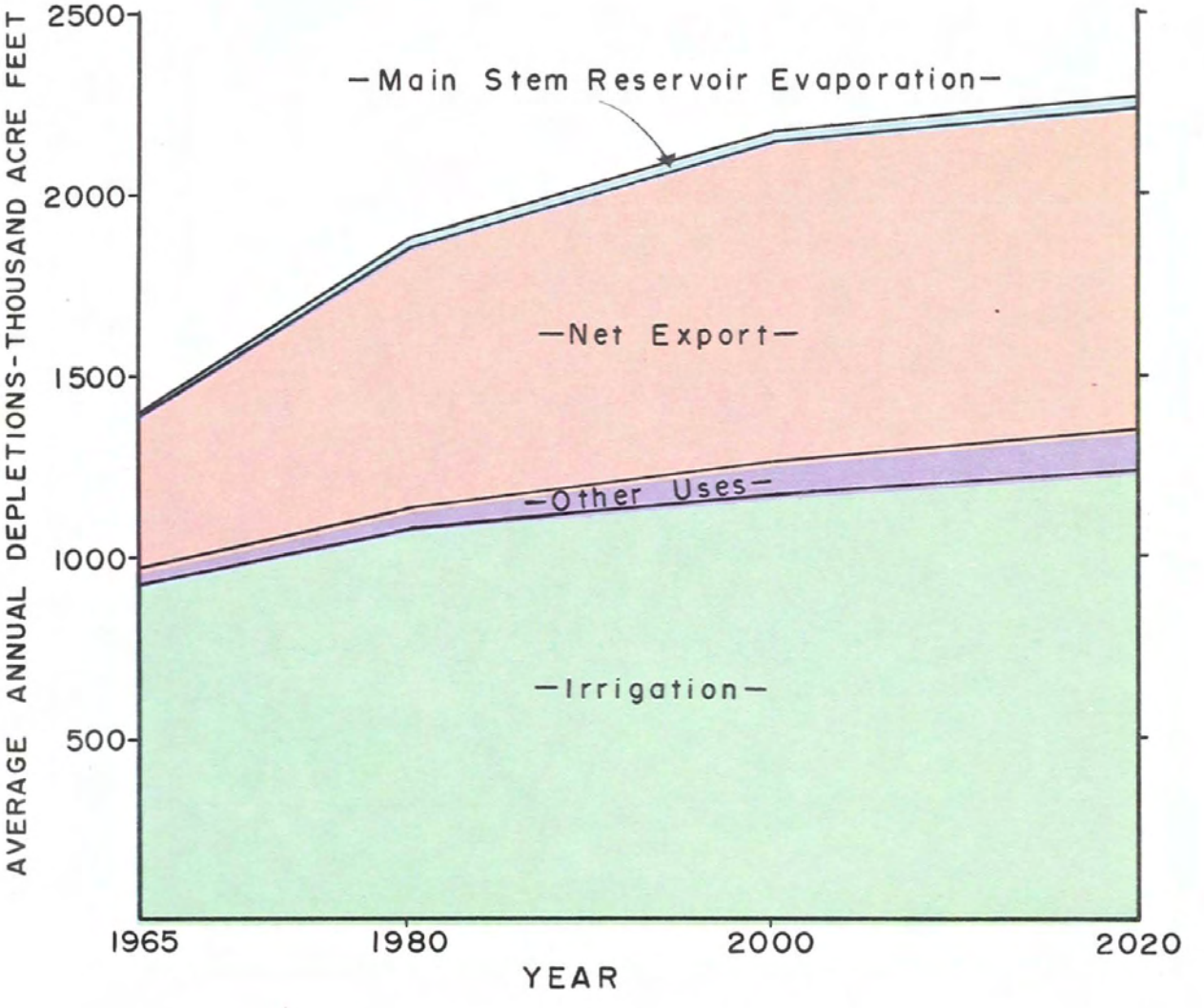
UPPER COLORADO REGION

UPPER MAIN STEM SUBREGION

WATER USE

For the Regionally Interpreted OBERS
level of development



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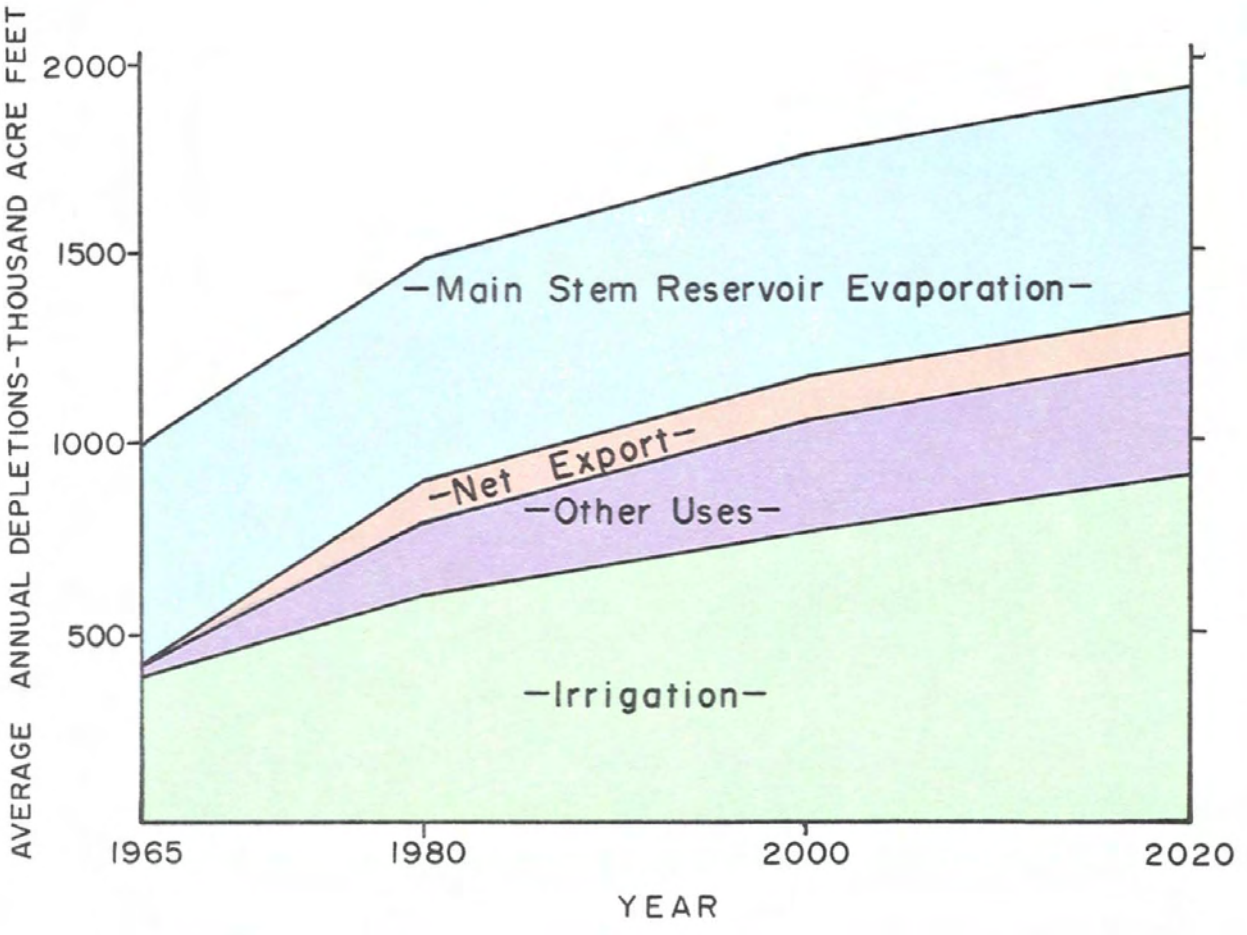
UPPER COLORADO REGION

SAN JUAN-COLORADO SUBREGION

WATER USE

For the Regionally Interpreted OBERS
level of development



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GPO 832-459

PART VI

FRAMEWORK PLAN AND ALTERNATIVES

The basic purpose in formulating the framework plan is to provide a broad guide to outline development of water, land, and related resources to meet requirements to the year 2020. Development of the plan incorporates coordinated analysis for all water and related land use with consideration of constraints imposed by physiographic characteristics, the overall shortage of water, and the legal and institutional environments. Plans, goals, and needs of the states and other localized areas were also considered.

Water allotments, priority of use, and delivery commitments within the terms of the Colorado River Compact, the Mexican Water Treaty, and the Upper Colorado River Basin Compact set forth obligations which were considered. These factors, along with separate state water codes, imposed significant constraints.

This study gives cognizance to environmental assets for a pattern of future development which will preserve or enhance the esthetic and health-related attributes. The plan includes features which minimize adverse environment impacts and largely compensate for unavoidable effects. Identification of problems in this study should permit resolution of conflicts and allow timely and coordinated use of the resources in meeting future demands.

The comprehensive framework plan is based upon identified needs and requirements, using available resources to meet regionally interpreted OBERS projections through the year 2020. This plan is described and then is followed by a discussion of alternative plans that reflect emphasis on different uses for the available water supplies and resources. The alternative plans are identified as:

(1) States' alternative to the framework plan (6.55 million acre-foot level of development),

(2) States' alternative at the 8.16 million acre-foot level of development, and

(3) States' alternative for water supply physically available at site in the region (9.44 million acre-feet).

Consideration was initially given to formulation of a plan to meet the needs contained in the 1968 OBERS projections. Plans were not developed because of basic inconsistencies in the agricultural projections and a need to conform to planned and anticipated development in the minerals, timber, and power sectors.

It should be noted that these studies were made to demonstrate certain levels of water resource development and that these studies shall not prejudice the position of either the Upper or Lower Basin interests with respect to required deliveries at Lee Ferry pursuant to the Colorado River Compact. In particular, the depletions are site-located and do not necessarily reflect direct relationships to streamflow diminishment at Lee Ferry, Arizona.

Purpose and Summary of Framework Plan

The framework plan broadly outlines development of the region's water and related land resources to meet the regionally interpreted OBERS projections. Most project developments and structures have not been site-located. Further engineering, economic, and environmental analyses will be required in detailed planning for the individual segments. Estimates of costs and general adequacy of plans are discussed.

Water depletions will increase to 6.55 million acre-feet by 2020 while all of the region's land resources will receive continued and more intensive use.

Local water needs for municipal and industrial uses (excluding power, minerals, and agriculture) will remain small when compared to total water requirements. Future recreation, sport fishing, and hunting demand by residents and nonresidents will require a continuation and extension of present programs and management practices.

Projected total gross output for agricultural products to meet demands and needs would more than double for most subregions and sectors of production. Livestock and livestock products and food and field crops are the major sectors. Production on existing irrigated cropland would increase and 500,000 acres of additional irrigated land would be brought into production.

Output of timber products is projected to 340 million cubic feet due largely to demands from outside the basin.

Transmountain diversions from the region would triple to about 1.6 million acre-feet to meet a portion of the demands for municipal, industrial, and irrigation water in adjacent regions. Outflow to the Lower Colorado Region would continue as required by the Colorado River Compact.

Watershed management programs including land treatment, water control structures, and applied water management practices would reduce erosion, flood, and sediment damage by about 30 to 60 percent and would improve water yield in terms of quantity and quality. The flood control plan would reduce the estimated annual flood damage by about $6.7 million by the year 2020 and would eliminate 65 percent of the projected damage.

The capacity of electric powerplants would be about 19 times as great by 2020 as in 1965. Local use plus reserve will require about 18 percent of the total generation.

Value of mineral production in the region is expected to increase from $543 million in 1965 to $2,014 million in 2020.

New Proposals in Framework Plan

Agriculture

Potential programs for increasing production of crops and livestock and livestock products include developing new irrigated land and increasing production on the present irrigated, dry cropland, and grazing lands. These programs, together with those for timber, are tabulated in Tables 6 and 7.

Irrigated Cropland Development

Irrigated cropland would increase from the present base of about 1.6 million acres to approximately 2.1 million acres. New irrigated land totaling 587,000 acres will be needed by 2020 to meet additional needs and replace 87,000 acres lost to urbanization and other uses. Present lands will be developed for increased production by structural, cultural, and management practices.

Increased production on presently irrigated lands would be obtained by development of supplemental water for 421,000 acres, drainage of 437,000 acres, irrigation system improvement on 911,000 acres, increased water-use efficiency, and use of improved cultural management practices.

Participating projects of the Colorado River Storage Project authorized or funded for construction, in advance planning, or under preconstruction studies would develop water for 364,000 acres of new irrigated land and supplemental water for 253,000 acres. This includes 110,600 acres of new irrigated land in New Mexico for the Navajo Indians.

In addition, selected potential participating projects of the CRSP would bring into production 136,000 acres of new irrigated land and furnish supplemental water to 73,000 acres.

Non-Federal development would bring into production 87,000 acres of new irrigated land and furnish supplemental water to 95,000 acres presently being irrigated.

Ninety reservoirs with a storage capacity of 2.1 million acre-feet would be built for the primary purpose of supplying irrigation water.

However, they will also be multipurpose. Development of new irrigated land requires installation of new canals and ditches, land leveling and smoothing, and water control structures. An estimated 176,000 acres or 30 percent of the newly developed land will require on-farm and project-type drains.

Dry Cropland

About 100,000 acres of the 603,000 acres of presently dry cropland will be transferred to other uses, primarily to irrigation. Improved cultural management practices applied to dry cropland would result in a small increase in yields. The programs for increasing production on these lands include: (1) use of improved plant varieties, (2) fertilization, (3) reduction of erosion by contour and cross-slope tillage, (4) constructing 100 miles of diversion ditches, (5) establishment of grass waterways covering 3,000 acres, (6) fall chiseling on 100,000 acres annually in areas of deep snow accumulation, and (7) limited tillage using stubble-mulch methods on 150,000 acres annually.

Fall chiseling of wheat stubble makes soil receptive to winter moisture and reduces erosion.

Table 6 - Irrigated land use and on-site water depletions (consumptive use, reservoir evaporation, and incidental use)
Framework plan
Upper Colorado Region

State	Irrigated land (1,000 acres) Total	Irrigated land (1,000 acres) Supplemental[1]	Water depletions (1,000 acre-feet)
	1980		
Arizona	10.0	0	7
Colorado	1,003.2	113.9	1,479
New Mexico	104.2	5.5	245
Utah	334.7	102.6	588
Wyoming	341.5	59.0	334
Total	1,793.6	281.0	2,653
	2000		
Arizona	9.4	0	8
Colorado	1,087.5	166.2	1,633
New Mexico	139.2	5.5	329
Utah	338.6	109.6	605
Wyoming	379.5	85.0	407
Total	1,954.2	366.3	2,982
	2020		
Arizona	9.4	0	9
Colorado	1,151.9	201.4	1,723
New Mexico	174.2	5.5	411
Utah	394.1	119.2	723
Wyoming	392.5	95.0	428
Total	2,122.1	421.1	3,294

1/ Supplemental acreage included in total.

Table 7 - Projected land management production programs
Framework plan
Upper Colorado Region

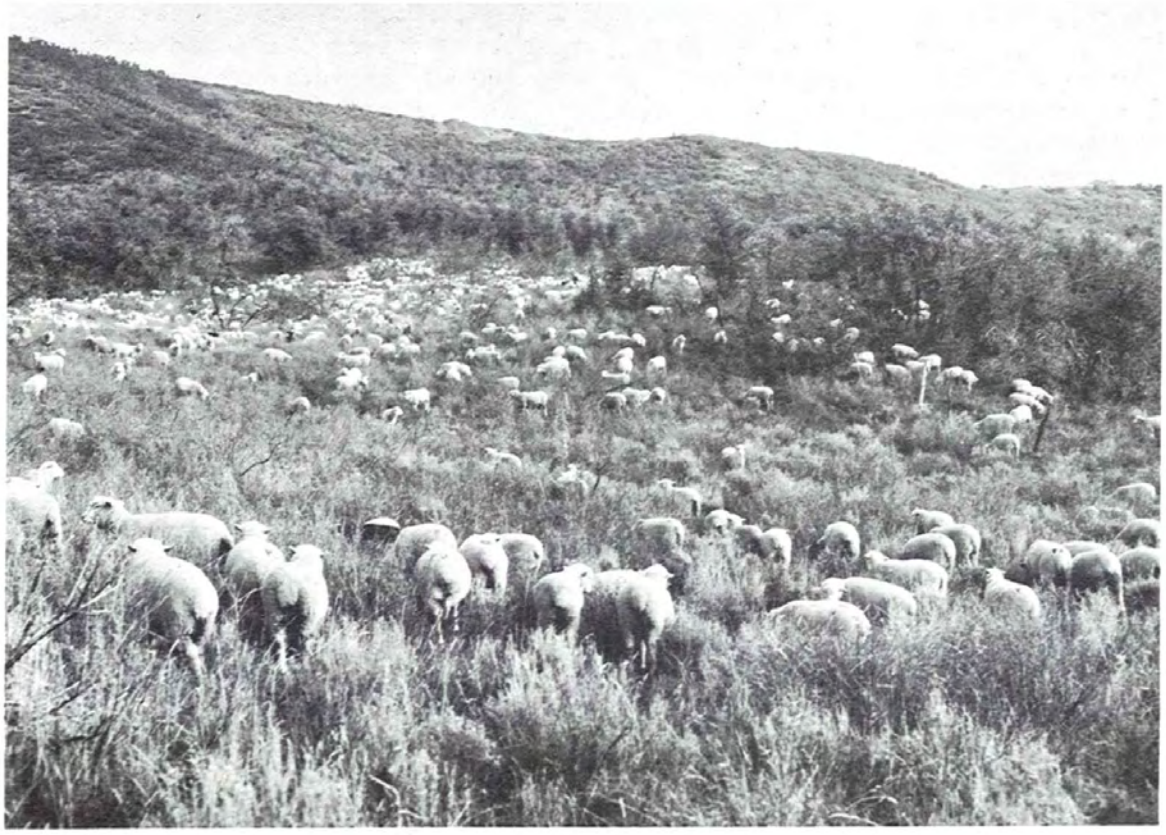
Practice	Unit	1966-1980	1981-2000	2001-2020
		Federal Land		
Wood production				
Timber management systems[1]	Acres	7,574,000	7,553,000	7,535,000
Thinning, pruning	Acres	227,000	379,000	153,000
Planting, seeding	Acres	114,000	189,000	75,000
Forage production				
Grazing management systems[1]	Acres	30,975,000	30,975,000	30,975,000
Water developments	No.	7,861	10,118	1,860
Fences	Miles	5,522	6,563	1,912
Plant control	Acres	223,563	223,563	41,400
Revegetation	Acres	43,052	43,052	8,630
		Private Land[2]		
Forage production				
Grazing management systems[1]	Acres	23,505,529	23,505,529	23,505,529
Water developments	No.	1,543	3,400	1,970
Fences	Miles	1,500	2,380	1,600
Plant control	Acres	439,504	522,316	436,461
Revegetation	Acres	231,710	369,638	286,086
Wood production				
Timber management systems[1]	Acres	1,777,000	1,713,000	1,659,000
Thinning, pruning	Acres	36,000	36,000	21,000
Planting, seeding	Acres	18,000	18,000	11,000
On-farm irrigation systems				
Canals and ditches	Miles	500	580	371
Irrigation water control structures	No.	77,330	77,490	53,730
Land leveling and smoothing	Acres	570,800	565,140	362,335
Drainage (tile and ditches)	Miles	1,601	2,629	1,517
Drainage (tile and ditches)	Acres	170,025	281,450	179,425
Crop production improvement (dry)				
Diversion	Miles	62	127	62

1/ Grazing and timber management systems' acreage should be summed by time frames.

2/ Includes Indian land.

Grazing Development

Forage on range and forest land will be increased 1.3 million animal unit months of grazing. In spite of unsuitable lands being retired to other uses, overuse and abuse being curtailed, and demands of grazing land for other uses, total production will increase 20 percent. The program for obtaining the increased production includes management practices, land treatment, and installation of structures.



Sheep grazing in sage and oak brush areas.
Good management improves rangeland.

Timber Production

In order to meet projected needs by 2020 the output of timber products must be increased to over seven times the 1965 production. The programs to be instituted to obtain such production are: (1) 42 marketing and utilization studies, (2) 852,000 acres of thinning and pruning, (3) tree planting and seeding 425,000 acres, (4) timber inventory of 9.4 million acres, and (5) protection from wildfire, insects, and disease. The need for an intensified timber management program will become more imperative when the full extent of current reductions in commercial forest acreage is known.

Watershed management and flood control

Watershed Management

Average annual upstream watershed damage is presently $8.71 million. This will increase to $25.6 million by the year 2020 if no additional protection programs are initiated after 1965 due to population, growth, and economic activity. The program of upstream watershed management practices, including land treatment and water control structures, is listed in Table 8. Man-created erosion and sediment production and associated damage will be decreased 40 to 60 percent. Upstream flood and sediment damage will be reduced about 30 to 50 percent. In addition, applied management practices can improve water yield in terms of quantity, quality, and timing.

Flood Control

Average annual flood damage in the region would increase to an estimated value of $10,551,000 by year 2020 with no additional flood control measures after 1965. The flood control plan consisting of flood control storage in reservoirs, levees, and channels; improved flood forecasting; land treatment; and other nonstructural measures would reduce the estimated average annual flood damage in 2020 by $6,744,000 or about 65 percent of the amount that would occur without the program. The structural components of the plan are shown in the table below. Nonstructural measures, such as zoning, flood proofing, use of building codes, subdivision regulations, and other similar techniques to limit flood damage at the principal urban areas of the region, are also included in the plan.

Flood control programs
Framework plan
Upper Colorado Region

Subregion	Time frame	Multiple-purpose reservoir capacity (1,000 acre-feet)	Land treatment 1/ (1,000 acres)	Single-purpose programs: Reservoir capacity (1,000 acre-feet)	Single-purpose programs: Levees (miles)	Single-purpose programs: Channels (miles)
Green River	1980	466	974	21	0	0
	2000	123	1,302	46	5.4	3.6
	2020	75	527	28	0	0
Upper Main Stem	1980	1,172	641	7	0	3.0
	2000	293	873	20	2.0	0
	2020	0	308	6	0	0
San Juan-Colorado	1980	1	797	2	0	0
	2000	0	924	14	0	4.0
	2020	20	766	6	2.0	0
Region	1980	1,639	2,416	30	0	3.0
	2000	416	3,099	80	7.4	7.6
	2020	95	1,601	40	2.0	0
Region total		2,150	7,112	150	9.4	10.6

1/ Included in watershed management program.

Table 8 - Projected watershed management programs
Framework plan
Upper Colorado Region

Practice	Unit	1966-1980	1981-2000	2001-2020
Federal Land				
Erosion, sediment, and runoff control				
Land treatment				
Brush and weed control	Acres	929,014	1,265,800	393,017
Watershed tillage	Acres	116,300	174,200	79,720
Seeding	Acres	360,768	501,600	247,900
Stabilization	Acres	12,657	12,657	2,367
Gully control	Miles	1,966	1,976	422
Sheet erosion control	Acres	150,300	151,300	31,000
Water control				
Detention dams	No.	184	307	214
Check and drop structures	No.	14,629	24,091	12,773
Diversion dams	No.	100	230	277
Dikes	No.	83	156	228
Streambank-lakeshore stabilization	Miles	533	547	109
Debris basins	No.	18	17	3
Water yield improvement				
Type conversion	Acres	376,710	379,410	75,442
Private Land[1]				
Erosion, sediment, and runoff control				
Land treatment				
Watershed tillage	Acres	79,228	103,440	90,245
Tree and shrub planting	Acres	1,066	965	713
Stabilization	Acres	78,935	61,122	40,366
Water control				
Detention dams	No.	561	564	298
Check and drop structures	No.	7,611	5,189	2,881
Diversion dams	No.	1,134	1,448	804
Water spreading	Acres	139,710	149,198	94,777
Grade stabilization structures	No.	311	622	311
Floodway	Feet	10,650	21,400	10,650
Debris and sediment basins	No.	815	1,630	815

1/ Includes Indian land.

Industrial activity

Thermal-electric Power Development

By 2020 additional plants will be installed with a capacity of 40,820 megawatts, bringing the total installed capacity to 42,081 megawatts of thermal-electric power. Several small plants will be retired during the development period. Table 9 shows the location and size of these power installations and retirements from the system.

Minerals

Increased development of mineral fuels, primarily petroleum and uranium together with bulk metal and nonmetal production of phosphate, potash, molybdenum, and trona is foreseen. Coal production will be adequate to meet needs for thermal-power generation. Oil shale and other synthetic fuel developments are not included in the framework plan.

Projected value distribution among sectors of the minerals industry
(Unit--thousands of 1958 dollars)

Subregion and minerals	1980	2000	2020
Green River			
Oil and gas	172,000	155,700	48,000
Coal and gilsonite	84,000	358,500	342,200
Uranium and nonfuels	244,200	269,700	499,200
Subregion total	500,200	783,900	889,400
Upper Main Stem			
Coal	20,000	39,000	37,000
Oil and gas	4,000	3,600	1,100
Uranium	426,900	392,000	392,000
Zinc	20,800	20,800	20,800
All other	93,600	119,600	136,600
Subregion total	565,300	575,000	587,500
San Juan-Colorado			
Coal	65,000	127,000	122,000
Oil and gas	124,800	124,500	85,200
Uranium	240,400	244,300	298,600
All other	37,000	29,800	31,700
Subregion total	467,200	525,600	537,500
Region total	1,532,700	1,884,500	2,014,400

Municipal and Industrial Water

Future municipal and industrial water supply requirements will be met by developing additional surface and ground water sources. In a few isolated cases, needs will be met by conversions of irrigation use to municipal and industrial uses. The amount of water these conversions represent is small, however. Use of surface sources will be by far the most common means and account for the largest segment of meeting the future needs. This is borne out by the fact that authorized projects are underway or will be constructed in all major areas of expanding needs. Where populations are lightly concentrated, multipurpose projects have been planned and, in many cases, are authorized with adequate allocations for municipal and industrial requirements developed from projections. It is estimated that 70 to 80 percent of the future water supply in each time frame would be met by non-Federal development. Because of the rural character of the region, many small community systems will be developed by non-Federal funds.

Self-supplied systems delivering ground water will continue to make up a small portion of the future industrial supplies. The program includes installation of water development, conveyance, and treatment facilities.

Recreation - fish and wildlife

Recreation

Recreation land and water facilities will be made available for resident and nonresident use, totaling an increase of about 170 million recreation-days by 2020. About 435,000 acres of additional land will be developed for recreation needs. Undeveloped lands will be managed for optimum recreation use as well as other compatible uses. Increased use of multiple-use land for recreation is desirable. In addition, many large areas would provide more recreational opportunities if better access were provided.

It is important that land use studies be completed to determine the best uses of all lands in the region. As a part of this type analysis, optimum carrying capacities of recreation lands would be established and the areas administered accordingly to prevent deterioration of the resource base and to insure quality experience to the recreationists. Since most of the demand for recreation opportunities is generated by nonresidents of the region and the quality of the region's recreation resources is still relatively high, special care would be taken to insure well-planned development of facilities and measures would be initiated to prevent overdevelopment, overuse, or misuse.

Special efforts will be made to increase opportunities for recreational use of water in streams and reservoirs. This will require road construction, right-of-way acquisition, and revised legislation.

Table 9 - Staging of thermal-electric power generating plants, framework plan, Upper Colorado Region

	Capacity (megawatts)	Location by state
Plants in service in 1965		
Durango	5	Colorado
Animas	31	New Mexico
Four Corners 1, 2, and 3	633	New Mexico
Oliver	3	Colorado
Cameo	75	Colorado
Bullock	10	Colorado
Nucla	38	Colorado
Rock Springs	25	Wyoming
Naughton No. 1	163	Wyoming
Carbon	189	Utah
Hayden No. 1	163	Colorado
Total in service - 1965	1,335	
Actual and proposed additions to 1980[1/]		
Naughton No. 2	220	Wyoming
Naughton No. 3	330	Wyoming
Four Corners No. 4	795	New Mexico
Four Corners No. 5	795	New Mexico
San Juan No. 1 and No. 2	660	New Mexico
Navajo Nos. 1, 2, and 3	2,310	Arizona
Kaiparowits	2,400	Utah
Four Corners No. 6	800	New Mexico
Jim Bridger Nos. 1, 2, and 3	1,500	Wyoming
Emery County No. 1	330	Utah
Emery County No. 2	440	Utah
Hayden No. 2	500	Colorado
Craig	1,000	Colorado
Total additions	12,080	
Actual and probable plant retirement to 1980		
Rock Springs (actual)	25	Wyoming
Oliver	3	Colorado
Durango	5	Colorado
Total retirements	33	
Net plants in service - 1980	13,382	
Proposed additions 1981-2000[1/]		
Blacksfork No. 1	1,200	Wyoming
Four Corners No. 7 and No. 8	1,600	New Mexico
San Juan No. 3	340	New Mexico
Kaiparowits	2,400	Utah
El Paso	1,500	New Mexico
Jim Bridger No. 4	500	Wyoming
Hayden No. 3	1,000	Colorado
Milner	1,000	Colorado
Northwest Colorado (not necessarily one plant)	11,700	Colorado
Upper Green No. 1	2,000	Wyoming
Upper Green No. 2	2,000	Wyoming
Sweetwater	2,000	Wyoming
West Central Colorado	1,500	Colorado
Total proposed additions	28,740	
Probable retirements 1981-2000		
Bullock	10	Colorado
Animas	31	New Mexico
Total retirements	41	
Net plants in service - 2000	42,081	

(No additions or deletions of installed capacity 2001-2020)

Steamplant capacity in service

State	1965 (megawatts)	1980 (megawatts)	2000 (megawatts)	2020 (megawatts)	Depletions (acre-feet) year 2000
Colorado	294	1,786	16,976	16,976	254,600
New Mexico	664	3,714	7,123	7,123	106,800
Wyoming	188	2,213	9,913	9,913	148,700
Utah	189	3,359	5,759	5,759	86,400
Arizona	0	2,310	2,310	2,310	34,100
Total	1,335	13,382	42,081	42,081	630,600

1/ The construction time sequence of the powerplants should not be construed as reflecting agreement by the power companies or the states as to priority of construction. Also, in addition to those listed as retired, other capacity will reach normal retirement age (30-35 years) during the study period. Retirement will depend on the then existing condition and the need for peaking and reserve capacity.

Service facilities, especially lodging and restaurants, are needed to support the increased tourism and recreation activities. Development oriented to year-round rather than seasonal-type use would justify the construction of such service facilities.

Fish and Wildlife

Plans and programs for sport fishing facilities, including fishing impoundments, access development, fish hatcheries, and habitat improvement and management, are planned to meet a fishing demand which will more than double. Sport hunting facilities and programs, including land acquisition and/or development, access roads, and habitat management and improvement, are planned for a hunting demand which will almost double. Table 10 lists these practices.

Export of water

Existing facilities for exporting water from the basin to meet industrial, municipal, and irrigation needs will be enlarged and new facilities constructed as required. In Colorado existing facilities and enlargements of collection systems will provide most of the capacity for export. Projects, some of which are listed below, are under construction or are planned for construction in the near future. The San Juan-Chama Project export facilities in Colorado and New Mexico are under construction for export of 110,000 acre-feet to the Rio Grande Basin in New Mexico. Utah is in the process of constructing facilities to export 166,000 additional acre-feet of water from the Uinta Basin to the Great Basin through the Bonneville Unit of the Central Utah Project. This figure includes 29,500 acre-feet of reservoir evaporation associated with the transmountain diversion. Other planned developments under study could increase the Utah total to 467,000 acre-feet. Wyoming has constructed a part of the Cheyenne-Laramie transmountain diversion, which will have an ultimate capacity of 31,000 acre-feet, and plans include additional diversion of 154,000 acre-feet to the North Platte River starting in 1980.

Water quality, pollution control, and health factors

Water depletions will nearly double during the study period and additional salt pickup will occur.

A Colorado River Basin salinity program is proposed which would maintain the salinity concentration at Lees Ferry at about present levels. The programs (not fully evaluated until research and demonstration projects underway or proposed have been completed) include plugging wells and springs, desalting the flow of springs, controlling diffused sources, and minimizing the pickup of salts by various irrigation system improvements.

Acid mine drainage from active and abandoned hard-rock mines would be reduced. About 75 percent of these mines are located in the Upper Main Stem Subregion and the remaining 25 percent are located in the San Juan-Colorado Subregion.

Table 10 - Projected sport fishing and sport hunting facilities and programs
Framework plan
Upper Colorado Region

Type	1965-1980	1981-2000	2001-2020	Total
	Sport Fishing			
Construction of fishing impoundments (acres)1/	8,923	2,200	3,290	14,413
Acquisition of reservoir water rights (acre-feet)	9,192	3,000	-	12,192
Reservoir fishing leases (units)	3	6	5	14
Access development				
Streamside or lakeside (miles)	53	70	70	193
Roads (miles)	305	400	400	1,105
Public-use facilities (units)	654	1,300	1,400	3,354
Fish hatcheries (units)	5	1	3	9
Habitat improvement				
Stream (miles)	1,317	1,750	1,750	4,817
Impoundment or lake (acres)	2,412	3,200	3,200	8,812
Fish introduction2/ (number of species)	2	-	-	2
	Sport Hunting			
Land acquisition and/or development for				
Big game (acres)	37,420	50,000	50,000	137,420
Waterfowl (acres)3/	47,814	4,100	5,000	56,914
Access development				
Roads (miles)	200	270	270	740
Habitat improvement				
Range plant management (acres)	295,159	400,000	400,000	1,095,159
Waterhole development (units)	573	750	750	2,073
Fencing (miles)	711	1,000	1,000	2,711
Species management				
Wildlife stocking2/ (number of species)	10	-	-	10

1/ Acreage includes land and water requirements.

2/ Long-range projections uncertain because of research nature of the program.

3/ Needs beyond 1980 may change on the basis of overall flyway requirements.

Waste-water treatment facilities will be built to accompany all new facilities and the backlog of presently needed facilities will be overcome. A minimum of conventional secondary or equivalent treatment will be required for all domestic, municipal, and industrial waste waters. Disinfection of effluents will be required as necessary. Removal of nutrients from waste waters will probably be needed in some areas by 1980. Toxicants and other chemical pollutants will be removed as needed to comply with water quality standards. Ground water resources will be protected from contamination by domestic, municipal, and industrial wastes.

Watershed protection is planned for forest, rangeland, irrigated, and dryland to overcome pollution from land runoff. Thermal discharges would be controlled at the source. The relationship of minimum streamflow to water quality requirements would be studied. Environmental health programs are planned which will emphasize increased protection and surveillance of domestic water supplies and initiate better control and monitoring of air pollution, solid waste disposal, radiological pollution and disease vectors.

Costs

Summaries of program costs for water development only and for total program costs for water development plus associated development are presented (Tables 11 and 12). Installation costs correspond to those structures or programs that will be needed to meet the regionally interpreted OBERS requirements after the base year 1965. Operation, maintenance, and replacement costs are directly tied to the structures or programs to be installed and generally reflect the annual funds required at the end of the stated period. Cost estimates are in constant dollars indexed to 1965 levels.

Installation costs are estimated by the two general components designated as specific and joint facilities. Specific facilities are those readily identified with one major function with costs data drawn from the programs developed in the several appendices and costs for the facilities to convey water to the point of use by these programs. Joint facilities are those serving two or more functions such as reservoirs, main conveyances, structures, and collection systems. Joint costs are prorated to the applicable major function based upon proportionate use of the facility.

Included in the program costs for water development only are all joint costs and specific costs for municipal and industrial water supply; irrigation (except for on-farm systems) and drainage; hydropower generation, hydropower transmission, and conveyance systems to deliver cooling water to thermal-electric plants; flood control; water-based recreation; fishery improvements and waterfowl habitat development; water quality except salinity control; land management for erosion, sediment, and runoff control on all lands and water-yield improvements on Federal lands; and other water resource development, including export.

Table 11 - Summary of program costs for water development only
Framework plan
Upper Colorado Region
(Unit--$1,000, indexed to 1965)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
				OM&R			OM&R		Installation		
	Installation	OM&R (Increm.)	Installation	Increm.	Cumul.	Installation	Increm.	Cumul.	Specific	Joint	Total
1. M&I water supply	44,300	950	41,580	1,630	2,580	43,500	2,370	4,950	76,780	52,600	129,380
2. Irrigation	375,720	2,890	260,290	2,600	5,490	143,930	1,220	6,710	510,740	269,200	779,940
3. Electric power	115,100	4,730	162,060	9,760	14,490	0	0	14,490	208,160	69,000	277,160
4. Flood control	21,100	180	29,990	220	400	9,440	80	480	27,430	33,100	60,530
5. Recreation	182,280	1,600	200,630	2,610	4,210	302,210	3,790	8,000	471,720	213,400	685,120
6. Fish and wildlife	88,030	2,350	27,420	720	3,070	22,010	1,280	4,350	64,460	73,000	137,460
7. Water quality	19,400	970	12,800	820	1,790	15,400	1,040	2,830	47,600	0	47,600
8. Land management	47,670	2,290	55,880	410	2,700	23,490	(-1,040)	1,660	127,040	0	127,040
9. Other water resource development	296,700	1,580	283,700	1,520	3,100	98,800	700	3,800	564,400	114,800	679,200
Total program	1,190,300	17,540	1,074,350	20,290	37,830	658,780	9,440	47,270	2,098,330	825,100	2,923,430
Federal	936,340	5,010	699,600	2,470	7,480	388,190	2,070	9,550			2,024,130
Non-Federal	253,960	12,530	374,750	17,820	30,350	270,590	7,370	37,720			899,300

Table 12 - Total program costs for framework plan
Upper Colorado Region
(Unit--$1,000, indexed to 1965)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
				OM&R			OM&R		Installation		
	Installation	OM&R (Increm.)	Installation	Increm.	Cumul.	Installation	Increm.	Cumul.	Specific	Joint	Total
1. M&I water supply	44,300	950	41,580	1,630	2,580	43,500	2,370	4,950	76,780	52,600	129,380
2. Irrigation	404,340	4,580	288,280	4,260	8,840	163,470	2,360	11,200	586,890	269,200	856,090
3. Electric power	2,284,100	200,650	5,328,000	445,800	646,450	0	(-41,600)	604,850	7,543,100	69,000	7,612,100
4. Flood control	21,100	180	29,990	220	400	9,440	80	480	27,430	33,100	60,530
5. Recreation	623,850	9,880	897,020	15,940	25,820	1,640,820	21,810	47,630	2,948,290	213,400	3,161,690
6. Fish and wildlife	94,440	2,650	37,090	1,120	3,770	33,690	1,680	5,450	90,220	73,000	163,220
7. Water quality	19,400	970	12,800	820	1,790	15,400	1,040	2,830	47,600	0	47,600
8. Land management	102,910	12,050	138,200	1,760	13,810	53,340	(-720)	13,090	294,450	0	294,450
9. Other water resource development	296,700	1,580	283,700	1,520	3,100	98,800	700	3,800	564,400	114,800	679,200
Total program	3,891,140	233,490	7,056,660	473,070	706,560	2,056,460	(-12,280)	694,280	12,179,160	825,100	13,004,260
Federal	1,128,540	19,620	1,007,260	13,460	33,080	837,930	14,840	47,920			2,973,730
Non-Federal	2,762,600	213,870	6,049,400	459,610	673,480	1,218,530	(-27,120)	646,360			10,030,530

The installation costs of salinity control features for the combined Upper and Lower Colorado River Basins are estimated to be $241 million. The estimated annual operation and maintenance cost after completion of construction is $7,590,000. Salinity control costs are not included in the cost tables.

The program costs for associated development include specific costs for on-farm irrigation systems; thermal-electric plants and the transmission lines therefrom; nonwater-based recreation; and fish and wildlife for improving hunting, other than waterfowl hunting, by managing and improving the habitats, acquiring and improving access to hunting lands, and species management.

Adequacy of Framework Plan

Land and water supply is generally not a limiting factor in the framework plan in meeting the regionally interpreted OBERS level of development.

Agricultural sector

The framework plan will meet regionally interpreted OBERS production goals from irrigated lands by developing new land and water and increasing production on the present lands. Although 100,000 acres of dry cropland are shifted to other uses, the remainder, using proper management, is adequate to meet requirements. Although 7.1 million acres of grazing land will be retired or shifted to other uses, forage production will be adequate to support the livestock industry and wildlife requirements. Timber production requirements will be met only if the accelerated programs are put into effect.

Watershed management and flood control

Watershed management treatment programs will reduce the man-created erosion and sediment production and associated damage by 40 to 60 percent. The remaining damages are largely geologic in nature and not economically susceptible to treatment. Some natural problems may be susceptible to treatment. Upstream flood and sediment damage will be reduced 30 to 50 percent. Multipurpose reservoirs built on the stream system will trap sediment and reduce sediment contribution to many downstream areas. The plan is in agreement with existing protection and development programs.

The framework plan would reduce average annual flood damages in the amounts shown in the tabulation on the following page. Flood damage would be reduced to a reasonable level by the structural and nonstructural measures of the plan. However, a large portion of the estimated future flood damage is located in the sparsely populated upstream nonurban areas where it is not feasible to provide all necessary measures to

eliminate future flood damages. Nonstructural flood plain management would be implemented in urban areas and other areas subject to development to reduce flood damage by regulating the use of flood-prone lands.

Subregion	Estimated average annual flood damage reduction in $1,000		
	1980	2000	2020
Green River	302	1,053	2,115
Upper Main Stem	485	1,431	2,725
San Juan-Colorado	153	871	1,904
Total	940	3,355	6,744

Industrial activity

Proposed thermal-electric generation will meet all inbasin and a share of adjacent regions requirements. Mineral production, including the large amounts of coal for thermal-electric plants, can meet all the projected requirements. Planned development of municipal and industrial water supply can meet future needs.

Recreation - fish and wildlife

Generally, an adequate number of acres of land and water will be available to meet projected recreation needs. However, problems relating to use of these resources should be solved if demand is to be met. This will include providing adequate access, suitable funding to build recreation facilities, and sufficient supporting services--especially food and lodging.

Most of the region can expect to meet projected fish and wildlife needs through 2020. However, Arizona and New Mexico will have shortages of fish and wildlife. A possibility for water for fisheries in Arizona and New Mexico would be the recommitment of developed water now dedicated to other uses or purchase existing water rights. Wyoming also will have a significant shortage of game animals. If wildlife conservation is given adequate recognition as a prominent objective of development and management in the key habitat areas, wildlife habitat will remain available and its capacity may possibly be improved. There is adequate potential for both preservation of wildlife and increased livestock use by balanced management methods.

Export of water

The plan includes provision to export water to adjacent regions. All water subject to distribution between regions is in accordance with existing approved compacts or legal agreements.

Water quality

Plans for controlling water quality are generally adequate in applying corrective measures that are physically possible and feasible.

Water supply situation

After development of the framework plan, as described, approximately 8.3 million acre-feet of outflow would pass Lee Ferry in the year 2020 (Figure following page 78.)

Economic Impact of Framework Plan

Economic activity for agriculture and other projected sectors of the economy were analyzed by an input-output model to indicate the level of economic growth by subregions and time frame. Table 13 shows the figures for population, employment, personal income, and gross regional product.

Population

This population projection is based on economic subregions and does not include the 64,300 population independently projected for 2020 for the hydrology portion of Arizona in the Upper Colorado Region. Population density would increase from 3.8 per square mile in 1980 to 5.8 in 2020 for the economic subregions.

Employment

Coefficients were used in connection with projected total gross outputs to project the employment figures shown. Employment is projected to increase 126 percent for the region from 1965 to 2020.

Personal income

Personal income projections reflecting economic activity were obtained by multiplying the projected per capita income by the population projections (OBE). The major components of personal income are wage and salary payments, proprietor's income, property income, and income payments under Social Security, pensions, and similar funds.

Gross regional product

Gross regional product (GRP) is the sum of the four major expenditure components in the regional economy. These are (1) personal consumption expenditures, (2) government purchases of goods and services, (3) gross private investment, and (4) net export of goods and services.

Table 13 - Population, employment, personal income, and gross regional product for the framework plan, Upper Colorado Region

Subregion and year	Population	Employment	Personal income ($1,000)	Gross regional product ($1,000)
Green River				
1965	100,579	32,900	213,104	
1980	116,989	42,233	468,775	735,887
2000	145,876	55,287	1,070,730	1,595,067
2020	173,424	65,381	2,206,127	3,107,250
Upper Main Stem				
1965	136,725	48,770	333,522	
1980	168,618	62,726	589,320	870,365
2000	185,305	73,566	1,139,070	1,630,428
2020	213,289	85,742	2,326,770	3,257,425
San Juan-Colorado				
1965	99,625	29,720	183,372	
1980	150,337	50,363	518,813	813,377
2000	202,915	72,035	1,262,131	1,751,784
2020	273,464	100,088	3,039,005	4,105,192
Region				
1965	336,929	111,390	729,998	1,142,000
1980	435,944	155,322	1,576,908	2,419,629
2000	534,096	200,888	3,471,931	4,977,279
2020	660,177	251,211	7,571,902	10,469,867

UPPER COLORADO REGION

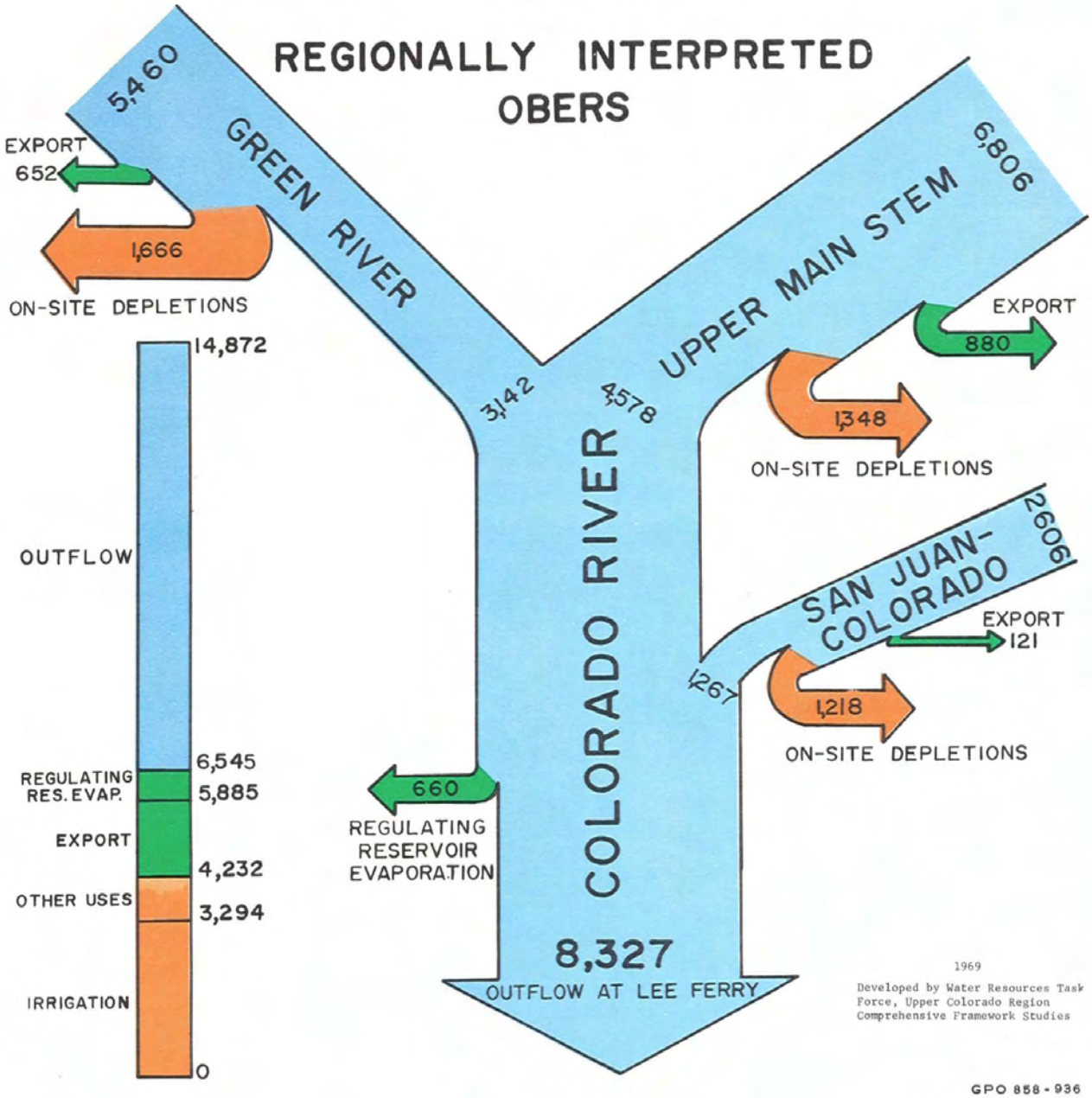
WATER SUPPLY (1914-1965),

ON-SITE DEPLETIONS & OUTFLOW FOR 2020

(In Thousands of Acre Feet)

YEAR 2020

REGIONALLY INTERPRETED OBERS



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Developed by Water Resources Task Force, Upper Colorado Region Comprehensive Framework Studies

GPO 858-936

Environmental Considerations of Framework Plan

Economic development to meet the projected needs with minimum adverse effects on the natural environment of the region has been the basic goal in formulating the framework plan. Many programs and functions have been outlined that would protect and contribute to the overall quality of living in the region in addition to providing the basic economic opportunities. These programs have been described in preceding sections.

Practically all programs and developments would increase the consumptive use of water and impact on the land in varying degrees. Development of water resources in many instances requires storage in reservoirs for efficient utilization. Construction of these reservoirs, in turn, causes some disruption on stream regimen and effects fish and wildlife habitat and natural features of the environment. However, with proper planning considerations many values are created that compensate for the changes. Streams are often regulated for flood control, sediment is removed, water quality fluctuations are diminished, and the streams are converted to conditions that support a higher type of fish life. Reservoirs themselves provide abundant fishing and other water-based recreation in this area where natural bodies of water are few in number and widely spaced. Detailed requirements to control pollution at construction sites are included in most contracts.

Based on the experience of the past 50 years, the proposed programs will irreversibly commit important segments of the region's archeological resource to total destruction or to such serious impairment as to destroy its usefulness to scientific investigation. This resource is the only source of information of the history of the American Indian prior to the accounts of the European Explorers. The loss of this heritage poses a serious dilemma to modern man. A properly planned and adequately funded regionwide program of investigations and salvage of the archeological resource will tend to mitigate this adverse effect.

Eliminating the abuse and placing all grazing on a sustained yield basis will alleviate most of the adverse effects connected with grazing and provide for required forage production.

Addition to the present irrigated land base of the projected 587,600 acres would cause loss of big-game habitat and conversion of the wildlife population to a farm game-type. Additional contribution of dissolved materials, pesticides, and nutrients in streams will occur unless proper control measures are developed and applied. Watershed management and flood control may have effects on fish and wildlife habitat and esthetics but will contribute materially to control of sediment, improvement of vegetative cover, reduce flood damage, improve base flows, provide open spaces on flood plains and protect frail lands.

If mineral development is managed properly, it can be accomplished with a minimum of detrimental effect. Strip-mining regulations must provide for reshaping and revegetation; land subsidence must be controlled by leaving sufficient support or refilling underground excavations or introduction of water to replace liquid petroleum. It is imperative that proper management regulates disposal of tailings and polluted drainage from all mining operations.

The tremendous increase projected in development of thermal-electric power would use a substantial amount of water but would occupy only a relatively small land area for plant and associated mining activities. Problems that need careful attention to minimize adverse impacts on the environment include disposal of waste heat, stack emissions, and location and construction of large transmission lines. Emission of sulfur products from fossil-fueled plants can become a major problem in this area of relatively clean air even considering the low sulfur content of most of the region's coal.

Accelerated timber management practices are needed to enhance the long-range quality of human environment which includes both appreciation of natural beauty and the need for basic materials for food and shelter. Special measures are taken to accelerate the growth of new forests needed to meet the rapidly increasing demand for wood for homes, offices, warehouses, plastics, paper and literally hundreds of items now considered essential everyday items. Timber harvesting in the region is designed to remove the overmature trees which are a hazard to recreationists and also to make more space available for younger trees to mature.

The resultant cutting patterns, if carefully designed, can add to the natural beauty of an area by creating new "open space" for new recreation opportunities, creating improved wildlife habitat, and increasing water yield.

The region now provides unexcelled opportunity for recreation to enhance the quality of living for nonresidents as well as the comparatively sparse resident population. However, if projected needs are met in the future, a tremendous increase in pressure is anticipated and careful consideration must be given to managing the natural environment to avoid unwarranted deterioration. Proper design and management of resort areas, campgrounds, and other facilities would alleviate concentrations.

The projected increase in population leaves the region with a very low average density and few urban concentrations. Construction is projected to alleviate the present backlog of sewage treatment facilities and upgrade treatment for future time periods. Plans have also been made for control of air pollution, solid waste disposal, radiological hazards, and disease vectors.

States' Alternative to the Framework Plan

Elements of plan

For comparative purposes the states proposed, as one alternative, a plan utilizing the same depletion amount (6.55 million acre-feet per annum) as the framework plan. Under this alternative the state distribution of consumptive use equals the Upper Colorado River Compact percentage allotments with adjustments in types of uses expressed by the respective states (Table 14).

In the framework plan, there is the need to service a large electric power market from potential fuel-burning electric powerplants in the Upper Colorado Region. Each of the States of Colorado, New Mexico, Utah, and Wyoming has programmed a part of its coal and water resources for the production of such energy. Previously the states had agreed to maintain proportionate levels of water development very close to their respective percentage allotments in the Upper Colorado River Compact. Without upsetting a multitude of water uses set forth in the framework plan, the approximate state percentages could be maintained only by an arbitrary assignment to each state of portions of the needed thermal-electric power installations as necessary to bring each state's total water uses to amounts approximating the compact percentages. Although this assignment depicted a reasonable satisfaction on a regionwide basis of the requirements for a framework plan, there were certain features objectionable to Colorado and Utah.

Changes made from the basic data, contained in the framework plan, are given in the following narrative and in Tables 14, 15, and 16.

Arizona retained its exact allotment of 50,000 acre-feet per annum in the revised year 2020 distribution with no change in types of uses.

Colorado varied its water depletions for full and supplemental irrigated land by 88,000 acre-feet less in 1980; 145,000 acre-feet more in 2000; and 31,500 acre-feet more in 2020. Irrigated land acreage varied by 18,000 less acres in 1980; 80,000 more acres in 2000; and 6,500 acres more in 2020. An oil shale industry of 1 million barrels-per-day capacity, with a support population of 78,000 depleting 97,000 acre-feet annually, was added. A coal-byproducts plant, using 15,000 acre-feet, and a potash plant, capacity 1.5 million tons annually, using 9,500 acre-feet annually, are projected. Exports are increased by 2,400 acre-feet and fish and wildlife by 600 acre-feet annually. It appears that Colorado would deplete its 51.75-percent allotment by the year 2000. Thermal-electric power installed capacity is lessened by 9,690 megawatts from the framework plan, depleting 146,400 acre-feet less annually. In addition, 22,100 acre-feet of irrigation water would be transferred between 2001 and 2020 to meet municipal and industrial requirements.

Table 14 - Water use for the States' alternative to the framework plan (6.5 MAF level of development) 1980, 2000, and 2020 Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
				- - 1980 - -					
Municipal and industrial	2,900	22,100	7,200	10,100	4,300	46,600	12,200	16,200	18,200
Electric power (thermal)	34,100	10,700	90,000	125,400	33,200	293,400	56,700	1,600	235,100
Minerals	400	19,500	11,800	10,300	19,000	61,000	31,500	13,700	15,800
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stockpond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	118,800	176,300	80,300	532,300	165,900	53,800	312,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,000	1,391,100	245,000	576,600	334,000	2,553,700	935,400	1,007,800	610,500
Export		663,400	117,500	190,000	65,000	1,035,900	255,000	660,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	481,300	940,300	479,300	4,119,300	1,356,300	1,722,500	1,040,500
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,779,300	1,423,300	1,739,500	1,616,500
				- - 2000 - -					
Municipal and industrial	4,800	48,300	13,600	16,800	5,900	89,400	26,100	31,900	31,400
Electric power (thermal)	34,100	108,200	90,000	261,800	148,700	642,800	331,100	16,600	295,100
Minerals	300	128,300	17,400	10,300	22,100	178,400	74,400	67,700	36,300
Fish and wildlife	1,200	39,400	6,800	22,200	18,800	88,400	49,500	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stockpond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	355,800	131,200	321,700	201,500	1,052,600	500,700	142,600	409,300
Irrigation: consumptive use, incidental and reservoir evaporation	7,600	1,778,200	411,000	660,600	407,000	3,264,400	1,197,500	1,184,500	882,400
Export		885,400	117,500	267,000	150,000	1,419,900	417,000	882,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,019,400	659,700	1,246,700	758,500	5,734,300	2,115,200	2,210,000	1,409,100
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						6,394,300	2,182,200	2,227,000	1,985,100
				- - 2020 - -					
Municipal and industrial	7,200	70,000	29,100	32,100	9,200	147,600	42,600	47,400	57,600
Electric power (thermal)	30,100	108,200	55,600	261,800	148,700	604,400	331,100	16,600	256,700
Minerals	300	124,500	32,500	52,900	21,500	231,700	109,400	71,800	50,500
Fish and wildlife	1,200	39,400	6,800	22,200	18,800	88,400	49,500	8,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stockpond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	379,500	128,200	382,300	205,300	1,136,300	556,000	166,100	414,200
Irrigation: consumptive use, incidental and reservoir evaporation	9,000	1,754,500	411,000	695,200	427,100	3,296,800	1,253,300	1,166,500	877,000
Export		885,400	117,500	267,000	185,000	1,454,900	452,000	882,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,019,400	656,700	1,341,900	817,400	5,885,400	2,261,300	2,215,500	1,408,600
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						6,545,400	2,328,300	2,232,500	1,984,600

Table 15 - Projected installed capacity and water depletions for thermal-electric power generation for the states' alternative to the framework plan (6.5 MAF level of development) Upper Colorado Region

Subregion and state	Installed capacity and consumptive use					
	1980		2000		2020	
	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet
Green River						
Colorado	663	9.1	4,663	69.1	4,663	69.1
Utah	959	14.4	7,559	113.3	7,559	113.3
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Subregion total	3,835	56.7	22,135	331.1	22,135	331.1
Upper Main Stem						
Colorado	123	1.6	1,123	16.6	1,123	16.6
Subregion total	123	1.6	1,123	16.6	1,123	16.6
San Juan-Colorado						
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	0	0	1,500	22.5	1,500	22.5
New Mexico	5,623	90.0	5,623	90.0	5,623	55.6
Utah	7,400	111.0	9,900	148.5	9,900	148.5
Subregion total	15,333	235.1	19,333	295.1	19,333	256.7
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	786	10.7	7,286	108.2	7,286	108.2
New Mexico	5,623	90.0	5,623	90.0	5,623	55.6
Utah	8,359	125.4	17,459	261.8	17,459	261.8
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Region total	19,291	293.4	42,591	642.8	42,591	604.4

Table 16 - Irrigated land use and on-site water depletions for the states' alternative to the framework plan (6.5 MAF level of development), Upper Colorado Region

State	Irrigated land (1,000 acres) Total	Irrigated land (1,000 acres) Supplemental 1/	Water depletions (1,000 acre-feet)
	1980		
Arizona	10.0	0	7.0
Colorado	985.4	60.5	1,391.1
New Mexico	104.2	5.5	245.0
Utah	350.8	33.0	576.6
Wyoming	341.5	59.0	334.0
Total	1,791.9	158.0	2,553.7
	2000		
Arizona	9.4	1.0	7.6
Colorado	1,167.4	170.2	1,778.2
New Mexico	174.2	5.5	411.0
Utah	371.1	111.6	660.6
Wyoming	379.5	85.0	407.0
Total	2,101.6	373.3	3,264.4
	2020		
Arizona	9.4	2.0	9.0
Colorado	1,158.4	170.2	1,754.5
New Mexico	174.2	5.5	411.0
Utah	383.6	119.2	695.2
Wyoming	392.5	95.0	427.1
Total	2,118.1	391.9	3,296.8

1/ Supplemental acreage included in total.

New Mexico, in order to stay within its 11.25-percent apportionment of the 6.55 million acre-foot level of development, changed its uses involving a net decrease of 9,500 acre-feet annually. A large reduction, 51,200 acre-feet, resulted from an arbitrary programed reduction in installed generating capacity. However, mineral production would materially increase, and an additional municipal and industrial use of 11,800 acre-feet would be required to serve a population increase of 64,500.

Utah desired that a much greater portion of its potential thermal-electric power production be included and projected an additional 11,700 megawatts to be installed. This required a support population of 26,000 people. Utah also added an oil shale industry with a capacity of 500,000 barrels-per-day with a support population of 39,000 people. In order to stay within its 23-percent allotment, Utah revised downward its irrigation acreage (-10,500 acres) and likewise revised downward (-200,000 acre-feet annually) its export to the Bonneville Basin.

Wyoming also suggested no changes in its type of uses but revised its irrigation depletions downward 900 acre-feet per annum to stay exactly within its 14-percent allotment.

Economic impact

The regional input-output model was used to measure the economic impact of the states' alternative plan. Figures are tabulated below for the resulting population, employment, personal income, and gross regional product.

Population, employment, personal income, and gross regional product for the states' alternative at 6.5 MAF level of development

Subregion and year	Population	Employment	Personal income ($1,000)	Gross regional product ($1,000)
Green River				
1980	115,217	41,593	461,675	721,730
2000	143,377	54,340	1,052,387	1,558,498
2020	205,371	77,425	2,612,524	3,494,116
Upper Main Stem				
1980	167,861	62,444	586,674	867,018
2000	240,332	95,412	1,477,321	2,389,201
2020	257,968	103,703	2,814,173	3,993,444
San Juan-Colorado				
1980	163,447	54,755	564,056	917,030
2000	212,233	75,343	1,320,089	1,848,662
2020	282,831	103,516	3,143,100	4,224,931
Region				
1980	446,525	158,792	1,612,405	2,505,778
2000	595,942	225,095	3,849,797	5,796,361
2020	746,170	284,644	8,569,797	11,712,491

States' Alternative at the 8.16 Million Acre-foot Level of Development

Elements of plan

This is an alternate plan of development which reflects 8.16 million acre-feet of man-made depletions in the Upper Basin. It includes the amounts of water evaporated from main stem reservoirs. This plan assumes the Colorado River water supply would be firmed to meet the division of water by the Colorado River Compact. Depletion distribution among the states in 2020 equals their percentage shares under the Upper Colorado River Compact.

Development of some resources would not be limited by present water availability. States have assumed that a market for the increased production associated with this level of development would readily be absorbed within national and increasing western markets. This is especially true since the added increment is a small part of the national market and would accordingly have a small impact.

Table 17 enumerates water depletions by states, subregions, types of use, and by time frames 1980, 2000, and 2020, and Table 18 details the installed capacity and water depletions for thermal-electric generation.

Arizona retained its allotment of 50,000 acre-feet for 2020 with no changes in types of uses previously described for the framework plan.

Colorado plans to irrigate 1,256,300 acres in 2020, which is 104,400 acres more than the framework plan, with a depletion of 1,941,500 acre-feet. Oil shale complexes, starting in the 1981-2000 time frame and totaling 2 million barrels-per-day capacity by 2020 are anticipated as divided equally between the Green River and Upper Main Stem Subregions. A coal byproducts plant, using 15,000 acre-feet in the San Juan-Colorado, and a potash plant, capacity of 1.5 million tons annually, using 9,500 acre-feet, are projected. Fish and wildlife uses would total 71,400 acre-feet, a substantial increase over the framework plan. Thermal-electric power capacity of approximately 10,000 megawatts would deplete 153,200 acre-feet annually. Export would increase to 1.36 million acre-feet annually. This plan would meet regionally interpreted OBERS requirements for all sectors except power, which would be met by Utah.

New Mexico plans no change in agriculture, fish and wildlife, or recreation from the framework plan. Population by 2020 is estimated at 189,500 and the minerals industry is projected to increase as a result of available reserves and national need. Thermal-electric powerplant installed capacity would be 5,623 megawatts. Export to the Rio Grande Basin via the San Juan-Chama Project would be increased 125,000 acre-feet over the framework plan for a total export of 243,000 acre-feet.

Table 17 - Water use for the States' alternative at the 8.16 MAF level of development, 1980, 2000, and 2020
Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
					1980				
Municipal and industrial	2,900	22,100	7,200	10,100	5,500	47,800	13,400	16,200	18,200
Electric power (thermal)	34,100	10,700	90,000	125,400	22,000	282,200	45,500	1,600	235,100
Minerals	400	19,500	19,800	10,300	23,900	73,900	36,400	13,700	23,800
Fish and wildlife	1,200	38,800	6,800	22,200	20,100	89,100	50,700	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stock-pond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	126,800	176,300	76,500	536,500	162,100	53,800	320,600
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,000	1,391,100	245,000	576,600	431,500	2,651,200	1,032,900	1,007,800	610,500
Export		663,400	117,500	190,000	65,000	1,035,900	255,000	660,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	489,300	940,300	573,000	4,221,000	1,450,000	1,722,500	1,048,500
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,881,000	1,517,000	1,739,500	1,624,500
					2000				
Municipal and industrial	4,800	50,000	13,600	20,200	7,300	95,900	29,500	31,900	34,500
Electric power (thermal)	34,100	153,200	90,000	291,800	37,000	606,100	234,400	61,600	310,100
Minerals	300	128,300	38,800	10,700	47,100	225,200	99,600	67,700	57,900
Fish and wildlife	1,200	39,400	6,800	22,200	20,100	89,700	50,800	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stock-pond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	402,500	152,600	355,500	117,500	1,070,500	433,900	187,600	449,000
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,600	1,792,500	411,000	660,600	534,500	3,406,200	1,325,000	1,198,800	882,400
Export		925,400	243,000	437,000	125,000	1,730,400	602,000	882,900	245,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,120,400	806,600	1,450,500	777,000	6,204,500	2,360,900	2,269,300	1,574,300
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						6,864,500	2,427,900	2,286,300	2,150,300
					2020				
Municipal and industrial	7,200	84,100	29,100	42,500	14,900	177,800	64,300	54,400	59,100
Electric power (thermal)	30,100	153,200	90,000	291,800	148,700	713,800	346,100	61,600	306,100
Minerals	300	207,500	54,000	165,600	136,700	564,100	378,600	113,300	72,200
Fish and wildlife	1,200	71,400	6,800	22,200	20,100	121,700	50,800	40,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stock-pond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	553,600	184,100	535,400	327,500	1,641,600	863,200	291,600	486,800
Irrigation: consumptive use, incidental use, and reservoir evaporation	9,000	1,941,500	411,000	733,700	562,500	3,657,700	1,470,100	1,262,600	925,000
Export		1,360,300	243,000	447,000	153,000	2,203,300	640,000	1,305,800	257,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,855,400	838,100	1,713,500	1,043,000	7,500,000	2,973,300	2,860,000	1,666,700
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						8,160,000	3,040,300	2,877,000	2,242,700

Table 18 - Projected installed capacity and water depletions for thermal-electric power generation for states' alternative at the 8.16 MAF level of development, Upper Colorado Region

Subregion and state	Installed capacity and consumptive use					
	1980		2000		2020	
	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet
Green River						
Colorado	663	9.1	4,663	69.1	4,663	69.1
Utah	959	14.4	8,559	128.3	8,559	128.3
Wyoming	1,463	22.0	2,463	37.0	9,913	148.7
Subregion total	3,085	45.5	15,685	234.4	23,135	346.1
Upper Main Stem						
Colorado	123	1.6	4,123	61.6	4,123	61.6
Subregion total	123	1.6	4,123	61.6	4,123	61.6
San Juan-Colorado						
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	0	0	1,500	22.5	1,500	22.5
New Mexico	5,623	90.0	5,623	90.0	5,623	90.0
Utah	7,400	111.0	10,900	163.5	10,900	163.5
Subregion total	15,333	235.1	20,333	310.1	20,333	306.1
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	786	10.7	10,286	153.2	10,286	153.2
New Mexico	5,623	90.0	5,623	90.0	5,623	90.0
Utah	8,359	125.4	19,459	291.8	19,459	291.8
Wyoming	1,463	22.0	2,463	37.0	9,913	148.7
Region total	18,541	282.2	40,141	606.1	47,591	713.8

Utah would increase its use by irrigated crops 10,700 acre-feet over the framework plan and irrigate about 401,200 acres by 2020. There are no changes in fish and wildlife, recreation, or stock-pond evaporation and livestock use. Export to the Great Basin by 2020 would increase to 447,000 acre-feet, which is 20,000 acre-feet less than the framework plan. Major changes are increased thermal-electric power to 19,500 megawatts installed capacity and increased mineral activity, including mining coal for powerplants, a million barrel-per-day shale oil output, processing oil-impregnated sandstone, and conversion of coal.

Wyoming's development includes a substantial increase in the mineral industry, including a million barrel-per-day shale oil production, depleting 97,000 acre-feet of water, and conversion of coal. Trona plant capacity would continue to increase. Population would increase to 148,000 by the year 2020. The agricultural base of irrigated land would increase to 513,300 acres by the year 2020.

Thermal-electric power installed capacity is estimated at almost 10,000 megawatts. Transbasin diversions to the North Platte are estimated at 153,000 acre-feet, which is a 32,000-acre-foot reduction from the framework plan.

Economic impact

Economic impacts were estimated by use of the regional input-output model. Data are tabulated below for the resulting population, employment, personal income, and gross regional product.

Population, employment, personal income, and gross regional product for the states' alternative at 8.16 MAF level of development

Subregion and year	Population	Employment	Personal income ($1,000)	Gross regional product ($1,000)
Green River				
1980	115,028	41,525	460,917	718,728
2000	139,201	52,757	1,021,735	1,500,853
2020	355,518	134,030	4,522,544	5,595,200
Upper Main Stem				
1980	167,861	62,444	586,674	867,018
2000	243,487	96,664	1,496,715	2,439,790
2020	260,691	104,800	2,843,878	4,059,576
San Juan-Colorado				
1980	163,978	54,933	565,888	922,091
2000	214,383	76,106	1,333,462	1,872,249
2020	284,600	104,164	3,162,760	4,251,146
Region				
1980	446,867	158,902	1,613,479	2,507,837
2000	597,071	225,527	3,851,912	5,812,892
2020	900,809	342,994	10,529,182	13,905,922

States' Alternative--Water Supply Available at Site (9.44 MAF depletions)

Development which would be possible if the states of the Upper Colorado Region utilize water which would be physically available at site of project development is described briefly below. There has been no agreement between the states or within the states that this can be accomplished in the way indicated, but rather this discussion indicates utilization of water that is physically available for development. It is contemplated that there would be shifts between types of use as the needs develop. The plan would require substantial augmentation to meet Colorado River Compact requirements for delivery at Lee Ferry. If the Colorado River is augmented below Lake Powell, exchange arrangements would have to be made. Proper consideration of possible detriment to power revenues and of augmentation costs will be required.

Additional uses of 1.28 million acre-feet above the 8.16 million acre-foot level are described briefly by state, and summaries for total uses are shown in Table 19.

Colorado has identified additional uses by 2020, which would increase export to the eastern slope of the Rocky Mountains by 113,000 acre-feet annually and increase irrigation use by 69,000 acre-feet, primarily in the Upper Main Stem Subregion.

New Mexico water depletions would increase 228,900 acre-feet, primarily for electric power, irrigation, and export to the Rio Grande Basin.

Additional developments in Utah would all occur in the period 2001-20. Irrigation projects not previously incorporated in plans would require over 200,000 acre-feet of water; coal conversion would double and require 22,300 acre-feet more water; and a 100,000 addition would be exported to the Great Basin Region.

Project depletions of the Colorado River system by Wyoming total 1,588,000 acre-feet, which is 545,000 acre-feet more than at the 8.16 million acre-foot level of development. Increases in depletions occur primarily in mineral production and export.

1968 OBERS

Early study of the 1968 OBERS projections, as published for agriculture, revealed inconsistencies that were incompatible with the history of agricultural production in the Upper Colorado Region. The primary departure from established practice was the projected source of livestock feed required to meet the livestock production assigned to the region by

Table 19 - Water use for the States' alternative for water available at site, Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
				- - 1980 - -					
Municipal and industrial	2,900	22,100	7,200	10,100	10,500	52,800	18,400	16,200	18,200
Electric power (thermal)	34,100	10,700	112,000	125,400	22,000	304,200	45,500	1,600	257,100
Minerals	400	19,500	11,800	10,300	48,900	90,900	61,400	13,700	15,800
Fish and wildlife	1,200	38,800	6,800	22,200	20,100	89,100	30,700	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stockpond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	140,800	176,300	106,500	580,500	192,100	53,800	334,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,000	1,391,100	245,000	576,600	431,500	2,651,200	1,032,900	1,007,800	610,500
Export		663,400	118,000	190,000	115,000	1,086,400	305,000	660,900	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	503,800	940,300	653,000	4,315,500	1,530,000	1,722,500	1,063,000
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,975,500	1,597,000	1,739,500	1,639,000
				- - 2000 - -					
Municipal and industrial	4,800	50,000	13,600	20,200	19,300	107,900	41,500	31,900	34,500
Electric power (thermal)	34,100	153,200	131,000	291,800	37,000	647,100	234,400	61,600	351,100
Minerals	300	128,300	17,400	10,700	140,100	296,800	192,600	67,700	36,500
Fish and wildlife	1,200	39,400	6,800	22,200	20,100	89,700	30,800	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stockpond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	402,500	172,200	355,500	222,500	1,195,100	538,900	187,600	468,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,600	1,792,500	491,000	660,600	534,500	3,486,200	1,325,000	1,198,800	962,400
Export		925,400	243,000	437,000	300,000	1,905,400	777,000	882,900	245,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,120,400	906,200	1,450,500	1,057,000	6,584,100	2,640,900	2,269,300	1,673,900
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						7,244,100	2,707,900	2,286,300	2,249,900
				- - 2020 - -					
Municipal and industrial	7,200	84,100	29,100	42,500	38,900	201,800	88,300	54,400	59,100
Electric power (thermal)	30,100	153,200	131,000	291,800	148,700	754,800	346,100	61,600	347,100
Minerals	300	207,500	32,500	187,900	307,700	735,900	571,900	113,300	50,700
Fish and wildlife	1,200	71,400	6,800	22,200	20,100	121,700	50,800	40,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stockpond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	553,600	203,600	557,700	522,500	1,878,400	1,080,500	291,600	506,300
Irrigation: consumptive use, incidental and reservoir evaporation	9,000	2,010,500	571,000	935,500	562,500	4,088,500	1,550,900	1,385,600	1,152,000
Export		1,473,400	293,000	547,000	503,000	2,816,400	1,090,000	1,418,900	307,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	4,037,500	1,067,600	2,037,600	1,588,000	8,780,700	3,721,400	3,096,100	1,963,200
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						9,440,700	3,788,400	3,113,100	2,539,200

the national projections. The published projections of feed output were not adequate to produce the livestock output without very large feed imports from outside the region.

Table 20 shows the required imports of feeds and corresponding surplus of pasture and range.

If imports were assumed to be the source for supplying the necessary feed, a net reduction of 70,700 acres of irrigated land would ensue from 1965 to 2020. This would, in turn, be incompatible with present detailed plans contained in federally authorized projects and contemplated private developments of 401,500 acres.

Because the projection of livestock production appeared to be more realistic than the livestock feed requirements and because of other technical considerations associated with the development of model coefficients, no further studies were attempted for the agricultural sector.

Table 20 - Feed crop imports and range forage surplus
1968 OBERS, Upper Colorado Region

	Unit price (per ton)	Amount (tons)	Value (dollars)
	Imports		
Feed grain, corn equivalent			
1980	$40	163,470	$6,538,800
2000	40	405,208	16,208,320
2020	40	648,517	25,940,680
Hay			
1980	25	492,806	12,320,150
2000	25	598,576	14,964,400
2020	25	572,266	14,306,650
Corn silage			
1980	8	95,612	764,890
2000	8	107,975	863,800
2020	8	100,200	801,600
Total feed crop imports			
1980			19,623,840
2000			32,036,520
2020			41,048,930

	Surplus of Present Production	
	Unit price	Amount (AUM's)
Surplus pasture and range		
1980	NA	221,473
2000	NA	506,368
2020	NA	745,790

PART VII

COMPARISONS AND CONCLUSIONS

Five levels of development are defined and evaluated in this study, i.e.:

Present (1965) level.
Regionally interpreted OBERS.
States' alternative - 6.55 million acre-feet.
States' alternative - 8.16 million acre-feet.
States' alternative - water supply available at site - 9.44 million acre-feet.

The framework plan, based upon the regionally interpreted OBERS projection, was developed first and was used as the basis and cornerstone for other studies. Three "states' alternatives" or choices were developed to reflect capability of the region to supply goods and services not fully evaluated in the OBERS projections. The 1968 OBERS and the ongoing programs were also studied and will be discussed.

The effect of the various levels of development on water and related land resources and economic and agricultural activity, as well as conclusions reached, are presented in this section.

Comparisons

Water supply

Average annual historical discharge at the principal measuring point for the Colorado River, at Lee Ferry, Arizona, averaged 12,426,000 acre-feet for the 52-year period, 1914 through 1965. Because of variations in precipitation and other climatic influences, the extremes were 21,894,000 acre-feet in 1917 and 4,396,000 acre-feet in 1934. For the same period, average annual virgin or undepleted flow, as it would have been without man's influences, would have averaged 14,870,000 acre-feet.

The future outflow at Lee Ferry will depend on which level of development actually occurs, as well as augmentation. Augmentation practices considered as possibilities include water-yield improvement and weather modification which may increase the supply by about 1 to 2 million acre-feet.

Augmentation will definitely be required by 2020 for the two highest levels of depletion to meet Colorado River Compact apportionment to the lower basin. Local shortages in the region may occur at any level of development.

On-site water depletions

Four projected levels of depletion for alternative resource development are shown in Table 21. The present base of 1965 is used as a reference for projections. Data in Table 21 compares the on-site depletions of the four projected levels of development for the year 1965 and for the year 2020. Depletions are shown by type of use, states, and subregions. Depletions are estimated to nearly double from the present 1965 level to the level of the framework plan in 2020 and states' alternative at the 6.55 million acre-foot level. Irrigation depletions and export, which will account for about 75 percent of total depletions, will each increase about a million acre-feet. Thermal-electric power uses will have the greatest percent of increase--at the 8.16 MAF level of development about 3,000 percent.

Water for mineral uses will increase significantly with oil shale development being included in the three "states' alternatives." For comparative purposes the alternative at 6.55 MAF was defined by the states at the same total depletion level in 2020 as the framework plan. Departure from the framework plan due to states' adjustment in types of use is shown in Table 22. Two additional states' alternatives for greater depletion levels were then defined. Departure from the framework plan due to states' adjustment in type of use for the 8.16 MAF level of depletion is shown in Table 22.

Agricultural activity

Agriculture in this region is tied to irrigated cropland production. Therefore, the increase in production on existing irrigated lands and the development of new irrigated land relates to a large portion of the agricultural activity. (See Table 23.) Projected irrigated acreage for the alternative levels of development by time frame is as follows:

Level of development	Irrigated acreage (thousand acres)			
	1965	1980	2000	2020
On-going program	1,622	1,732	1,878	2,024
1968 OBERS	1,622	1,499	1,529	1,551
Regionally interpreted OBERS	1,622	1,794	1,954	2,122
States' alternative (6.55 MAF)	1,622	1,792	2,102	2,118
States' alternative (8.16 MAF)	1,622	1,872	2,224	2,354
States' alternative (water available)	1,622	1,872	2,259	2,579

The on-going program is based on installation of authorized Federal projects and development of new irrigated land by private interests. About 70 to 80 percent of the present lands having short water supply

Table 21 - Summary of water resources development, Upper Colorado Region

			States' alternatives		
	1965	Framework plan Year 2020	6.5 Million Acre-feet Year 2020	8.16 Million Acre-feet Year 2020	Water Available At Site Year 2020
			(Acre-feet)		
VIRGIN WATER SUPPLY (1914-65)	14,872,000	14,872,000	14,872,000	14,872,000	14,872,000
ON-SITE WATER DEPLETIONS					
By type of use					
Municipal and industrial	27,400	110,100	147,600	191,800	201,800
Electric power (Thermal)	23,200	626,600	604,400	713,800	754,800
Minerals	33,700	52,800	231,700	550,100	735,900
Fish and wildlife	11,700	87,800	88,400	121,700	121,700
Recreation	1,300	5,200	5,200	5,200	5,200
Stockpond evaporation and livestock use	34,900	59,000	59,000	59,000	59,000
Subtotal	132,200	941,500	1,136,300	1,641,600	1,878,400
Irrigation	2,127,800	3,294,000	3,296,800	3,657,700	4,088,500
Export	550,300	1,652,500	1,454,900	2,203,300	2,816,400
Less import	(-)2,600	(-)2,600	(-)2,600	(-)2,600	(-)2,600
Subtotal of above	2,807,700	5,885,400	5,885,400	7,500,000	8,780,700
Main Stem Reservoir evaporation	643,000	660,000	660,000	660,000	660,000
Total	3,450,700	6,545,400	6,545,400	8,160,000	9,440,700
By state					
Arizona	10,100	50,000	50,000	50,000	50,000
Colorado	1,706,600	3,009,800	3,019,400	3,855,400	4,037,500
New Mexico	144,900	666,200	656,700	838,100	1,067,600
Utah	664,000	1,341,100	1,341,900	1,713,500	2,037,600
Wyoming	282,100	818,300	817,400	1,043,000	1,588,000
Total	2,807,700	5,885,400	5,885,400	7,500,000	8,780,700
By subregion					
Green River	1,059,500	2,385,100	2,328,300	3,040,300	3,788,400
Upper Main Stem	1,397,300	2,245,200	2,232,500	2,877,000	3,113,100
San Juan-Colorado	993,900	1,915,100	1,984,600	2,242,700	2,539,200
Total	3,450,700	6,545,400	6,545,400	8,160,000	9,440,700
OUTFLOW	11,421,300	8,326,600	8,326,600	6,712,000	5,431,300

Table 22 - Departure from the framework plan due to States' adjustment in types of uses

Upper Colorado Region

Type of use by Sub-basin	Colorado		New Mexico		Utah		Wyoming		Total	
	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet
6.5 MAF level of development in year 2020										
Electric power (thermal) (Megawatts)	-9,690	-146,400	-1,500	-51,200	+11,700	+175,400	-	-	+510	-22,200
Oil shale development (Barrels per day)	+1,000,000	+83,000	-	-	+500,000	+41,500	-	-	+1,500,000	+124,500
Potash development (Tons per year)	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
Coal byproducts and general minerals	(Unidentified)	+15,000	(Unidentified)	+29,900	-	-	-	-	(Unidentified)	+44,900
Municipal and industrial (Population)	+78,000	+14,000	+64,500	+11,800	+65,000	+11,700	-	-	+207,500	+37,500
Irrigated land (acres)	+6,500	+31,500	-	-	-10,500	-27,800	-	-900	-4,000	+2,800
Exports (acre-feet)	-	+2,400	-	-	-	-200,000	-	-	-	-197,600
Fish and wildlife	-	+600	-	-	-	-	-	-	-	+600
Total	-	+9,600	-	-9,500	-	+800	-	-900	-	0
8.16 MAF level of development in year 2020										
Electric power (thermal) (Megawatts)	-6,690	-101,400	-1,500	-16,800	+13,700	+205,400	-	-	+5,510	+87,200
Oil shale development (Barrels per day)	+2,000,000	+166,000	-	-	+1,000,000	+83,000	+1,000,000	+83,000	+4,000,000	+332,000
Potash development (Tons per year)	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
Coal byproducts and general minerals	(Unidentified)	+15,000	(Unidentified)	+51,400	(Unidentified)	+71,200	(Unidentified)	+18,200	(Unidentified)	+155,800
Municipal and industrial (Population)	+156,000	+28,100	+64,500	+11,800	+124,000	+22,100	+110,000	+19,700	+454,500	+81,700
Irrigated land (acres)	+104,400	+218,500	-	-	+7,100	+10,700	+120,800	+134,500	+232,300	+363,700
Exports (acre-feet)	-	+477,300	-	+125,500	-	-20,000	-	-32,000	-	+550,800
Fish and wildlife	-	+32,600	-	-	-	-	-	+1,300	-	+33,900
Total	-	+845,600	-	+171,900	-	+372,400	-	+224,700	-	+1,614,600

Table 23 - Comparisons of selected agricultural and industrial activity at five alternative levels of development
Upper Colorado Region

Type of production	Units	1965 base	Frame-work plan in 2020	States' alternatives: 6.5 million acre-feet in 2020	States' alternatives: 8.16 million acre-feet in 2020	States' alternatives: Water available at site in 2020
Agricultural Activity						
Irrigated land	1,000 acres	1,622	2,122	2,118	2,354	2,579
Dry cropland	1,000 acres	603	503	503	503	503
Range grazing production	1,000 AUM's	6,368	7,665	7,665	7,665	8,392
Timber production	Mil. cu. ft.	48	340	340	340	340
Industrial Activity						
Electric power						
Thermal	Megawatts	1,335	42,081	42,591	47,591	50,391
Hydro	Megawatts	1,300	1,300	1,300	1,300	1,300
Minerals						
Shale oil	Mil. bbl/day	0	0	1.5	4	4
Coal byproducts	Equivalent mil. bbl./day	0	0	0.2	0.8	1.6
Potash	Tons/day	0	0	4,100	4,100	4,100
Fish and Wildlife - Recreation						
Fish and wildlife						
Sport hunting	1,000 man-days	1,268	2,374	2,634	2,955	3,072
Sport fishing	1,000 man-days	3,547	8,667	9,221	9,691	10,094
Recreation	Mil. rec.-days	56	225	225	225	225
Watershed Management and Flood Control						
Watershed management						
Sediment yield reduction	Ac.-ft./yr.		2,764	2,764	2,764	2,764
Flood Control						
Flood damage reduction	1,000 dollars		6,744	7,063	7,754	
Economic Activity (Economic Boundaries)						
Population	1,000's	337	660	746	901	
Employment	1,000's	111	251	285	343	
Gross regional product	Mil. dollars	1,142	10,470	11,712	13,906	
Personal income	Mil. dollars	730	7,572	8,570	10,529	

will receive supplemental water in connection with new land development, except for the 1968 OBERS alternative. It is assumed in the 1968 OBERS level that agricultural activity will increase only by importing feed and feeder calves for projected feedlot operations.

Timber production under on-going programs will increase about 5 percent in each time frame of the projected period. The 1968 OBERS timber production shows an increase of four times the present production by 2020. For the framework plan and the three states' alternatives, production will increase about sevenfold over the present.

Livestock grazing production under on-going programs is estimated to increase only 0.3 million AUM's by 2020. The 1968 OBERS projections would require a reduction in going programs with a resultant waste of the resource. The framework plan shows an increase of 1.3 million AUM's. Optimum grazing production would provide an increase of over 2 million AUM's. This production is available as an alternative for the framework plan and the three states' alternatives. In Table 23 it is shown only under the "water at site" level of development, because grazing is not affected by the alternative water supplies analyzed under the other two states' alternatives.

Industrial activity

Two significant sectors of industrial activity in the region are production of minerals and thermal-electric power. Thermal-electric power capacity installed to supply local use and for export would increase from the present 1,300 to 47,600 megawatts at the highest level of development. Mineral activity planned for the states' alternative levels includes four shale oil plants with a total capacity of 4 million barrels-per-day. Coal conversion by hydrogenation is planned. This, together with coal mined for thermal-power production, approximates 200 million tons annually. Uranium production will increase significantly. Trona production in Wyoming is projected to increase to four times the present level.

Fish and wildlife - recreation

Present sport hunting and fishing demand is projected to nearly double by 2020 under both the on-going and the framework plan. Alternative plans are based upon projected population changes. Recreation demand, 97 percent by nonresidents, will increase fourfold.

Watershed management

Watershed management is planned to reduce the average annual damages by about 50 percent from man-created watershed problems and about 10 percent relative to natural problems. This program also includes improving water yield in terms of quantity, quality, and timing as a result of vegetal manipulation. The going program will accomplish about 40 percent of the framework plan.

No alternative levels of damage reduction are included for the states' alternatives because programs such as oil shale development are planned to include the necessary watershed protection measures as a part of the development cost itself. The increased population under alternative levels and resultant impact on the watershed may increase the cost of accomplishing the planned protection. Adequate data to estimate the costs are not available.

Flood control

One basic plan has been prepared for flood control. However, flood damage and damage reduction have been evaluated for two alternative levels of development. A comparison of estimated average annual flood damages (1965 prices and project conditions) under the framework plan and the alternative projections, exclusive of "water available at site," follows:

Estimated average annual flood damage
(thousands of dollars)

		States' alternative	
1965	Framework plan in 2020	6.55 million acre-feet in 2020	8.16 million acre-feet in 2020
2,792	10,600	10,900	11,900

The flood damage reduction under these alternative levels of development is shown in Table 23.

Economic activity

Comparisons of population, employment, gross regional product, and personal income are shown in Table 23.

Costs

Cost data have previously been presented for water development and associated development programs for the framework plan. Average annual expenditures for water development during the 5-year period 1965-69 were also compiled from agency and state reports. Comparison of these data is shown on the following page.

	Water development		Associated development	
	Federal	Non-Federal	Federal	Non-Federal
	(thousands of dollars)			
1965-69 average annual installation	54,880	16,000		
OM&R	10,000	1,250		
Framework plan average annual installation				
1966-1980	62,420	16,930	12,820	167,240
1981-2000	34,950	18,740	15,410	283,730
2001-2020	19,410	13,530	22,490	47,400
Increased annual OM&R (at end of period)				
1966-1980	5,010	12,530	14,610	201,340
1981-2000	2,470	17,820	10,990	441,790
2001-2020	2,070	7,370	12,770	-34,490

The large expenditures for the associated development program are primarily designated for the acquisition and development of recreational land and facilities and the installation and operation of thermal-electric generating plants.

The 1965-69 figures represent the average in a period of declining Federal expenditures. Compared to the $64.9 million average, 1966 estimates showed $76.0 million and 1969, $47.6 million. Non-Federal expenditures remained at about the same level during the 1965-69 period.

Conclusions

The framework plan as outlined is general in nature and presents one way in which the region's water and related land resources can be developed and utilized to meet projected demands through the year 2020. Three states' alternative plans were formulated to reflect the capacity of the region to utilize resources and to supply goods and services not required under the framework plan.

While the plan and the alternative levels of development were not studied in sufficient depth to identify alternative means of meeting needs and outline specific programs and projects, they satisfy the objectives of delineating the adequacy of the region's resources. The plans also identify associated problems and considerations in relation to conserving the resources and to providing for the overall well-being of people.

The framework plan generally meets all needs and demands of the regionally interpreted OBERS projections. The three "states' alternative"

plans also generally meet the regionally interpreted OBERS needs and demands plus additional needs associated with higher levels of development.

Natural resources are available to meet all needs except for part of the water-related recreation demand imposed by the projected heavy nonresident activities and shortages resulting from localized hunting and fishing pressure. The programs of watershed management and flood control do not provide full treatment and protection due to economic considerations. Although ample resources have been identified to meet the other projected needs, there are conflicting land and water uses which remain unresolved. Additional studies are needed to identify and weigh alternative developments. Land use studies are needed to identify areas which should be preserved and to designate the prime use of areas where resource availability overlaps. State water plans are under various stages of preparation along with Federal and private water development investigations. Completion of these and additional studies appear necessary to give a basis for selecting developments which will be in the best public interest.

Expenditures would have to be increased substantially, particularly by the Federal Government, to accomplish the $2.9 billion water-related programs under the framework plan. Very large expenditures would also be required by non-Federal interests to provide for installation of the $7.6 billion electric power facilities and the acquisition of lands for the $3.2 billion recreation program under the total framework plan.

Legal and Institutional

Legal and institutional arrangements now provide broad and complex systems for the development and administration of the land and water resources of the region. The arrangements provided by state and Federal laws are largely complementary and have produced a high degree of cooperation. However, challenges and conflicts have arisen and still exist within the Upper Colorado Region and in the relationships with adjacent regions. The principal problems requiring solutions or adjustments are centered in the field of reserved water rights, interpretations of the compacts regulating the use of the water of the Colorado River system, water pollution, land use, and environmental considerations. Further legal remedies will be sought as water resources development approaches the limit of available supplies.

Economic activity

Economic development restraints imposed by the relatively large distance to major population centers and markets, the small population base and other factors are expected to continue to restrict development of many of the region's resources. Although total gross output is expected to increase from about $0.5 billion in 1965 to about $3 billion in 2020, this merely maintains the relative position of the region in terms of the growth rate projected for the Nation.

Water supply

Sufficient water is physically available for on-site regional use and export to meet the needs projected by the regionally interpreted OBERS (6.55 million acre-feet) and the three states' alternatives at 6.55, 8.16, and 9.44 million acre-feet. However, augmentation of the Colorado River system water supply will be required to meet the higher development levels and downstream commitments. The exact quantity of augmentation cannot be determined because of varying interpretations of compacts and treaties which affect the Colorado River Basin water supply.

Land resources

Land resources exist in sufficient quantity to meet requirements of all projected levels of development. Potentially irrigable land over that used in 1965 totals 7.06 million acres. Selection from these lands can be made to meet irrigated land needs up to the 1 million additional acres projected under the largest alternative. Of the 60.4 million acres used for grazing in 1965, 5.8 million acres should be retired as they are unsuitable for continued grazing use. Placing of all remaining grazing lands on a sustained yield basis will provide for increasing forage production from 6.4 to 8.39 million animal unit months. The small total requirements for urban, industrial, transportation, utilities; developed recreation, fish and wildlife; and developed minerals can be selected as needed but will result in decreases in land available for grazing, timber production, and dry cropland.

Need will continue to select and preserve lands for wilderness, primitive, outstanding natural, historic, and cultural areas and scenic rivers. Management is required, under the multiple-use concept, of about 41 million acres for key habitat of wildlife. Nearly all lands are available for extensive use as undeveloped recreation and hunting areas.

Commercial timber exists on 9.4 million acres. Reduction in commercial forests of about 225,000 acres will result from conversion of forest lands to other uses. This will necessitate an intensified timber management and timber harvest program to achieve the required production--about seven times the present production.

Minerals

There is ample evidence to suggest that the resource base of the more important minerals customarily produced during the past two decades in the Upper Colorado Region is sufficient to meet all reasonable demands through 2020. The physical presence and production potential of such commodities as molybdenum, coal, and trona clearly fit this assumption. Oil, gas, and uranium are examples of minerals that appear to have a less favorable

resource base. However, synthetic fuel potential from oil shale, rock asphalt, and coal offers alternatives that can relieve demand pressure on conventional fuels. The on-coming development of the uranium breeder reactor, which would produce the fuel plutonium, would also replace conventional fuels.

Watershed management

If no additional watershed land treatment or flood protection programs are initiated, average annual damages will increase from the present $8.7 million to $25.6 million by 2020, assuming the framework plan level of development. Management and protection programs include land treatment on 24 million acres and installation of 78,000 water control structures. These will correct most of the existing problems that can be treated. Increased protection is an integral part of the future production activity. Cost of the erosion, flood, and sediment prevention and the water yield improvement programs in terms of average per-year expenditures for installation and operation, maintenance, and replacement for 1966 to 2020 is $24.4 million.

Erosion, the most significant problem affecting 30.5 million acres, requires an immediate action program to treat 3.9 million acres in critical erosion condition.

Watershed treatment programs needed to correct the treatable existing problems will be the same for all alternatives, and will be accomplished if funding is available. The "going program" based on 1964-69 level of development would accomplish about 78 percent of the proposed program. The additional protection needed for states' alternatives will be an integral part of the increased development cost.

Flood control

Without additional flood damage reduction measures, annual flood damage is estimated to increase from $2.8 million (1965) to approximately $4.2 million by 1980, $6.8 million by 2000, and $10.6 million by 2020. To reduce the hazards to health and human life and excessive economic losses from floods, an appropriate degree of protection should be provided through structural and nonstructural measures, consistent with other uses of water and land resources. The future flood damage reduction program consists of 0.2 million acre-feet of single-purpose flood control storage and 2.1 million acre-feet of multipurpose storage capacity; construction of 9 miles of levees and 11 miles of channel improvement; nonstructural measures including improved flood forecasting, dissemination of flood hazard information, flood plain zoning, and other measures by local authorities; and land treatment on 7 million acres under watershed management programs. The program would reduce potential annual flood damages by $6.7 million in the year 2020.

Recreation

Over 90 percent of the impact on recreation resources is estimated to result from nonresidents of the region. The low resident population, adjacent metropolitan areas, and high quality natural resources are the major factors that combine to create this situation. There is an abundance of undeveloped land available in public ownership to provide land-related recreation opportunities for residents and nonresidents. However, there are areas of outstanding quality not now in public ownership that need to be purchased to ensure their protection. Also, locally, there are needs for these lands because of inadequate distribution of public lands. To provide more people the opportunity to enjoy these areas, there is need for more recreation facility development and for supporting services. This need is related to private developments and to the presently inadequate funding and staffing of land administering agencies. Regionally, there are no surface water needs projected until 2020; however, there are needs locally because most of the water surface area is concentrated at a few locations. To make more existing and newly developed water areas available to recreationists, there is considerable need for more access. This may require legislation, special agreements, or the construction of more roads, as the case may warrant.

Fish and wildlife

Sport hunting and fishing capacity can continue to satisfy demands over future years with the exception of hunting and fishing in Arizona and New Mexico and the big-game hunting in Wyoming. Continued effective management will be essential and on-going plans and programs of the state and Federal fish and wildlife management agencies must be vigorously pursued to sustain the habitat capacity.

Electric power

A total power generating capacity installation of 43,400 megawatts is projected under the framework plan by the year 2000 to satisfy region and export requirements. This total includes a very large increase in thermal-electric generation facilities which will consume about 631,600 acre-feet of water annually for cooling purposes. No significant increase of hydroelectric plant installation is planned beyond those presently authorized or under construction. Pumped storage sites are available in the region but will not be developed soon as equally good sites are available at points closer to the large loads in adjacent regions. Generation by nuclear-fired plants or other methods is considered unlikely due to competition with lower cost coal fuel.

Water quality

The quality of surface and ground water supplies would generally decrease with the projected levels of use. However, the utility of water

in the region will not be seriously affected. Feasibility studies on potential water quality improvement projects for the Colorado River Basin are needed.

PART VIII

RECOMMENDATIONS

Introduction

Adoption of the framework plan and alternatives as a means for meeting future needs is recommended for general use as being indicative of the magnitude and type of future development. While there are some differences in the type of water uses for the alternatives, these have been identified. Major differences, particularly in the higher water use alternatives, reflect the extent to which the mineral resources will be developed, the need for more agricultural production, and the need for greater water exportation to adjacent regions. Development of these latter alternatives requires augmentation of the Upper Colorado Basin water supply. While more study will be needed prior to making some of these long-range decisions, there are many recommendations which are basic to the needs of the region and have been outlined below.

General Recommendations

1. The authorized Federal water resource development programs should be funded and constructed in order to help meet the production of required goods and services as the initial steps in the implementation of the framework program. Annual funding should be increased from the actual level of $47.6 million in 1969 to approximately $73 million for the period to 1980. Non-Federal funding should be approximately doubled for the same period.

2. Planning options in resource development should be considered to the fullest extent in order to protect and enhance the environment, particularly if opportunities are available outside the region to meet needs.

3. An effective water quality improvement program for the entire Colorado River Basin should be implemented immediately with high priority. This program should seek solutions to present water quality problems and should include measures to alleviate the effects of additional development to the extent practicable.

4. The high quality recreation, fish, wildlife, and open space values of the Upper Colorado Region should be recognized as national assets that should be preserved and given special recognition in land- and water-use planning.

5. An extensive land use and capacity analysis should be made to insure the best use of all resources.

6. An expanded land management program should be pursued through the existing land-administering agencies and private interests for purposes of coordinating future land uses and instituting land treatment and protection measures.

7. Detailed land use studies of presently irrigated lands and additional land classification surveys of potentially irrigable lands should be conducted to insure proper management and best use of the land and water resource for future developments.

8. Future needs of the mineral industry should be provided by: (1) reasonable access to mineral-bearing lands for both exploration and development purposes, (2) availability of dependable water supplies based upon competitive principles, and (3) the emergence of a government-industry "policy climate" that would encourage domestic minerals development, supported by meaningful research efforts, and with due consideration to long-range social and environmental obligations of industry.

9. A flood damage reduction program should be adopted as a general guide for solving the flood problems of the region. The proposed possible solutions to the serious flood problems should be studied in detail and followed by timely implementation of appropriate damage reduction measures.

10. Balance among economic sectors should be sought in the planned economic development of the region. For instance, development of recreational areas should be supported by related service-type needs of the industry.

11. A more comprehensive evaluation of the effect of regional water development and management programs in terms of production and utilization of labor and capital is needed. The region contains underdeveloped areas and areas of economic depression and in many cases an immobile work force. Providing jobs and income to those areas should be an important objective of the region and the nation.

12. Additional analyses of alternatives and assumptions should be conducted--particularly as they pertain to efficiencies of water use, alternative cropping patterns, alternative crop yields, level of water availability, agricultural production possibilities of food and livestock products for export (red meat), and alternative government agricultural programs.

13. The economic impacts of private or public investment in regional mineral resources development (oil, shale, coal, uranium, etc.) upon the rate and level of regional economic growth as measured in terms of employment, personal income, output, and relative contribution to gross regional product should be analyzed in depth.

14. Additional analyses on how water resource development programs change employment participation rates, types of employment, income distribution patterns, educational levels, or other socio-economic factors for low income, minority, and rural population sectors should be initiated.

15. Legal and institutional arrangements should be modified to promote greater flexibility for future uses of water and land.

Specific Recommendations

1. Encourage local governmental agencies to take advantage of the opportunity for early implementation of nonstructural flood plain management measures because of the present sparse population and lack of extensive developments in the flood plains. This would permit sound land use planning in guiding development and use of the flood plains to minimize future flood losses and eliminate the need for channelization or other structural flood control measures. Studies should be made to determine the degree of participation of Federal, State, and local government levels in the implementation and enforcement of land use constraints.

2. Provide for storage of floodwaters in multiple-purpose reservoirs concurrent with needed watershed treatment measures. Install levees and channel improvement only at critical locations where other alternatives fail to provide the needed protection.

3. Consider establishing State authority, similar to that in Colorado, to allow State governments to furnish the local share of project cost when the financial ability of local interests is exceeded in order that needed flood protection projects can be installed.

4. Implement watershed management protection programs--including land treatment on 24 million acres and installation of 78,000 water control structures in conjunction with management. Immediate attention should be given to the 3.9 million acres in critical erosion condition.

5. Develop supplemental irrigation water for established irrigated areas to stabilize existing developments.

6. Improve irrigation water management and conveyance facilities and apply land treatment measures to increase irrigation efficiencies.

7. Complete detailed land use and land classification studies to identify lands considered submarginal for efficient irrigation.

8. Identify and eliminate from future irrigation development lands that would increase the salt load significantly in the stream system.

9. Continue development of improved plant and crop species, fertilizers, and insect and disease control on dry and irrigated cropland to meet the increased food and fiber production requirements.

10. Expand the range, treatment, and management program to approach the optimum of 8.4 million AUM's per annum of production for livestock and wildlife grazing.

11. Accelerate the intensive forest management program to utilize the harvestable timber resource through improved marketing and expanded harvest management. These programs include timber stand improvement practices, increased protection from insects, fire, and disease, and improved forest product utilization.

12. Include provisions for investigation and salvage of the archeological resources in feasibility studies.

13. Study free-flowing rivers, and others of high quality to determine their suitability for inclusion in a national or state system of wild, scenic, or recreational rivers. Those found suitable for such designation should be given protection by enactment of appropriate legislation.

14. Determine more clearly the optimum carrying capacities and best uses of existing and potential recreation land and water resources. When this information is available, a system to regulate kinds and amounts of recreation activities at each area should be implemented to avoid overuse and insure quality recreation experiences.

15. Develop and apply an objective system for evaluating environmental assets associated with water resource and other developments on a par with economic considerations.

16. Protect outstanding natural, primitive, and historic and cultural areas by expansion and establishment of wilderness areas, national parks, national monuments, and national recreation areas.

17. Routing of utilities, land transportation facilities, and aircraft should be based on additional factors other than solely economic considerations or short-range benefits. Expanded consideration should be given in selection of multiple-use corridors.

18. Provide public access to recreation, hunting, fishing, scenic areas, and other multiple-use areas.

19. Design and operate reservoirs to provide maximum multiple-use within the reservoir basin and provide optimum downstream benefits.

20. Adopt regulations by governmental agencies to protect and restore natural lakes by:

a. Prohibiting alteration of remaining natural lakes with outstanding scenic and biologic qualities.

b. Prohibiting further development of lakes on which reservoirs were superimposed but which still retain outstanding attributes.

c. Retiring storage reservoirs that have been constructed over lakes whenever they are abandoned or there is opportunity for transfer of the storage capacity to larger multiple-purpose reservoirs, such retirement to be followed by rehabilitation to productive levels at which they can function as fishing lakes.

21. Provide for maintenance or improvement of the food and cover plants required by wildlife occurring in the areas of brush control and other range rehabilitation, especially for mule deer, antelope, and sage grouse.

22. Control of phreatophytes should not be undertaken in moose range or in other stream-bottom areas where significant fish and wildlife values are dependent upon the plant species to be removed.

23. Incorporate in mining activities such measures as are necessary to control the emission of pollutants into the streams and, in the case of surface mining, provide measures to restore the topography and vegetation of excavated areas to original conditions, insofar as possible, upon cessation of the mining activities.

24. Adopt appropriate mitigation measures in drainage practices involving Federal participation where wetlands of value to fish and wildlife are involved.

25. Develop environmental control programs at all levels of Government to support present programs which protect the public from health hazards from air, water, and vector-borne diseases.

26. Clarify the Federal reservation doctrine relating to water rights and quantity of Federal water claims at an early date.

27. Conduct research and studies on the production and transmission of electrical energy, including control methods for particulate matter, sulphur and nitrogen oxides, disposal of fly ash, utilization of low grade waste heat available in cooling water, environmental impact of plant sites and transmission line routings, and control of associated mining areas.

28. Re-evaluate the needs and install necessary instrumentation to monitor evaporation, water quality, flood forecasting, soil conditions, and air quality data.

29. Follow the present Framework Study of the Region by detailed studies through which the findings of the Type I Study can be translated into specific planning proposals.