TEN RIVERS IN AMERICA'S FUTURE

No. 2. The Central Valley

OF CALIFORNIA

FROM VOLUME 2,

THE REPORT OF THE

PRESIDENT'S WATER RESOURCES POLICY COMMISSION

No. 2. The Central Valley of California

Foreword

This study of the Central Valley was prepared by the staff of the Commission and by experts from Federal agencies assigned to the Commission. It is 1 of a series of 10 river basin studies (Columbia, Central Valley of California, Missouri, Rio Grande, Colorado, Potomac, Connecticut, Alabama-Coosa, Ohio, and Tennessee). The analysis is based on materials contributed by the several agencies and other applicable documents. Those materials were critically reviewed in open committee discussion for many extended sessions.

The basin studies were prepared as background data for the members of the Commission, as they sought to work out the major policy issues set forth in volume 1 of their report to the President. They have been so used. All of the details, however, have not been reviewed by all of the Commissioners.

The study is published because it is considered valuable information for the citizens of California, men and women whose deepest interests lie in that area and who are interested in the most intelligent development of its water, land, and mineral resources; and because it gives regional insight into basic reasons for Commission decisions.

The study also illustrates the major steps which must be taken in efficient, integrated, socially just water resources development. The study is not considered complete, nor does it represent a final plan for the development of the basin. But it deserves attention by every citizen as a description of the problems in development which lie ahead.

The Central Valley lies almost wholly within the borders of a single State. In this it differs from the nine other basins discussed in volume 2, all of which include larger segments of several States. The valley is not dominated by a single river system. Two major rivers transverse its length. The small enclosed basin at its southern end is in every way a part of it.

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It differs in many other respects, but in one most importantly: the basic plan for development is a State product. The "Central Valley Plan" was the outgrowth of an intensive study by the California State Engineer, begun in 1921. This plan, submitted to the State legislature in 1931, provided for irrigation, municipal water supply, flood control, salinity control, navigation, and production of hydroelectric power. It has been characterized as "the most carefully considered and complete plan of its kind ever drawn up." [1]

Only failure of the citizens of California to approve the large bond issue necessary to raise the funds for its prosecution prevented its going forward at that time as a State project. The State continues its deep interest in every phase of the program as it is being carried forward by Federal agencies.

Another difference between the Central Valley and all but two or three of the other basins studied by the River Program Analysis Committee is the considerable degree of integration among the various uses in the conservation of water resources. Multiple-purpose planning is the key to a completely integrated program.

Other differences grow out of disagreements over the application of the 160-acre limitation on ownership of irrigated land entitled to secure and use water from publicly financed water projects; the degree to which irrigation was developed initially without Federal aid through local irrigation districts; the extent to which private utilities used the rivers to produce hydroelectric power; and the rapid population growth in California and the bearing this has upon the need for additional electric power and additional industrial and agricultural employment to sustain the State's economy.

[1] President's Committee on Waterflow (H. Doc. No. 395, 73d Cong., 2d sess.)

Contents

Chapter 1

Regional Character and Problems[1]

The Basin's Significance

The Central Valley is one of the world's choice agricultural regions. The large acreages of deep, smooth alluvial soils, the mild climate, the long hours of brilliant sunshine in summer, and the controlled application of water have been used effectively for the production of high value crops. Five Central Valley counties are among the first 10 counties in the Nation in value of agricultural commodities produced. Besides supplying significant portions of the food needs of California's rapidly growing urban centers, the Central Valley furnishes nearly all of the national supply of some fruits, and a significant share of the national rice production. It also makes important additions to the total production of cotton and several vegetable crops.

This astonishingly large agricultural production has been achieved by the use of only a part of the available irrigable soils. Limitations on irrigable land use have resulted from an inadequate water supply, and to a lesser extent, from marketing difficulties. However, water supplies for irrigation are the critical element in further expansion of agriculture in the Central Valley.

This basin differs from the nine others studied by the Commission in two important respects. First, the entire basin is contained in one State. Second, plans for its development were worked out by the State over many years prior to 1930. The plans are now the pattern for joint effort by the State and Federal Governments.

During the past decade the growth of population and industry in California has been phenomenal.

[1] The original draft of this study was prepared during 1950 by the Committee on River Program Analysis of the Commission. The following persons served on the committee, participated in the planning or review of the report, and contributed data to it:

George G. Adkins, Federal Power Commission.

Robert S. Anderson, Federal Power Commission.

James Bowman, Tennessee Valley Authority.

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Raymond H. Davis, Soil Conservation Service, Department of Agriculture.

R. H. Dewante, Corps of Engineers, Department of the Army.

S. H. Gale, Corps of Engineers, Department of the Army.

Paul Haney, Public Health Service.

William E. Holy, Public Health Service.

Carl F. Izzard, Bureau of Public Roads, Department of Commerce.

Maurice LeBosquet, Public Health Service.

Edward N. Munns, Forest Service, Department of Agriculture.

Victor Roterus, Department of Commerce.

R. F. Stellar, Corps of Engineers, Department of the Army.

E. F. Sullivan, Bureau of Reclamation, Department of the Interior.

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Frank L. Weaver, Federal Power Commission.

Wesley Calef, President's Water Resources Policy Commission, committee secretary.

Edward A. Ackerman, President's Water Resources Policy Commission, committee chairman.

The study is based on information available between May and October 1950, including special basin reports submitted to the Commission by interested Federal agencies. Following preparation of the original draft by the Committee on River Program Analysis the study was edited and revised for the Commission by Edward A. Ackerman, John C. Beebe, John M. Carmody, Patricia Howse, Edward N. Munns, Evelyn S. Myers, and Jane G. Perry. Individual committee members or the agencies where they are employed therefore may or may not be in agreement with particular conclusions here presented.

More people have moved to California since 1940 than live in the entire State of Iowa. The growth of industry and population has greatly advanced the local demands for electric power and food. To keep pace with these demands, attention will have to be directed toward the Central Valley. Here is the only part of the State where appreciable amounts of agricultural land can be improved. Here are the principal sources of developed and undeveloped water power. Because of these potentialities and its present productivity, and because of its location, the Central Valley is the heart of California.

Physical Characteristics

The Central Valley Basin includes a third of the total land area of California. Throughout its entire length it is bordered by mountains. The crest of the massive Sierra Nevada is its easternmost boundary, and the long ridge of the Coast Range limits it on the west. These two ranges meet at Mount Shasta at the northern end of the basin, and in the Tehachapi Range, which encloses the southern end of the valley. The only opening in this mountain rim is the narrow outlet in the middle of the basin to the west made of Suisun Bay, San Francisco Bay, and the Golden Gate. Through this outlet the merged waters of the two principal streams, the Sacramento and San Joaquin Rivers, flow to the sea.

The valley is thus divided topographically into two major parts—the flat, broad, alluvium-covered valley floor approximately 400 miles long and averaging 45 miles in width, and the surrounding rugged foothill and mountain areas. On the valley floor, covering an area of approximately 18,000 square miles, nearly all the people in the basin live. The surrounding foothill and mountain areas are very sparsely inhabited.

The Central Valley has a humid-winter, dry-summer type of climate. The principal rains fall only in the winter half of the year; the summers have prolonged spells of complete drought. Precipitation is not evenly distributed over the valley. It increases from south to north and also from lowlands to highlands. The northern part of the valley floor has from 20 to 25 inches a year, and the high Sierras to the east may have from 80 to over 100 inches. On the valley floor in the extreme south annual average precipitation is from 5 to 10 inches and reaches from 25 to 50 inches in the adjacent Sierra Nevada Mountains. (See figure 1).

The Coast Ranges to the west have considerably heavier precipitation than the valley floor and about half that received by the Sierra Nevada. The duration of the rainy season is longer in the north than in the south. The extended dry season makes production of nearly all agricultural crops impossible in the southern section without irrigation. The longer rainy season and greater precipitation permit some early maturing grains to be grown without water and others without the use of as much water in the northern section of the valley.

Another condition of major importance is the wide annual variation in quantity of precipitation. Figures of average yearly precipitation mean little because some years are far above the average and nearly as many years are much below the average. Consequently, there are wide variations in annual runoff. Moreover, there is a cyclical aspect to these variations. Several above-average years may occur in succession, followed in turn by several below-average years, thus accentuating the effects of variable runoff.

Nearly all precipitation occurs in the cooler part of the year, with snow falling characteristically in the mountains and rain in the lowlands. High mountain snowfall is the major source of the water supply, as the snows above 5,000 feet do not usually melt much before May. However, the valley floor, the foothills, and the lower elevations of the Coast Range may experience prolonged rainstorms in winter. In such periods, much of this moisture concentrates rapidly in the streams, thus giving rise to a flood hazard.

The valley floor is made up of two distinct major physical sections. The Sacramento Valley, the northern section, is drained by the Sacramento River, originating in the mountain knot at the northern end of the valley, and its tributaries from both the east and west, but primarily from the Sierra and Coast Ranges. It receives a moderate amount of rainfall, its streams carry a moderately large volume of water, and its lowlands are subject to periodic flooding.

The San Joaquin Valley, the southern and larger part of the Central Valley, is characterized by a warmer climate, less precipitation, and a greater deficiency of water. The principal stream, the San Joaquin River, is fed by relatively few tributaries, virtually all of which flow from the Sierras. The south end of the valley is a closed basin draining

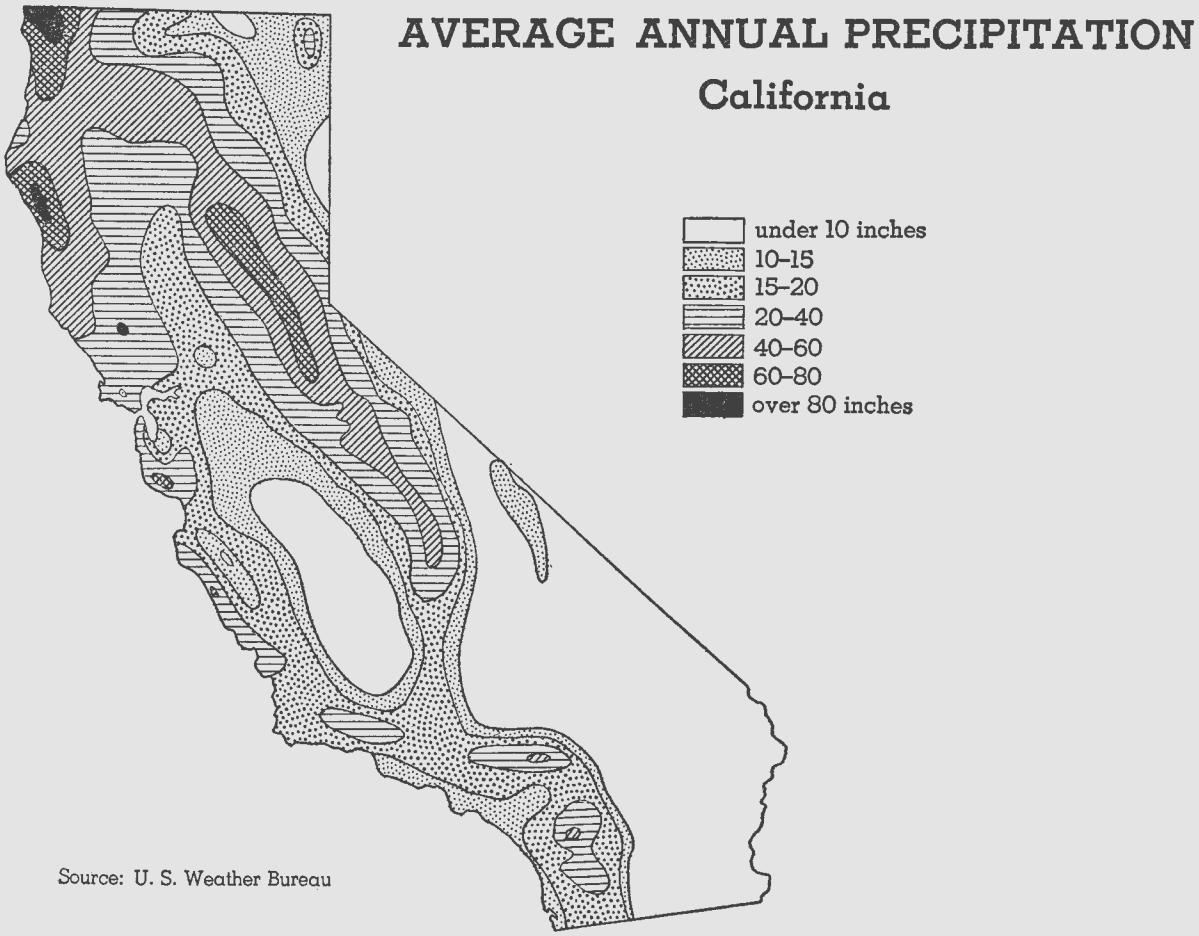

FIGURE 1

into Tulare Lake and constituting a third section. Only rarely in recent times has this lake overflowed into the San Joaquin.

The waters of the San Joaquin and Sacramento Rivers meet about midway in the valley, and have formed a low-lying, marshy delta which is crossed by a maze of winding, sluggish channels and sloughs. This is really a fourth section of the valley, distinct in its problems but small in area by comparison to either the Sacramento or San Joaquin Valley.

Population

Three million people live in the Central Valley. In addition, the 2.5 million people of the San Francisco Bay metropolitan area are dependent on the water resources of the valley for almost all of their water needs.

The principal cities in the valley are Sacramento, Marysville-Yuba City, Stockton, Fresno, Bakersfield, Merced, Modesto, Redding, and Chico. Sacramento, with a population of 134,000, is the largest, and the only city of considerable size in the valley. Over 60 percent of the people live in the San Joaquin section.

The population in the valley is predominantly rural and its distribution follows closely the distribution of irrigated land. The livelihood of most of the people of the valley is closely tied to agriculture, either directly as farmers or indirectly by furnishing goods and services to the farm population or by processing agricultural products. This close dependence on agriculture by most of the population suggests that expansion of irrigation agriculture will have an important effect on the Central Valley economy.

Nature of the Economy

Employment is strongly concentrated in primary industries. Agriculture, forestry, and mining together are relatively more important in the Central Valley than for the Nation. Manufacturing occupies a minor position, and perhaps as much as half of the employment in manufacturing is in the food and raw materials processing industries. However, the Central Valley is a part of the larger California area, where San Francisco and Los Angeles are major manufacturing centers. The Central Valley, therefore, is part of a larger region which has a more balanced economy than the valley itself.

Present Forms of Resource Use

Agriculture

The economy of the Central Valley is dominated by agriculture—overwhelmingly irrigation agriculture. The total irrigated area in 1949 was over 4 million acres, more than four times the acreage irrigated in 1900. This acreage is divided among 59,000 farms. The per acre productivity, in dollars, of Central Valley farms is twice as great as the average of other agricultural lands in the United States. Intensity of cultivation and specialization plus the favorable climatic conditions are largely responsible for this high productivity.

Livestock is a major source of income on 30 percent of the farms of the Central Valley, and the valley accounts for about half of the total livestock production of the State. Despite a high production of livestock and livestock products, the rapid growth of California's population has resulted in increased imports of these products. The most rapidly growing regional deficit is in dairy products.

The major field crops are dry beans, barley, alfalfa, and sugar beets. Cotton, rice, potatoes, table and wine grapes, and figs, nuts, and hops are important specialty crops. Also of prime importance are truck and fruit farming. The foothill agricultural areas are primarily devoted to raising deciduous fruit and to grazing.

Manufacturing

Half of all manufacturing plants in the valley process foods. The primary industry is the canning of fruits and vegetables. Other major industries are the manufacture of cans for the food processing industries, and of agricultural machinery.

The importance of the Central Valley to manufacturing cannot be measured only in terms of its industries. It furnishes water, power, and raw materials for many of the industrial enterprises of the important San Francisco Bay region.

Mining

The value of mineral production in the Central Valley is very high and the variety of minerals produced is great; but the greater part of the total value is contributed by petroleum, natural gas, and gold.

Lumbering

The pine region of the Sierra Nevada foothills produces 45 percent of California's large timber production. Most sawmills are located in the foothill area, but plants manufacturing finished products, like furniture, generally are near the major markets, as in the bay area. Many of the sawmills are in the Sacramento Valley section. Because the high quality of local timber makes it valuable for export, the valley imports a large proportion of its lumber needs. California ranks second among the States in volume of lumber cut, about three-fourths, or 2 billion feet, coming from the Central Valley.

Recreation

The Sierra Nevada includes the outstanding mountain and lake recreation area of the Nation. From Mount Shasta at the northern end of the Sacramento Valley through the sub-basins of the Pit, Feather, Yuba, Bear, American, Mokelumne, and others, to the Kern River, draining the southern slope of Mount Whitney on the south, the entire area provides accessible recreation for the people of the valley and the coastal cities, summer and winter.

The basin includes four of the Nation's finest national parks: Lassen, Yosemite, King's Canyon, and Sequoia. The increase in California's population and the postwar tourist expansion have greatly increased use of these parks. Parts of the Yosemite Valley are faced with a serious problem of overcrowding.

National forests include the Shasta, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, and Sequoia. In addition, there are several State parks,

and numerous municipal and local parks and camps. Many lakes and reservoirs provide intensively used recreation facilities.

Private developments consist mainly of tourist overnight facilities, and numerous lodges and camps, chiefly in the Sierra Nevada. Local recreational facilities during the summer season and again during winter sports season are seriously deficient throughout the mountain area, and water resources development may contribute to meeting this expanding need.

Major Basin Problems and Potentialities

The major problems of the Central Valley are all closely related to water development. They are (1) providing economic opportunities for a rapidly growing population; (2) providing additional water for the many needs of the valley; and (3) problems of reconciling new water development programs with existing rights and claims of private interests, local governments, and national interests.

Providing Economic Opportunities for a Rapidly Growing Population

In many ways, and particularly from a social point of view, the basic problem of the Central Valley is provision for adequate economic opportunity. During the last 20 years there has been a great influx of people into the Central Valley. Because of the high level of economic activity these people have been able thus far to maintain themselves; but from a long-term point of view their economic situation is reported to be unstable. Many have been unable to establish themselves in permanent positions. The desirability of fitting these people into stable communities as permanent members of a functioning economy is obvious.

Unfortunately, most resources of the valley capable of easy exploitation with small amounts of capital and limited organization were exploited long ago. Agriculture not only has been expanded to the limits of the locally available water supply, in many places, it has been expanded beyond those limits and irrigation has been mining the reserves of underground water. Nevertheless, there are opportunities to provide more permanent employment. These lie in such directions as the expansion of agriculture, the associated food processing industries, and recreational servicing. Much of this expansion in turn is dependent on additional water supplies.

The Problem of Providing Additional Water

Agriculture cannot expand without additional control and distribution of water. Despite the present dearth of usable water, much of the water of the basin is lost in floods which sometimes are destructive. Irrigation as a single-purpose enterprise has very nearly reached the limit of feasible economic expansion. Expansion is possible, however, if water is conserved and used for multiple purposes simultaneously with land management practices. One highly favorable aspect of the situation is the very high productivity of agriculture, which enables it to incur high costs for irrigation water and still remain solvent.

Integrating New Water Development Programs with Existing Rights and Claims of Private Interests, State and Local Governments, and National Interests

The intensity of water development by private means and the fierce competition for water have resulted in a myriad of water rights, disputes over water rights, and in complicated arrangements for apportioning water. Moreover, local and State law on the subject is voluminous and complex. Consequently, new water developments must be integrated with the existing framework with extreme care or they will come into conflict with previously established rights. In many cases, irreconcilable conflicts in beneficial uses of water are encountered.

The technical, economic, and policy problems of integrating future with present developments in the Central Valley present a challenge not only to local, State, and Federal agencies, but to the citizens of California, to apply their skill and knowledge in an atmosphere of good will and unselfish cooperation toward solution in the public interest.

Chapter 2

Streams and Ground Water

The Central Valley is divided into three drainage basins. The two principal streams, the Sacramento and San Joaquin, drain the northern and southern sections of the valley respectively. The extreme southern end of the San Joaquin Valley, however, is a closed basin, separated from the San Joaquin system by a low ridge of erosional debris spread out on the valley floor by the Kings River.

The Sacramento River rises in the vicinity of Mount Shasta and flows south and southwest to the delta. In its upper course it is a swift-flowing mountain stream enclosed by steep walls. North of Red Bluff it breaks out onto the valley floor and proceeds southward in a winding, sluggish course. Numerous small tributaries, mostly from the Sierras, enter it. The Pit and McCloud Rivers, which drain the extreme northeast section of the valley, join the main stem at Shasta Reservoir. The Feather, Yuba, Bear, and American Rivers join the Sacramento on the valley floor. Three smaller tributaries drain the east flank of the Coast Range. In addition, numerous small tributaries contribute a large flow to the Sacramento.

The San Joaquin River rises in the Sierras northeast of Fresno, flows westward to the center of the valley floor and there turns northwest to the delta. The Fresno, Chowchilla, Merced, Tuolumne, and Stanislaus Rivers are the principal tributaries draining the Sierra Nevada. Three other streams from the Sierras, the Calaveras, Mokelumne, and Cosumnes Rivers, enter the delta directly.

At the southern end of the San Joaquin Valley is a closed basin. Tulare Lake lies in the bottom of the depression. In wet years, prior to extensive irrigation, this lake discharged into the San Joaquin. A large part of this lake bed is now leveed to form a reservoir. During flood years water flows into the lake, then is pumped out during the following irrigation season or seasons. In most years, Tulare Lake is dry and the lake bed farmed. The lake is fed by floods from the Kings, Kaweah, Tule, and Kern Rivers.

The annual regimen of the streams is highly irregular and is related to precipitation. During winter, if prolonged rains occur over the basin, runoff can be heavy and rapid. Under such circumstances flooding of the lowlands is apt to be widespread. Also, snow accumulates to great depths in the high Sierra Nevada. In the spring the probability of flood-producing rains decreases before the high snow fields begin to melt. This is of major importance. It permits storage reservoirs which are used for flood control during the winter rainy season to be used also for storage of water released by snow melt during the summer. As stream flow from the mountain snow pack can be forecast with considerable accuracy, reservoir storage permits a maximum of water control and conservation.

The great flows from the high snowfields are confined largely to the months of May, June, and July. By the end of July many mountain streams have low discharge rates, which continue until the beginning of the winter rains. Consequently, storage either in reservoirs or underground is absolutely essential if large-scale irrigation is to be practiced in the late summer and early fall.

The streams of the low-lying delta lands are subject to tidal action 40 miles upstream from the mouth. Under natural conditions the flow of the rivers was sufficient to keep salt concentrations at the delta margins to a minimum. As larger and larger quantities of water have been diverted from the natural flow for other purposes, the salinity concentrations have increased in the delta area.

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Some lands have already been ruined for agricultural production, and other much larger areas are threatened. Consequently, certain minimum flows must be maintained in the rivers to arrest this salt intrusion.

One of the principal reasons for further water resources development is the difference in amount of runoff between the Sacramento and San Joaquin Valleys. The heavier rainfall and smaller area of irrigable land gives the Sacramento Valley a surplus of water while the San Joaquin, especially the southern end, has a large water deficiency. Consequently, one of the main objectives in present plans is the transfer of Sacramento Valley water to deficient areas in the San Joaquin.

About 40 percent of the area now irrigated in the Central Valley is supplied by pumping from the underlying gravels. These underground basins have been only partially investigated, but are known to be immense. The draft annually exceeds the refill in many portions. This source of water, on hand at all times for domestic, industrial, and irrigation uses, is perhaps one of the most important characteristics of the basin.

Chapter 3

Water Development Needs, Opportunities, and Programs

The Central Valley is already highly developed. A large privately developed, profitable, specialized irrigation agriculture utilizes the water resources of the valley on an extensive scale. A well developed network of roads and railroads serves the densely populated irrigated sections of the valley floor. A large volume of hydroelectric power is generated from the steep mountain streams. The mineral and forest products industries are highly developed. The unirrigated areas are used for dry farming and grazing.

More than 100 years ago Sutter discovered gold in the American River, only a few miles above Sacramento. That discovery made water the important resource of California for years, for the extensive placer operations that followed would not have been possible without large quantities to operate the "giants" and sluices, and to move the debris down the stream channels, and out of the miners' path. Thus many dams were built, at that time engineering wonders. Many are still useful and substantial structures. Ditches, pipelines, and flumes were constructed, many of which, upon cessation of mining, were taken over for irrigation and power use, and are still a part of the basin's economy.

The Central Valley is not in any sense a frontier area. Although there are many opportunities for using the water resources more fully, these must be fitted into and supplement a complex and intensively developed economy. The needs are great because of the rapidly growing population and the difficult social and economic problems associated with the population growth. But the present extensive development does not preclude further expansion. Opportunities are large because of high agricultural productivity and steadily growing demands for electric power. Nevertheless, water resources are limited. The program for expansion must be sound, so that maximum results may be obtained from the control and use of the remaining water resources.

Irrigation

The Present Situation

Irrigation agriculture has been the backbone of the Central Valley economy since 1880. Expansion has proceeded about as far as available physical structures will permit. Present agriculture depends primarily on works constructed by private enterprise and local public agencies. These largely are local developments, independent of each other. The area now irrigated exceeds 4 million acres. Lands are irrigated by diverting the natural flow of streams, by using storage from reservoirs, and by pumping underground water.

The greatest overexpansion of agriculture has occurred in those areas primarily dependent on ground water. During the last two decades ground water levels have been lowered from 25 to 200 feet over wide areas. Without replenishment of these underground reservoirs large irrigated areas eventually will have to go out of production. On the east side of the southern San Joaquin Valley alone, the total ground water deficit is estimated to be 1.9 million acre-feet annually.

The only completed Federal irrigation project in the Central Valley is the Orland Project on Stony Creek, which supplies water for about 20,000 acres in the Sacramento Valley. However, parts of the Central Valley Project,[1] notably Shasta Reservoir,

[1] The Central Valley Project of the Bureau of Reclamation does not include all of the Central Valley area.

Friant Reservoir, and related canals, have been completed. They are delivering water to parts of the Sacramento and San Joaquin Valleys for surface application and also for replenishment of underground water supplies.

The California State Water Plan

The 1921 California State Legislature directed that a plan be prepared for the maximum conservation, control, storage, distribution, and application of all the waters of the State. It also declared "that the people of California have a paramount interest in the use of all the waters of the State and that the State of California shall determine what waters of the State, surface and underground, can be diverted to public use, or controlled for public protection."

The report covering the Central Valley, prepared by the Division of Water Resources, was submitted to the 1931 legislature.[2] It outlined a comprehensive plan for the Central Valley to meet its requirements, to reserve water for the irrigable lands of the mountainous areas, to provide for exportation of domestic and industrial water to San Francisco and the East Bay Municipal Utility District, and for flood control, navigation, salinity control, and hydroelectric power. When adopted by the State legislature it was referred to as the State Water Plan.[3] Funds were authorized to initiate the plan. The State bond issue failed. In 1935, by Executive Order, Federal funds were made available to undertake work on key elements of the plan. When Congress authorized the activity, control passed from the State to the Federal Government, although the State has several times since considered taking over the work.

The term Central Valley Project originated at the time Shasta and Friant Dams and other works, parts of the State Water Plan, were authorized for construction by the Bureau of Reclamation.[4] Subsequently other projects, when authorized for construction by the Bureau, have been added as elements in the Central Valley Project. Thus, many projects authorized to other agencies for construction and proposed by the Bureau of Reclamation for construction are not now units of the Central Valley Project, although they may be parts of the ultimate development of the basin's resources.

The Central Valley Project

The plan for irrigation as proposed by the Bureau of Reclamation has taken up the development of the Central Valley after a long history of improvement of the area by private and municipal groups under State supervision. These previously constructed projects included the lowest cost and most easily constructed possibilities and irrigated the areas most accessible to the available water supply. Some 4 million acres now are irrigated, about 40 percent by pumping from underground supplies.

The following figures present two estimates of the net irrigable acreage in the basin and indicate important possibilities of extending irrigation, to make maximum use of the water supply. This supply averaged 18.4 million acre-feet annually during the very dry period 1927–34, and 33 million acre-feet during the 40-year period between 1903–43.

	Estimates of total net irrigable area[1]	
	Bureau of Reclamation	*State*
Geographical division:	*Acres*	*Acres*
Sacramento Valley	1,600,000	2,386,000
Delta	360,000	392,000
American River and Lower San Joaquin	1,360,000	1,930,000
Upper San Joaquin, east side	2,200,000	2,856,000
Upper San Joaquin, west side	710,000	792,000
Foothills and mountain valleys	350,000	1,614,000
Total	6,580,000	9,970,000

[1] Includes land now irrigated.

Much of the land now irrigated is in need of supplemental water above that required at the time the projects were built, because of present intensified use as compared with the early agriculture.

Projects Under Construction and Authorized

The water distribution systems of the initial Bureau of Reclamation Central Valley Project structures will go into full operation in 1951. Within a decade they are expected to deliver water to 550,000 acres of new land and supplemental water to another 500,000 acres.

Three projects under construction by the Corps

[2] Bulletin No. 25, California State Division of Water Resources, Sacramento, 1930, 204 pp.

[3] 1941 State legislature, ch. 1185 Cal. Stat. 1941.

[4] First authorized by Executive Order on September 30, 1935, under the Emergency Relief Appropriation Act of April 8, 1935, 49 Stat. 115, 117. Reauthorized by the Congress as a Federal reclamation project by Act of August 26, 1937 (50 Stat. 844, 850) and by Act of October 17, 1940 (54 Stat. 1198, 1199).

of Engineers include irrigation as one of their primary purposes. The Pine Flat Dam on Kings River and Isabella Dam on Kern River, insofar as they affect irrigation, will be used primarily to regulate present runoff and provide supplemental water. The irrigable areas below these reservoirs are served by existing canals; no new canal construction will be required. Folsom Reservoir on the American River upon completion by the Corps of Engineers is to be turned over to the Bureau of Reclamation for operation. Irrigation water from Folsom Reservoir will be used initially to serve lands in conjunction with the initial features of the Central Valley Project. Studies of the Bureau of Reclamation indicate, however, that the water could best serve lands north and south of the American River, and such eventual use is contemplated.

Another small unit of the American River division of the Central Valley Project is the authorized Sly Park unit, on the American-Cosumnes River divide in the Sierra foothills. It is designed to furnish supplemental water to 3,850 acres and new water to 3,500 acres.

The authorized Bureau of Reclamation Solano Project on the western margin of the Sacramento Valley is designed to irrigate 78,000 acres of new land, provide supplemental water for 5,000 acres, and meet several municipal water-supply needs.

The Corps of Engineers has six authorized multiple-purpose projects which include irrigation as one of their objectives. They will serve land near the reservoirs. These are: (1) Terminus Project on Kaweah River; (2) Success Project on Tule River; (3) Black Butte Reservoir on Stony Creek; (4) New Hogan Project on Calaveras River; (5) New Melones Reservoir on the Stanislaus River; and (6) Iron Canyon Reservoir[5] on the Sacramento River. Construction of the Iron Canyon Reservoir has been deferred.

Situation at End of Present Authorized Program

The present authorized Central Valley Project is designed to irrigate an additional 770,000 acres of new land and to make supplemental water available for 1.6 million acres of land presently irrigated. Water will be available for an additional 150,000 acres of new land under the Folsom and Black Butte Reservoirs, for which the necessary canals have not been authorized.

[5] Either alternate for or complementary to the Table Mountain Project.

About half a million acres of irrigated land will still be in need of supplemental water, and strong local demands will still exist for water to irrigate at least several hundred thousand acres of new land. If the estimates of available water contained in the State Water Plan prove accurate, possibilities exist for irrigating many additional thousands of acres.

Programs for Further Development

Full control and use of the water resources of the Central Valley will demand a storage capacity of more than 20 million acre-feet of water. The Bureau of Reclamation has tentative plans for the construction of 38 major reservoirs and many smaller reservoirs to meet the combined demands of irrigation, municipal and industrial water supply, electric power, flood control, navigation, and other water uses.[6] Extensive use of ground water storage also will be necessary. Completion of this program may take many decades.

Hydroelectric Power

Capacity, Yearly Production, Area Served

The Central Valley has three Federal hydroelectric plants having a total installed capacity of 456,000 kilowatts. Most of this power is developed by the Bureau of Reclamation's Shasta and Keswick plants on the Sacramento River. Sixty-one existing utility hydroelectric plants of 2,500 kilowatts or more installed capacity have a total installation of 1,700,200 kilowatts. The total installed hydroelectric capacity in the basin is 2,156,200 kilowatts (table 1). In addition to the plants included in the table, there are 13 small utility plants of less than 2,500 kilowatts capacity with a total installed capacity of 18,540 kilowatts.

The total active storage capacity at existing hydroelectric developments in the basin amounts to about 6,684,000 acre-feet. The largest reservoirs are Shasta on the Sacramento River, Lake Almanor on the Feather River, Exchequer on the Merced River, Hetch Hetchy and Don Pedro on the Tuolumne River, and Pardee on the Mokelumne River.

A major portion of the hydroelectric power developed in the Central Valley Basin is marketed

[6] Many of these reservoirs also are included in plans of the Corps of Engineers.

TABLE 1.—Existing hydroelectric power developments

No.[1]	Plant name	River [2]	Operating agency or company [2]	Installed capacity	Average annual generation	Active storage capacity
	Federal plants			*Kilowatts*	*1,000 kilowatt-hours*	*Acre-feet*
1	Shasta	Sacramento	BR	379, 000	1, 624, 000	4, 000, 000
2	Keswick	do	BR	75, 000	315, 000	13, 000
3	Cascades	Merced	NPS	2, 000	11, 000	.....
	Totals—Federal plants			456, 000	1, 950, 000	4, 013, 000
	Non-Federal plants [3]					
4	Pit No. 1	Pit	PG&E	56, 000	288, 100	.....
5	Hat Creek No. 1	Hat Creek	PG&E	10, 000	33, 500	.....
6	Hat Creek No. 2	do	PG&E	10, 000	50, 800	.....
7	Pit No. 3	Pit	PG&E	72, 900	382, 400	.....
8	Pit No. 5	do	PG&E	128, 000	826, 000	.....
9	Kilarc	NF Cow Creek	PG&E	3, 000	16, 900	.....
10	Volta	NF Battle Creek	PG&E	6, 400	45, 800	.....
11	South	SF Battle Creek	PG&E	4, 000	35, 600	.....
12	Inskip	do	PG&E	6, 000	40, 000	.....
13	Coleman	Battle Creek	PG&E	13, 800	57, 500	.....
14	De Sabla	Big Butte Creek	PG&E	[4] 13, 000	[4] 83, 200	.....
15	Centerville	Butte Creek	PG&E	6, 400	35, 600	.....
16	Hamilton	Hamilton Branch	PG&E	4, 800	15, 000	24, 000
17	Caribou	NF Feather	PG&E	[4] 60, 000	[4] 451, 000	574, 000
18	Bucks Creek	do	PG&E	40, 000	188, 000	108, 000
19	Rock Creek	do	PG&E	113, 400	494, 000	.....
20	Cresta	do	PG&E	[4] 33, 750	[4] 159, 000	.....
21	Big Bend	do	PG&E	52, 000	454, 000	.....
22	Bullards Bar	NF Yuba	PG&E	6, 500	38, 900	10, 000
23	Colgate	do	PG&E	24, 000	80, 000	.....
24	Spaulding No. 3	SF Yuba	PG&E	6, 300	29, 100	108, 000
25	Spaulding No. 1	do	PG&E	6, 400	42, 100	143, 000
26	Spaulding No. 2	do	PG&E	3, 750	20, 000	.....
27	Narrows	Yuba	PG&E	9, 350	89, 000	45, 000
28	Deer Creek	Deer Creek	PG&E	5, 500	31, 300	.....
29	Drum	Bear	PG&E	44, 000	282, 500	.....
30	Dutch Flat	do	PG&E	22, 000	147, 000	.....
31	Halsey	Dry Creek	PG&E	10, 000	66, 800	.....
32	Wise	Auburn Ravine	PG&E	10, 000	90, 700	.....
33	Eldorado	SF American	PG&E	20, 000	97, 700	38, 000
34	American River	do	PG&E	5, 730	39, 800	.....
35	Folsom	American	PG&E	3, 000	21, 600	.....
36	Big Creek No. 8	San Joaquin	SCE	54, 000	284, 000	.....
37	Big Creek No. 1	Big Creek	SCE	67, 000	492, 000	89, 000
38	Big Creek No. 2	do	SCE	57, 750	423, 000	.....
39	Big Creek No. 2A	do	SCE	80, 000	300, 000	135, 000
40	Big Creek No. 3	San Joaquin	SCE	[4] 106, 500	[4] 743, 500	.....
41	San Joaquin No. 3	NF San Joaquin	PG&E	4, 800	20, 300	.....
42	A. G. Wishon	do	PG&E	12, 800	85, 900	.....
43	Kerckhoff	San Joaquin	PG&E	34, 080	275, 400	.....
44	Exchequer	Merced	MID	25, 000	127, 800	274, 000
45	Merced Falls	do	PG&E	3, 440	16, 100	.....

See footnotes at end of table.

TABLE 1.—Existing hydroelectric power developments—Continued

No.[1]	Plant name	River [2]	Operating agency or company [2]	Installed capacity	Average annual generation	Active storage capacity
				Kilowatts	*1,000 kilowatt-hours*	*Acre-feet*
46	Early Intake	Cherry Creek	SFUC	3,600	28,000	26,000
47	Moccasin	Moccasin Creek	SFUC	[4] 70,000	[4] 508,000	340,000
48	Don Pedro	Tuolumne	TID	26,990	199,800	262,000
49	La Grange	do	TID	3,730	25,200	.....
50	Spring Gap	MF Stanislaus	PG&E	6,000	48,200	34,000
51	Stanislaus	Stanislaus	PG&E	[4] 28,900	[4] 233,500	.....
52	Melones	do	PG&E	24,300	95,300	102,000
53	Salt Springs	NF Mokelumne	PG&E	9,350	42,800	147,000
54	Tiger Creek	do	PG&E	51,000	353,000	.....
55	West Point	do	PG&E	13,600	91,400	.....
56	New Electra	Mokelumne	PG&E	89,100	363,500	.....
57	Pardee	do	EBMUD	15,000	90,000	212,000
58	Tule	MF Tule	PG&E	4,800	24,500	.....
59	Kaweah No. 3	Kaweah	SCE	2,800	17,400	.....
60	Balch	NF Kings	PG&E	[4] 31,000	[4] 178,600	.....
61	Kern River No. 3	Kern	SCE	[4] 32,000	[4] 170,400	.....
62	Borel	do	SCE	8,200	54,900	.....
63	Kern River	do	SCE	[4] 16,000	[4] 152,500	.....
64	Kern Canyon	do	PG&E	[4] 8,480	[4] 59,600	.....
	Totals—Non-Federal plants (61)	.....	.....	1,700,200	10,237,500	2,671,000
	Totals—Federal and non-Federal plants (64)	.....	.....	2,156,200	12,187,500	6,684,000

[1] Numbers correspond to numbers on figure 2.

[2] Abbreviations are as follows:

NF—North Fork.
SF—South Fork.
MF—Middle Fork.
BR—Bureau of Reclamation.
NPS—National Park Service.
PG&E—Pacific Gas & Electric Co.
SCE—Southern California Edison Co.
MID—Merced Irrigation District.
SFUC—San Francisco Utility Commission.
TID—Turlock Irrigation District.
EBMUD—East Bay Municipal Utility District.

[3] Plants of 2,500 kilowatts or more installed capacity.

[4] Present capacity and generation at plants which include provisions for future capacity additions.

Source: Federal Power Commission and Bureau of Reclamation.

in northern and central California and northwest Nevada, with approximately one-sixth transmitted to the Los Angeles area. At the end of 1949, the total installed capacity of the utility systems in the principal market area [7] (except Los Angeles) was about 2,338,000 kilowatts, of which about 1,517,000 kilowatts was hydroelectric capacity and the remainder fuel-electric capacity.

[7] Power Supply Area 46, as designated by the Federal Power Commission.

Approximately a third of the capacity in the principal market area is supplied by fuel and two-thirds by hydro-generated power. The December 1949 peak demand on these systems was 2,244,000 kilowatts, indicating a narrow margin of reserve capacity. More than 95 percent of the area load is supplied through the system of the Pacific Gas & Electric Co. It is estimated that the peak demand on the systems in the area will exceed 3 million kilowatts by 1953.

Facilities in Construction and Authorized

One Federal hydroelectric plant was under construction in 1950 in the basin. The Bureau of Reclamation is authorized to construct power generating facilities, including the necessary afterbay plant, at the Folsom Dam and Reservoir Project now being built by the Corps of Engineers. Power development was also authorized at the Table Mountain (Iron Canyon [8]) Project to be constructed by the Corps of Engineers. This project has been deferred indefinitely, largely because of local opposition. These authorized Federal plants would have a total installed capacity of 234,000 kilowatts. The projects would provide approximately 1,345,000 acre-feet of active storage capacity.

The two non-Federal hydroelectric plants now under construction in the basin will provide a total capacity of 113,000 kilowatts. These plants are Big Creek No. 4 (Southern California Edison Co.), and Bear River Unit (Pacific Gas & Electric Co.). A plant at Cherry Valley of 75,000 kilowatts is proposed for construction in the near future by San Francisco.

The hydroelectric plants under construction and authorized, together with the Cherry Valley plant, will provide a total new installed capacity of 422,000 kilowatts (table 2). The total usable storage capacity that would be added by these projects amounts to some 1,365,000 acre-feet.

Situation at the End of Present Program

When the projects under construction and authorized are completed there will be six Federal hydroelectric plants in the basin, with a total installed capacity of 690,000 kilowatts. Sixty-four non-Federal electric utility plants of 2,500 kilowatts or more installed capacity would provide a total installation of 1,888,200 kilowatts. These projects would provide 2,578,200 kilowatts generating capacity and 8 million acre-feet of storage capacity.

Potentialities

A summary of the results of studies made by various Federal and State agencies and others indicates that some 133 potential hydroelectric sites would remain undeveloped after completion of projects under construction and authorized. These projects, plus additions to and redevelopments of some existing non-Federal projects, would have an estimated total installation of 5.2 million kilowatts. The total usable power storage contemplated in connection with these undeveloped water power projects amounts to about 18.6 million acre-feet. These include all known undeveloped projects and all sites listed in tables 2 and 3.

Programs to Develop the Potential

The Corps of Engineers and the Bureau of Reclamation have recommended projects which would develop substantial amounts of power (table 2). The proposed programs of these agencies would provide a total new installed capacity of about 540,000 kilowatts. The total usable power storage provided in connection with these projects is about 5 million acre-feet.

In addition to the proposed hydroelectric capacity indicated above, the Bureau of Reclamation has proposed the construction of steam-electric capacity amounting ultimately to 750,000 kilowatts, to firm hydroelectric generation. Less than half this total is recommended for present development.

Navigation

The mild winters of the Central Valley make inland navigation possible throughout the year. Like many other navigation channels the Central Valley waterways also are used extensively for recreational boat travel.

Present Navigation Conditions

The Stockton deep water channel is the principal existing navigation improvement. Its 30-foot channel in the San Joaquin River permits access to Stockton by oceangoing vessels. A 10-foot channel provides barge navigation on the Sacramento River as far as Sacramento. Additional channels for navigation have been provided to serve some communities in the basin.

An annual average of more than 6 million tons of cargo and approximately 100,000 passengers moved over these waterways during the period 1939–48. In 1948, petroleum and petroleum products made up 78 percent of the total river tonnage.

[8] Alternate site to Table Mountain.

TABLE 2.—Hydroelectric power developments under construction, authorized, and recommended

No.[1]	Project	River [2]	Operating agency or company [2]	Ultimate installed capacity	Average annual generation	Active storage capacity
	Non-Federal projects—under construction			*Kilowatts*	*1,000 kilowatt-hours*	*Acre-feet*
65	Big Creek No. 4	San Joaquin	SCE	84,000	490,000	20,000
67	Bear River Unit	NF Mokelumne	PG&E	29,000	141,000	.....
	Total			113,000	631,000	20,000
	Non-Federal plant proposed for immediate construction					
66	Cherry Valley	Tuolumne	SF	75,000	680,000	.....
	Federal projects—under construction					
35	Folsom Dam and Afterbay	American	BR	162,000	[6] 533,400	[3] 890,000
	Federal projects—authorized					
68	Iron Canyon (Table Mountain).[5]	Sacramento	CE	72,000	440,000	455,000
	Federal projects—recommended or proposed					
69	New Melones [9]	Stanislaus	BR [8]	48,000	205,000	1,000,000
70	Tulloch	do	BR	20,000	75,000	.....
71	Wishon	NF Kings	BR	[4] 4,000	[4] 21,200	120,000
72	Haas	do	BR	[4] 45,000	[4] 240,800	.....
60	Balch (enlargement)	do	BR	[4] 21,000	[4] 161,700	.....
73	Pine Flat [9]	Kings	(8)	[4] 45,000	[4] 124,600	[3] 900,000
21	Big Bend [7]	NF Feather	(8)	134,000	910,000	906,000
74	Bidwell Bar [7]	do	(8)	152,000	406,000	1,060,000
75	Elbow Afterbay	Feather	(8)	20,000	115,000	.....
22	Bullards Bar	Yuba	(8)	41,500	210,000	591,000
76	Nashville	Cosumnes	(8)	9,000	61,000	530,000
	Total			539,500	2,530,300	5,107,000

[1] Numbers correspond to numbers on figure 2.

[2] Abbreviations are as follows:
NF—North Fork.
MF—Middle Fork.
SCE—Southern California Edison Co.
SF—City of San Francisco.
PG&E—Pacific Gas & Electric Co.
CE—Corps of Engineers.
BR—Bureau of Reclamation.

[3] Dam and reservoir now under construction by the Corps of Engineers.

[4] Initial capacity and generation.

[5] Alternate site to Table Mountain.

[6] Addition to or redevelopment of existing plant.

[7] The Oroville Project, now being investigated, would replace the proposed Big Bend and Bidwell Bar Projects.

[8] Recommended by the Chief of Engineers to the Secretary of the Army, but not recommended to Congress for authorization. These projects are the responsibility of the Bureau of Reclamation under the President's "Folsom Formula," i. e., multiple-purpose dams in the Central Valley are the responsibility of the Bureau of Reclamation, and dams and other works exclusively for flood control are the responsibility of the Corps of Engineers.

[9] The New Melones and Pine Flat power developments were recommended by the Secretary of the Interior for authorization.

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TABLE 3.—Tentative list of hydroelectric power possibilities other than at projects under construction, authorized, and recommended [1]

No.[2]	Project	River [3]	Ultimate installed capacity	Average annual generation	Active storage capacity
			Kilowatts	*1,000 kilowatt-hours*	*Acre-feet*
77	Castle Crag	Sacramento	12,000	91,000	25,000
78	Pit 2	Pit	14,000	95,000	.....
79	Sugar Loaf	Hat Creek	5,000	42,000	.....
80	Pit 4	Pit	80,000	433,000	.....
81	Pit 6	.....do	36,000	200,000	.....
82	Pit 7	.....do	52,000	284,000	.....
83	Big Springs	McCloud	39,000	222,000	.....
84	Rinkle	.....do	22,000	86,000	150,000
85	Lady Bug	.....do	63,000	294,000	20,000
86	Spring Creek	Spring Creek	127,000	589,000	.....
87	Towerhouse	Clear Creek	46,000	319,000	.....
88	Table Mountain	Sacramento	150,000	786,000	4,540,000
89	Antelope Creek 1	Antelope Creek	6,500	45,600	7,800
90	Antelope Creek 2	.....do	4,000	22,400	.....
91	Antelope Creek 3	.....do	5,700	32,200	.....
92	Deer Creek 1	Deer Creek	18,000	109,000	38,300
93	Deer Creek 2	.....do	13,000	77,500	.....
94	Deer Creek 3	.....do	15,000	92,600	.....
95	Deer Creek 4	.....do	18,000	107,200	.....
96	Butte Meadows	Butte Creek	16,000	96,000	30,000
14	DeSabla 2	.....do	[4] 24,000	[4] 132,900	.....
97	DeSabla 1	.....do	8,000	44,800	12,000
15	Centerville	.....do	[4] 15,600	[4] 94,000	9,000
98	Butte Valley	.....do	40,000	133,000	.....
17	Caribou	NF Feather	[4] 66,000	[4] 53,000	.....
99	Yellow Creek	Yellow Creek	25,000	164,000	100,000
100	Greenville	Indian Creek	40,000	150,000	753,000
101	Belden	NF Feather	90,000	338,000	.....
20	Cresta	.....do	[4] 34,000	[4] 159,000	.....
102	Pulga	.....do	81,000	401,000	.....
103	Poe	.....do	37,000	187,000	.....
104	French Creek	.....do	20,000	90,000	.....
105	Inskip	W Br Feather	5,000	29,800	5,300
106	Plant No. 1	MF Feather	19,800	117,000	116,000
107	Plant No. 2	.....do	26,000	157,000	.....
108	Plant No. 3	.....do	65,000	415,000	.....
109	Plant No. 2A	.....do	24,300	164,000	.....
110	Plant No. 4	.....do	42,000	290,000	7,800
111	Plant No. 5	.....do	14,400	104,000	.....
112	Plant No. 1A	SF Feather	10,500	38,000	70,000
113	Sardine Unit	NF Yuba	13,000	102,000	27,000
114	Sierra City	.....do	2,100	7,200	53,000
115	Downieville	.....do	32,800	135,000	.....
116	Ramshorn	.....do	14,800	82,400	16,000
117	Mill Creek	.....do	39,000	218,000	72,000

See footnotes at end of table.

TABLE 3.—Tentative list of hydroelectric power possibilities other than at projects under construction, authorized, and recommended [1]—Continued

No.[2]	Project	River [3]	Ultimate installed capacity	Average annual generation	Active storage capacity
			Kilowatts	*1,000 kilowatt-hours*	*Acre-feet*
23	Colgate	NF Yuba	[4] 26,000	[4] 148,000	.....
118	Spaulding Rim	SF Yuba	5,200	30,000	.....
119	Scotts Flat	Deer Creek	4,000	26,000	.....
27	Narrows	Yuba	[4] 60,600	[4] 278,000	382,000
120	Chicago Park	Bear	22,000	152,000	.....
121	Garden Bar	.....do	4,000	20,000	138,000
122	Tadpole 1	NF American	4,500	17,600	.....
123	Pioneer 2	.....do	15,000	58,900	.....
124	Colfax 3	.....do	25,000	99,000	.....
125	Indian Creek	.....do	10,000	40,300	10,500
126	French Meadow	MF American	3,000	10,500	210,000
127	Ralston	.....do	56,000	318,000	.....
128	Upper Hell Hole	Rubicon	16,000	63,000	80,000
129	Lower Hell Hole	.....do	1,200	5,200	115,000
130	Gerle No. 2	.....do	33,000	180,000	83,000
131	Gerle No. 1	Gerle Creek	5,000	28,000	58,300
132	Rubicon No. 3	Rubicon	80,000	439,000	25,000
133	Rubicon No. 4	.....do	62,000	348,000	.....
134	Rubicon No. 4A	.....do	46,000	262,000	.....
135	Lady Canyon	MF American	35,000	165,000	17,000
136	Oregon Bar	NF American	100,000	427,000	613,000
137	Echo	SF American	4,000	17,500	5,000
138	Van Winkle	Silver Fork	10,000	53,500	4,700
139	China Flat	.....do	15,000	72,700	.....
140	Kyburz	SF American	20,000	120,000	63,000
141	Alder	Alder Creek	4,000	21,000	18,000
142	Ice House	Silver Creek	9,000	44,600	50,000
143	Union Valley	.....do	15,000	58,600	160,000
144	Big Bend	.....do	52,000	281,000	15,000
33	Eldorado 1	SF American	[4] 80,000	[4] 404,000	.....
145	Eldorado 1A	.....do	40,000	216,000	.....
146	Slab Creek	.....do	20,000	99,700	12,500
34	American River	.....do	[4] 56,800	[4] 312,000	.....
147	Kelsey	.....do	25,000	137,200	35,300
148	Salmon Falls	.....do	60,000	216,000	746,000
149	Monticello	Putah Creek	20,000	44,000	1,540,000
150	West Side 17	MF San Joaquin	12,700	54,700	.....
151	West Side 18	.....do	13,400	43,200	.....
152	West Side 16	.....do	35,000	147,000	46,900
153	West Side 9	San Joaquin	61,900	316,000	.....
154	West Side 10	Jackass Creek	23,100	96,800	.....
155	West Side 11	.....do	19,400	82,000	.....
156	West Side 15	Powerhouse Creek	23,100	94,700	.....
157	West Side 14	.....do	16,400	74,900	.....
158	West Side 13	Mugler Creek	15,700	76,500	.....

See footnotes at end of table.

TABLE 3.—Tentative list of hydroelectric power possibilities other than at projects under construction, authorized, and recommended [1]—Continued

No.[2]	Project	River [3]	Ultimate installed capacity	Average annual generation	Active storage capacity
			Kilowatts	*1,000 kilowatt-hours*	*Acre-feet*
159	West Side 12	Chiquito Creek	10,100	25,600	79,900
160	West Side 8A	San Joaquin	36,000	315,000	.....
40	Big Creek 3	.....do	[4] 25,500	([4])	.....
161	Exchequer 2	Merced	5,000	24,900	.....
162	O'Shaughnessy	Tuolumne	11,200	90,000	360,000
163	Early Intake 2	.....do	42,000	252,000	.....
164	Tuolumne	.....do	61,000	475,000	50,000
165	South Fork 1	SF Tuolumne	13,000	31,600	41,000
166	South Fork 3	Tuolumne	22,500	98,600	.....
167	Clavey River Diversion	.....do	13,500	100,000	65,000
168	Mouth Clavey	.....do	9,500	62,000	.....
169	Big Humbug Creek	.....do	8,000	55,000	.....
47	Moccasin	Moccasin Creek	[4] 42,000	[4] 250,000	.....
48	Don Pedro	Tuolumne	[4] 70,000	[4] 160,000	1,138,000
170	Highland	NF Stanislaus	13,000	91,000	69,000
171	Ramsey	.....do	7,000	42,600	20,000
172	Calaveras	.....do	21,000	154,000	.....
173	Dardanelles	MF Stanislaus	6,000	42,700	11,900
174	Donnells Flat	.....do	40,000	165,000	90,000
175	Low Beardsley	.....do	8,800	34,700	97,500
176	High Beardsley	.....do	17,000	109,000	.....
177	Sand Bar	.....do	10,000	78,000	.....
178	Collierville	Stanislaus	36,000	255,000	.....
51	Stanislaus	.....do	[4] 41,000	[4] 198,000	.....
179	Steinbeck	Angels Creek	1,600	12,000	.....
180	Knights Ferry	Stanislaus	6,000	26,000	.....
181	Sloughhouse	Folsom Newman	16,000	60,000	.....
182	Terminus	Kaweah	10,000	40,000	100,000
183	Simpson Meadow	MF Kings	60,000	368,000	150,000
184	Tehipite Valley	.....do	80,000	525,000	30,000
185	Paradise Valley	SF Kings	40,000	219,000	120,000
186	Cedar Grove	.....do	140,000	665,000	120,000
187	Junction 5	Kings	130,000	613,000	.....
71	Wishon	NF Kings	[5] 9,500	[5] 24,400	.....
72	Haas	.....do	[5] 61,500	[5] 116,200	.....
60	Balch (enlargement)	.....do	[5] 63,000	[5] 66,300	.....
188	Junction 1	.....do	30,000	96,000	.....
189	Peart	Dinkey Creek	30,000	100,000	60,000
190	Junction 2	.....do	50,000	200,000	.....
191	Kings River	Kings	39,000	129,600	.....
73	Pine Flat	.....do	[5] 75,000	[5] 164,400	.....
192	Kern Lake	Kern	25,000	157,500	70,000
193	Little Kern	.....do	40,000	236,000	25,000
194	Junction	.....do	60,000	350,000	100,000
61	Kern River 3	.....do	[4] 28,000	[4] 153,500	25,000
195	Monache	SF Kern	100,000	52,500	25,000

See footnotes at end of table.

TABLE 3.—Tentative list of hydroelectric power possibilities other than at projects under construction, authorized, and recommended [1]—Continued

No.[2]	Project	River[3]	Ultimate installed capacity	Average Annual generation	Active Storage Capacity
			Kilowatts	*1,000 kilowatt-hours*	*Acre-feet*
196	Rockhouse	SF Kern	5, 000	17, 500	.....
197	Onyx	.....do	25, 000	131, 000	23, 000
63	Kern River 1	Kern	[4] 94, 000	[4] 330, 000	.....
64	Kern Canyon	.....do	[4] 23, 500	[4] 80, 000	.....
198	Ant Hill	.....do	17, 000	70, 000	220, 000
	Total		4, 624, 700	22, 542, 700	[6] 13, 570, 700

[1] Data for the projects listed above are based on investigations which vary from reasonably complete surveys to studies of preliminary character. Much further study would be required, therefore, to determine more accurately the details and the physical desirability of some projects. The list also includes projects which may not be feasible because of conflicts with higher beneficial use. For example, some sites listed on the Middle Fork and South Fork Kings River may well be of this type.

[2] Numbers correspond to numbers on figure 2.

[3] Abbreviations are as follows:
NF—North Fork.
W. Br—West Branch.
MF—Middle Fork.
SF—South Fork.

[4] Addition to or redevelopment of existing plant.

[5] Additional capacity and generation beyond that which would be provided initially at recommended projects.

[6] Future reservoirs without power developments at the sites would provide an additional 1.7 million acre-feet of active storage capacity.

Facilities in Construction and Authorized

A project is presently under way to provide a 30-foot channel to Sacramento. A project for enlargement of Old River and other nearby channels in the San Joaquin delta to provide navigable depths of from 6 to 10 feet is being constructed.

Congress has authorized a shallow draft project to provide navigation depths on the Sacramento River of 6 feet for an 85-mile reach from Sacramento to Colusa; of 5 feet from Colusa to Chico Landing (50 miles), and for such depths as are practicable from Chico Landing to Red Bluff. Release of water for navigation and salinity control will maintain these depths during the greater part of the navigation season.

Further improvement of the San Joaquin River and the Stockton deep water channel also has been authorized.

Situation at the End of the Present Program

A well integrated system of navigable channels will serve the lower end of both the Sacramento and San Joaquin systems. Stockton and Sacramento will be deep water ports served by oceangoing vessels carrying all classes of domestic and foreign commerce. The network of shallow-draft channels will connect with other river and bay terminals and provide for extensive recreational boating.

Programs for Future Development

Upon completion of the present projects only a small additional program is contemplated. Improvements of port and harbor facilities include extending the harbor area and providing more adequate turning facilities at Stockton. Deeper channels and some extension of the waterway system are envisaged. Improvement of channels above tidewater would be accomplished primarily by reservoir regulation to improve low water flows. This might result in conflict with other beneficial uses. Channel extension will undoubtedly require considerable alteration of highway bridges.

Public Water Supply

The majority of the people in the Central Valley obtain their water from wells. The quality is high except for a slight hardness, which is increasing slowly. Thirty-seven communities, including Sacramento, obtain their water either directly from the stream channels or from artificial reservoirs. Water quality is very high in the mountain streams but becomes progressively poorer toward the delta areas. Sacramento River water is so polluted by the time it reaches Sacramento that full treatment, including aeration, chemical coagulation, filtration, and chlorination, is necessary to make the water suitable for domestic use. In the delta area surface water is so heavily polluted that it is unsatisfactory for water supply purposes without special treatment.

In addition to valley water supply demands, much of the water supply for the 2.5 million people of the San Francisco Bay area is obtained from the Tuolumne and Mokelumne Rivers of the San Joaquin drainage. Aqueducts 150 and 250 miles long serve the East Bay cities and San Francisco. The supplies are presently almost completely utilized.

The Bureau of Reclamation estimated in 1945 that only about 5 percent of the total available natural water supply of the valley will be needed for municipal and industrial use—1 million acre-feet. Exports to the San Francisco Bay region will be 450,000 acre-feet annually and use in the Central Valley itself will be 550,000 acre-feet annually. Present estimates indicate that the bay area requirements will be substantially greater than these 1945 data.

Increasing pollution of the streams, and conflicts in the use of the catchment watersheds, endanger domestic and industrial water supplies.

Two projects authorized or under construction have public water supply as a major feature. The Contra Costa Canal unit of the Central Valley Project carries water from the delta for domestic, industrial, and irrigation use along the south shore of Suisun Bay from Antioch to Martinez. Municipal and industrial demands have taken the greater part of this supply, and are expected to predominate in the future.

Additional demands upon the Contra Costa Canal are for the industrial requirements of Richmond and other communities. This situation now is under study by the Bureau of Reclamation. Also under study is the use of Central Valley water in the Santa Clara area where quantity and quality, surface and underground, have been deteriorating. The authorized Solano Project will provide supplemental water for the municipal supply of cities in Solano County, principally Vallejo, and also will furnish a water supply for military installations in the area. The Folsom Project, now under construction, also is expected to supply water for municipal and industrial purposes.

Flood Protection

The Present Situation

Extensive flooding of the lower parts of the Sacramento and San Joaquin Valleys is a natural occurrence. As settlement spread over the Central Valley, damages from floods steadily increased, with a concomitant demand for flood protection. By 1917 a comprehensive flood control plan for the Sacramento River had been adopted.

With no flood protection it is estimated by the Corps of Engineers that damages would average 25 million dollars annually. Flood protection works already constructed are estimated to prevent 10 million dollars' worth of flood damage annually. Major flood damage (15 million dollars annually) still occurs.

The principal works of the Sacramento Valley flood control project are levees and channel improvements along the Sacramento River; along the lower reaches of the American, Bear, Yuba, and Feather Rivers, Cache and Putah Creeks, Willow Slough, and many of the minor tributaries above Colusa; the Moulton, Colusa, Tisdale, Fremont, and Sacramento overflow weirs; and the Sutter and Yolo bypasses. With the exception of some enlargement and extension of the Sacramento River levees and construction of levees on minor tributaries, the project works have been completed and have operated to provide flood protection for many years.

When operated in conjunction with the existing and proposed storage units (including Shasta Reservoir) the flood control program will provide a high degree of protection to about 800,000 acres of fertile agricultural lands and to the major cities, including Sacramento, Marysville-Yuba City, and Colusa, as well as many smaller communities, and to transportation facilities.

Fewer measures have been undertaken to provide flood protection for the San Joaquin Valley. Four flood control reservoirs have been completed in the

San Joaquin Valley. These reservoirs have a combined capacity of 41,000 acre-feet. Big Dry Creek Reservoir, about 10 miles northeast of Fresno, provides protection to Fresno and Clovis and their adjacent agricultural and industrial areas. Mariposa, Owens, and Burns Reservoirs are units of a four-reservoir system, of which the fourth—Bear Reservoir—has not yet been constructed. The system will provide protection for about 136,000 acres of agricultural land and to Merced and smaller communities, as well as reduce flood outflows to the San Joaquin River.

As flood flows follow a seasonal pattern in the Central Valley it is possible to combine flood control and conservation storage in the same reservoir. Shasta Reservoir is used for flood control as well as for other purposes. Friant Dam also has flood control utility.

Facilities under Construction and Authorized

Five Federal reservoirs currently under construction will provide flood storage capacity exceeding 2 million acre-feet. These reservoirs are: Folsom Reservoir on the American River, to provide flood protection to the Sacramento urban area; Isabella Reservoir on the Kern River, to provide protection for 350,000 acres of agricultural and oil field land in the Kern River area, for the city of Bakersfield, and for 260,000 acres of cropland in the Tulare Lake area; Pine Flat Reservoir on the Kings River, to provide flood protection for about 80,000 acres of cropland in the Kings River service area; Farmington Reservoir on Littlejohn Creek, to help protect 58,000 acres of agricultural land and suburban areas and industrial sites immediately south of Stockton; and the Merced County stream group of four dams, which is considered under construction, though no work is now in progress. Three have been completed.

The Cherry Valley Reservoir is being constructed by San Francisco with Federal financial aid, and will provide 340,000 acre-feet of flood storage. In return for the Federal aid the city will operate the reservoir in conjunction with the Lake Eleanor and Hetch Hetchy Reservoirs for flood protection in the San Joaquin Valley. Further flood control storage will be provided in the New Don Pedro Reservoir, also to be constructed by local interests with Federal aid.

Authorization has been given for an additional six flood control reservoirs. These are: Black Butte Reservoir on Stony Creek; Success Reservoir on Tule River in Tulare County; Terminus Reservoir on Kaweah River; New Melones Reservoir on Stanislaus River; New Hogan Reservoir on the Calaveras River; and Iron Canyon Reservoir on the Sacramento River. These authorized reservoirs will provide an aggregate flood control storage of 1.5 million acre-feet.

Total flood control capacity in all under construction and authorized projects amounts to 3.6 million acre-feet. Of this total, 3 million will also be used for other purposes.

Channel improvement and levee construction for flood control are authorized for the lower San Joaquin River and tributaries, major and minor tributaries in the Sacramento Basin, Bear Creek in San Joaquin County, upper Butte Basin, and other locations. Some of these projects now are under construction.

Situation upon Completion of Present Authorized Program

The Corps of Engineers estimates that completion of the present program will prevent annual flood damages of 19 million dollars. Protection will be provided for more than 40 urban damage centers and for almost 2 million acres of agricultural land. It will have made possible a higher type of use on 200,000 acres of agricultural land.

However, it is anticipated that at the end of the current program, protection needs of urban areas will have increased and that further protection of agricultural land would be desirable. Average annual flood losses will still be in excess of 6 million dollars and some land will still be held to a lower form of use than would be possible if it were protected from floods.

Programs for Further Construction

A flood control survey report was presented in 1949,[9] which incorporates existing, authorized, and additional works into a basin flood control plan. This plan contemplates a total of about 30 reservoirs, with about 12 million acre-feet of capacity. The program also calls for extensive enlargement and rectification of flood channels, new levees, and improvement of existing levees along approximately 1,000 miles of streams and floodways.

[9] H. Doc. 367, 81st Cong., 1st sess. (1949).

Watershed Control Upstream and Related Land Programs

The Present Situation

It is estimated that at least 12.5 million acre-feet, or 60 percent of the annual runoff of the Central Valley, comes from the national forest lands. A large share of the remainder comes from private forest lands and a small amount from the 1.5 million acres of public domain.

Watershed management to bring about maximum useful water yields is a primary objective of national forest administration. Serious grazing problems formerly were common in the national forests but are becoming less acute as a result of reductions in livestock numbers and better range management practices. Erosion conditions generally are not a serious concern within the national forests, but they could be improved, especially in mountain meadows. An accelerated planting schedule is desirable for some 525,000 acres of forest land. Large volumes of good timber within the national forests have not been harvested because of inaccessibility. If these stands could be utilized, it would be possible to harvest stands which are declining because of losses in old growth and more quickly permit the development of sustained yield enterprises.

Timber cutting on private forests has not been well managed. Only about 25 percent of private cutting is adequately managed for proper watershed protection. Overgrazing on private lands within the national forests and in foothill areas has caused extensive erosion damage.

On the whole, erosion and sedimentation are not major problems within the Central Valley now, but the potential danger is great unless watershed lands are closely watched and properly managed. Complacency on account of the present situation could be dangerous because of the impact of the growing population on the forest resource.

There are 15 soil conservation districts in the Central Valley. They comprise only a small fraction of the total land of the valley. About 200,000 acres of land have received treatment.

On the irrigated lands of the valley most farms need better water application methods to conserve water and reduce erosion and leaching.

Drainage problems occur locally where water tables are high or where heavy alkaline soils and poor irrigation practices exist.

Present Programs and Program Needs

Fire hazards are high during the long, dry summers. Federal and State funds available for forest fire control protect the forests adequately, except during periods of extreme hazards. Present measures for protection of timber stands against insect and disease damages are adequate unless epidemic conditions should arise. Logging practices in national forests are generally good, but further improvement is necessary. More access roads are needed to insure maximum utilization of the timber resources. Grazing and big game management in the national forests needs to be strengthened. Recreational use of the forests is increasing so rapidly that facilities for such use need immediate expansion. Public acquisition and management of critical flood and sediment source areas in the mountains are needed.

The Secretary of Agriculture is authorized to cooperate with State forest officials to encourage the providing of technical services to private forest landowners with respect to management of forest lands.[10] This program needs to be expanded. Much more tree planting is needed on private forest lands. State forest lands should be consolidated into manageable units.

Attempts to convert brush lands to grass are creating new problems. In some areas this practice may prove beneficial, but many steep slope and thin soil areas will suffer severe erosional damage, and contribute to flood flows. Research to guide this work is urgently needed.

An expansion of the present program of watershed management research would assist greatly in achieving maximum benefits from this conservation effort.

Programs to guide and assist the farmers in initiating better irrigation practices need expansion. This will be especially true for farmers on new irrigated lands. Studies designed to insure application of limited water supplies to the most productive land are desirable.

Irrigation farming in the Central Valley requires large capital investments. A more extensive farm credit program will be necessary as new irrigated land is brought into production in order to achieve the most efficient production on these new lands.

[10] Act of August 25, 1950, § 1, 64 Stat. 473.

Recreation, Fisheries, and Wildlife

The Present Situation

Major outdoor water recreation activities are those related to boating, fishing, and hunting in streams and reservoirs, and camping and picnicking. Winter sports are growing in popularity.

While recreation facilities involving water use are extensive, they are not ample to meet the demands of the growing population of California.

The Central Valley is along an important west coast flyway for game birds. The area of swamps, marshes, and water bodies along this flyway has been steadily decreased. Future programs may further decrease their size unless provision for waterfowl is included in future plans.

Salmon support a minor commercial fishery but their major importance here is for recreational fishing. Trout and several other species of game fish are also sought by sportsmen.

Program for Development

Provision for recreational facilities at the various major reservoirs is planned. Fish are to be propagated in the reservoirs. Opportunities for boating, bathing, picnicking, and camping are to be provided where they can be developed in association with other important reservoir uses.

With a view to increasing the fish population for sport fishing, studies on fish management are under way. Until further information is available, one major reservoir (Iron Canyon) has been deferred, partly because of its harmful effect on anadromous fish migrations.

Plans for reservoir construction include use of the surrounding lands and the water surface to assist in maintaining waterfowl. Many small reservoirs are now being built in the upper portion of the tributary streams to improve the flow during dry seasons, increase the natural hatchery facilities, and save fish.

Finally, various major scenic and recreation areas that are becoming increasingly scarce in California will be protected against inundation.

Special Developments

Hydraulic gold mining on tributaries of the Sacramento and on northern San Joaquin tributaries washed millions of tons of soil and boulders down the channels, debouching onto the valley floor. The finer materials moved down the channels and filled them, flooding the riparian lands and interfering with navigation. In 1879 hydraulic mining was stopped in the Central Valley due to the damage, and in 1893 the California Debris Commission was created under the Corps of Engineers to license such mining provided the debris was kept out of the stream channels. Further legislation enabled the Corps of Engineers to construct dams for such storage, the Government to be reimbursed by the operators. Three such dams have been constructed, and two more have been authorized. It is questionable whether placer mining will return on any large scale because of the high cost of acquiring water and rehabilitating the necessary canals to carry the water to the mining properties.

Multiple-Purpose Aspects of the Program

Multiple-purpose use of water in the Central Valley is a necessity if all of the many pressing demands for water are to be met. This was the objective of the State Water Plan, adopted by the legislature of 1941, and continues to be the objective of Federal agencies.

Although conflicts in use are unavoidable, many uses of water are complementary. Storage of water for any purpose is beneficial to hydroelectric power developments. Surface application of irrigation water increases the underground water supply. Releases for salinity control and irrigation assist in maintaining navigation channel depths, and in assisting pollution abatement during low-flow periods. Moreover, by obtaining multiple benefits from water development works, greater water development is possible than could be economically attained on a single-purpose basis.

Existing Multiple-Purpose Projects

The initial features of the Central Valley Project perform several functions. Shasta Reservoir regulates floods, maintains navigation flows, supplies irrigation and municipal water supplies, is used for salinity repulsion, generates hydroelectric power, and provides recreation benefits.

The Delta Cross Channel furnishes water for irrigation and salinity control.

The Contra Costa Canal furnishes both municipal and irrigation water.

Friant Dam provides flood control and irrigation water and water supplies for underground storage.

Some non-Federal projects, like Hetch Hetchy Reservoir (electric power and water supply) and Don Pedro Reservoir also are multiple-purpose.

Multiple-Purpose Projects under Construction and Authorized

Folsom Dam, when completed by the Corps of Engineers, will have flood control, power generation, municipal water supply, and irrigation functions.

The authorized Sly Park Reservoir of the Bureau of Reclamation will supply irrigation water and municipal water.

The Solano Project authorized for Bureau of Reclamation construction will also furnish both irrigation and domestic water.

Two other Corps of Engineers "under construction" projects, besides Folsom, have multiple functions. These are Isabella and Pine Flat Reservoirs, which have flood control and irrigation functions. A number of private and local public projects for irrigation, power, or municipal supply also serve other purposes. Recreational benefits are provided incidentally at most of the reservoirs constructed for other purposes.

Projects of the Corps authorized but not under construction having multiple-purpose use are Iron Canyon and New Melones Reservoirs, for flood control, irrigation, and power; and the Success, Terminus, and New Hogan Reservoirs for flood control and irrigation.

Future Programs

All the reservoir projects recommended by the Chief of Engineers to the Secretary of the Army or under consideration are either multiple-purpose projects or call for eventual installation of additional functions at reservoirs existing or under construction.

Most of the numerous projects in the Bureau of Reclamation's plan for the Central Valley also have multiple-purpose functions.

Chapter 4

Project Economics, Accounting, and Repayment

Because of the current large Federal water development and control program in the Central Valley and because of the past extensive area of irrigated land in the valley, it might be assumed that extensive construction by Federal agencies had been carried on in the past. However, viewed in the light of the total water resources development in the Central Valley, the completed projects of the Federal agencies have not yet become of major importance.

Some Federal projects were initiated before modern concepts of economic analysis had been developed. Hence, for the older projects only a few totals can be presented. Another difficulty arises from the nature of the present Central Valley Project, which is not a project but a program made up of a number of projects designated as units. Several units are now under construction during a period of steadily rising costs; hence, most economic data represent historical estimates rather than present or future dollar benefits and costs.

Development Program as a Whole

Water development programs of the Federal Government in the Central Valley will have reached a total of 555.5 million dollars upon completion of the initial features of the Central Valley Project.

Of this total the largest single item is for irrigation, for which the total cost allocated is 222.5 million dollars. Irrigation costs are all reimbursable, though not necessarily by the water users. It is proposed by the Bureau of Reclamation that a large fraction of the irrigation costs be subsidized by the income from power.

Power costs are 131.5 million dollars. All of these costs are reimbursable. The rates must be set high enough to earn 3 percent interest on the investment, although under the present practices of the Department of the Interior the interest would not be returned to the Federal Treasury as payment on the power account. These costs are almost entirely associated with the Shasta and Keswick Dams and power plants, transmission lines, and the steam plant.

The only other reimbursable cost is for construction to serve municipal and industrial water requirements. This amounts to 11.7 million dollars. Charges are made by selling water "wholesale," and it is expected that such sales will more than cover expenses incurred by the Federal Government for providing this water.

Debris control for placer mining on certain streams has cost the Federal Treasury 5.3 million dollars. These costs are repaid in proportion to use, and reimbursement of the initial cost from mining interests will be obtained only if the facilities are used to the maximum of their capacity. These reservoirs meanwhile provide some recreation benefits, some power generation, and are valuable for arresting long-term downstream movement of the valley fill created by early mining. No interest is charged on the investment.

The nonreimbursable costs for flood control, navigation, and fish and wildlife make up roughly 40 percent of the total program costs.

Flood control costs have totaled 156 million dollars and are by far the largest nonreimbursable item. Over half of these costs have been met by local interests. Where protection is afforded by levees and other local works, local interests pay a significant share of the cost. The Federal Government bears the entire cost of flood protection reservoirs. In earlier flood control programs, local contributions were very large, but since recent costs have been for reservoir construction, they have been

largely Federal, as evidenced by the fact that over a third of the Federal investment for flood control has been in the recently completed Shasta and Friant Dams.

Navigation costs have been 25.8 million dollars. Nearly two-thirds of this figure is represented by the allocated costs to navigation in Shasta Dam. Roughly a tenth has been paid by local interests.

Both the navigation and flood control programs have been carried on over a long period during which no benefit-cost analyses were made. However, the Corps of Engineers reports that benefits are in excess of costs.

The Federal fish and wildlife program has cost 2.7 million dollars. No economic analysis is made of the projects and no income accrues directly to the Federal Treasury.

Hydroelectric Power

Hydroelectric power investments in the Central Valley by the Federal Government total 131.5 million dollars for facilities constructed, or soon to be completed. This figure represents the costs assigned to power in the Shasta and Keswick units of the Central Valley Project, with transmission lines and a steam plant.

The Central Valley is an area of medium power costs. The seasonal and annual variations in runoff and the two peaks of demand (in summer and winter) necessitate large steam capacity to supplement the output of hydroelectric plants. Prior to 1940 the Pacific Gas & Electric Co., which supplied practically all the power used in the area, had about a third of its installed capacity in steam plants and two-thirds in hydroelectric plants. Energy generation by the hydroelectric plants varied from 60 to 90 percent of the annual total, varying with the amount of runoff. In its present extensive power construction program, the Pacific Gas & Electric Co. is installing a higher percentage of steam plants and the system capacity is now approaching an equal division between steam and hydroelectric power.

As less favorable hydro sites are constructed, costs of hydroelectric generation will rise except insofar as multiple-purpose projects offer opportunity for sharing costs among several purposes. Also, as more steam power is added, the value of hydroelectric plants for peaking purposes will serve to justify higher costs.

Net revenues from Shasta and Keswick are expected to be more than double the cost of providing the generating facilities. The problems connected with the power rate, the interest component, and subsidy of irrigation costs by power revenues are discussed in chapter 5.

Irrigation

The Orland Project is the only completed Federal irrigation project in the Central Valley. It was constructed in two parts, the first costing 1.1 million dollars, and the second 1.3 million. The total cost per acre for the 20,000 acres included in the project, therefore, was about $125, a figure much below most current projects.

The total cost of the project is charged to irrigation, and all of the first 1.1 million dollars has been repaid, without interest. Financial difficulties encountered during the 1930's led to funding of the combined debt in 1936, with repayment required in 35 years. The ultimate cost, including penalties, interest, and funded operation and maintenance charges, will be $2,471,000. Full repayment is expected in 1977.

Costs will be higher in the future than on past projects, public or private. The most favorable sites were developed first, and price levels were lower. New irrigation will require large storage reservoirs, long canals and distribution systems, and in some cases large power requirements for pumping. Most of the acreage now planned for development will require capital investments of $300 to $600 per acre. These cost figures should, of course, be appraised in the light of the very high productivity of land in the Central Valley. Prices of land in the Orland Project, for example, range from $50 to $150 per acre for unimproved property, and from $130 to $750 per acre for improved property.

Firm data on the repayment to be expected from irrigators are not available. The Bureau of Reclamation estimates that of the 225.5 million dollars of construction costs on the initial features of its Central Valley Project (dams, main canals, and power allocated to pumping), 61 million dollars will be repaid by the water users. This is a repayment of 28 percent. However, if all irrigation costs of the entire project including operation and maintenance are considered, the payment expected of the irrigators rises to about 70 percent.[1] Further contributions by irrigators are made in costs of on-the-farm

[1] Calculated as a percentage of the combined total of the capital investment (without interest) and the cumulative operation and maintenance costs over the repayment period.

facilities. The latter are not considered in the above estimates. If on-the-farm expenditures were included, the percentage share contributed by local interests to the total would be much higher.

On the authorized Solano Project a repayment of over 75 percent of the irrigation costs is expected. Estimates on the other authorized and proposed irrigation projects could not be made in 1950 because water rates have not yet been established.

Cost allocations to irrigation have been made in conjunction with some of the Corps of Engineers reservoirs for flood control which have irrigation benefits from flow regulation. Estimates as to the repayments to be expected differ widely. On Pine Flat Dam the Bureau of Reclamation holds that irrigators should repay 14.2 million dollars. The Corps of Engineers estimates a return from irrigators of 12 million dollars and the State of California estimate is 10 million dollars.[2]

Navigation

Improvements for navigation have been made at a total cost of 25.8 million dollars including 18 million dollars of the cost of Shasta Dam. Two and a half million dollars of this is non-Federal. Of the allocation to navigation of Shasta Reservoir costs, 5.6 million dollars is for salinity control. Current benefit data are not available for navigation projects.

In addition to costs generally published for navigation works, there are unlisted costs to the general public. Additional costs are incurred, for instance, in construction and operation of highways and bridges. The Bureau of Public Roads estimates that the additional cost for highway bridges over the San Joaquin and Sacramento Rivers due to navigation amounts to an investment of $4,252,500, with $274,700 annual operation costs for lift or swing bridges.

One navigation project, the San Joaquin River and Stockton Channel, is authorized but not under construction. The estimated construction cost is 6.7 million dollars, and the benefit-cost ratio is estimated as 1.25 to 1, including some incidental flood control benefits.

Flood Control

Levee construction to prevent flood damage was initiated by private interests. These improvements later were incorporated into the more extensive system constructed by the Corps of Engineers.

The local investments, plus all the subsequent Federal costs over a period of more than 50 years, total 156 million dollars. Over half (85 million dollars) has been contributed by local interests. Of the total Federal expenses of 71 million dollars, allocations to flood control in Shasta and Friant Dams amount to 31.4 million dollars.

Estimated costs of flood control projects authorized since 1940 far exceed the total of all previous flood control costs. Total estimated cost of these new projects is 337 million dollars. Annual carrying charges total 15.9 million dollars and evaluated annual benefits amount to 22.1 million dollars, of which 10.9 million dollars are flood control benefits. The ratio of benefits to costs is 1.4 to 1. Local interests will pay 8.3 million dollars for strictly local benefits from local works.

The estimated construction costs for completing the remainder of the comprehensive flood control plan is 270 million dollars. The estimated benefit-cost ratio on these projects is 0.8 to 1, but it is assumed that further local expansion will increase the importance of flood control sufficiently so that larger benefits will be realized. Construction will be deferred until these demands have materialized.

Debris Control

The debris control structures in the Sacramento Valley were built under different Federal authorizations, and consequently differ somewhat in accounting and repayment aspects.

Daguerre Dam and restraining basins were constructed at a cost of $723,000, divided equally between the Federal Government and the State of California. Carrying charges averaging $60,000 annually are similarly divided. No reimbursement is required from beneficiaries. Annual benefits have not been evaluated.

A later Federal law authorized construction of four debris impoundment reservoirs. Two such reservoirs have been built at a cost of 4.6 million dollars of Federal funds. Annual benefits are not evaluated. Repayment is made in proportion to the amount of debris deposited in the reservoir. To date only $71,000 has been repaid to the Government. This constitutes an important subsidy to the mining interests, in that they may defer such payments interest-free as long as they wish and are in

[2] A discussion of the problems of irrigation contract negotiations is found in chapter 5.

no way responsible for eventual repayment of the reservoir costs.

The head created by one of the dams is utilized for power generation by the Pacific Gas & Electric Co., which at present pays the United States $18,000 annually. After the first 30 years this payment will be increased to $48,000 a year.

Fish and Wildlife

Three Federal wildlife refuges have been developed in the Central Valley at a total cost of 1.1 million dollars. They cover an area of 14,400 acres, and the cost was about $75 per acre.

The Fish and Wildlife Service operates the Coleman Fisheries Station on the upper Sacramento River. The investment in the station is 1.6 million dollars and the annual operation and maintenance expenses are approximately $100,000. The largest single unit of the station is a salmon hatchery.

Both the Federal Government and the State of California plan to extend their acreage of wildlife refuges. California has set aside 4 million dollars for land acquisition and the Federal Government has authorized $745,000 for new projects.

No evaluation of benefits from their projects is made by the Fish and Wildlife Service, and no repayment is expected.

Chapter 5

Policy Problems and Their Relation to Plans for Development

In reviewing the Central Valley situation, a number of problems related to the water resources program were disclosed. Some of them are of such importance that they were made the subject of a separate study.

Thirty-one separate policy problems are identifiable in Central Valley water resources development. The existence of so many issues may be attributed in part to the limited extent of water supplies in parts of the basin most suited to agricultural and urban development, in part to the long history of water resources development in California, and also to the number of agencies and interests concerned. Problems are of four general Don Pedro Reservoir, also are multiple-purpose. types: (A) Distribution of benefits and responsibilities, (B) Conflicts in beneficial use, (C) The character of development, and (D) Program procedures. They are listed below in the order of their presentation.

A. *Distribution of Benefits and Responsibilities*

1. The place of State and local agency participation in planning, programing, financing, and operation.
2. The place of private citizens and organizations in water resources control and development.
3. Desirability or handicap of acreage limitation laws in irrigation developments.
4. Extent of Federal Government concern with pollution control.
5. The need for a pooled account in power planning and administration.
6. The use of power revenues, including the interest component, in financing irrigation developments.
7. Reimbursability of allocations for fish and wildlife, and recreation.
8. Reimbursement to the Federal Government for ground water.

B. *Conflicts in Beneficial Use*

1. Conflicts of fishery, wildlife, and recreational interests with other water developments.
2. Principles for planning and construction of facilities in areas previously dedicated to scenic values.
3. Inundation of facilities of established enterprises.
4. Conflicts between upstream and downstream interests.
5. Extent of conflicts between and associated with domestic, irrigation, industrial, and other water uses.
6. Placer mining activities in relation to water resources development.
7. Mining claims on public lands.
8. Extent to which flood plain zoning is practicable.
9. Conflict between navigation developments and other water uses.

C. *The Character of Development*

1. Basic data essential to future plans.
2. The proper rate for future construction of facilities to provide water for supplemental irrigation, and new land development.
3. Ground water replenishment.
4. Land treatment programs in plans for water resources development.
5. Rate of construction and integrated operation of electric power facilities.
6. Facilities for future national defense needs.

7. Uniform policy on providing recreational facilities in reservoir areas.

8. Extent to which fish and wildlife programs should be included in planning for water resources development.

9. Measures for mosquito control.

10. Extent to which engineering and design of major works should take account of all probable future water needs.

11. Interbasin diversions of water into and out of the Central Valley.

12. Integrated planning, construction, and operation of facilities for water use in the Central Valley.

D. *Program Procedures*

1. Irrigation repayment contract principles.
2. Acquisition of property in reservoir areas.

Among the issues discussed, probably the most important are those which relate to integrated planning and operation of facilities, the allocation of water to different beneficial uses, the place of State, local, and private agency participation, application of acreage limitation to irrigation, and the nature of irrigation repayment contracts. Each of the other issues discussed has some significant bearing on the successful completion of efficient, comprehensive use of the water resources.

A. Distribution of Benefits and Responsibilities

1. *The Place of State and Local Agency Participation in Planning, Programing, Financing, and Operation*

The Problem

The extent to which State and local government agencies should participate, or be called upon to participate, in the planning, programing, financing, and operation of water resources developments in the Central Valley.

The Situation

Californians long have recognized the vital importance of water to their welfare. They have spent many millions of dollars, individually and collectively, to protect themselves and their works from floods, and even more millions to conserve and regulate their water and put it to beneficial use. In addition, much time and money have been spent by State and local agencies in investigating and planning the control and use of water and land resources. The State Water Plan of 1931,[1] developed over many years, is today the basic outline of Federal plans for improvement. Many other developments of California's water resources have been undertaken by private groups, first for mining, and then for irrigation and power.

Much legislation dealing with the control and use of Central Valley water has been enacted by the State. As a result, many local public agencies have been formed to plan, construct, and operate flood control, irrigation, drainage, soil conservation, municipal water supply, sanitation, power, and other works. Still other State and local agencies have been created to cooperate with the Federal Government, and to meet the established requirements of local cooperation.

Two examples of these agencies are the State Water Resources Board and the State Reclamation Board. The former conducts investigations and establishes State policies on the control and use of water. It recommends adoption of projects to the legislature, specifying the State share in the method of financing the non-Federal cost of projects. The State Reclamation Board acquires rights-of-way for local flood protection within the State, and participates in other activities including maintenance and operation of phases of these projects.

The experience acquired by State and local agencies has been helpful to responsible Federal agencies. Full cooperation and participation by State and local interests can promote speed and efficiency in the program. Because the drainage area is entirely within one State, local interest in its resources is much more intense than in interstate basins. Also, a capable force of State and local personnel, trained and informed with respect to the problems, is available for such participation. Extensive consultation among Federal, State, and local interests is a normal activity.

However, local interests desire even greater participation in planning, programing, and operation. They have participated financially in many projects, and have assumed complete responsibility for some. State and local agencies have expressed their views on water policy problems, particularly with respect to water rights and acreage limitations.[2]

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[1] Now being revised.

[2] State of California, Department of Public Works, *Views and Recommendations of State of California on Proposed*

Conclusions

The choice here presented is between a situation in which duly constituted local or State agencies, which presumably represent a majority of the people under their particular jurisdictions, have a maximum share in planning, programing, and operating water conservation facilities, and a situation in which they have a lesser share, depending on Federal initiative and activity. The place of private interests in development is considered in the following section.

If State and local participation is small, the course of future action, no matter how well-intentioned and otherwise efficient, is likely to be beset by local objections, needless delays, danger of project selection on nontechnical bases, and greater expense to the Federal Government than otherwise would be the case. The size of State organizations, the scope of State activities in the water programs, the extent of past locally organized developments, and the intrastate character of nearly all problems point toward the desirability of maximum State and local participation. However, in encouraging and recognizing such participation, care should be taken that the broad public interest rather than the special interest is protected and that financial investment is commensurate with participation.

Specifically, State and local participation might include:

(a) A larger voice in drafting basin-wide plans for control and use of waters and other resources, perhaps by means of formal unified coordination procedures among all local, State, and Federal agencies involved.

(b) Recommendations as to the relative need for specific projects and their rate of development.

(c) Recommendations as to the manner of operating projects, particularly as regards water use and regulation.

(d) Operation and maintenance, wherever practicable, of strictly local flood control, irrigation, domestic and industrial water supply, drainage, fish and wildlife, and recreation facilities.

(e) Construction, financing, and operation of projects which conform to a comprehensive plan.

(f) Payment for all or parts of Federal improvements which result in substantial and determinable local benefits.

Report of Secretary of Interior Entitled Comprehensive Plan for Water Resources Development, Central Valley Basin, California, April 1946, 343 pp. See also, S. Doc. 113, 81st Cong., 1st sess. *Central Valley Basin,* August 1949, pp. 291–431.

2. *The Place of Private Citizens and Organizations in Water Resources Control and Development*

The Problem

Participation of private enterprise in the future control and development of water resources.

The Situation

Extensive present use is made of the water resources of the Central Valley Basin for irrigation, municipal water supply, power, and other purposes. Existing works have been constructed by private groups and local public agencies, although there are important Federal projects, like Shasta, Keswick, and Friant Dams, and the Delta-Mendota Canal. Power has been an important field of construction by private groups. In a number of instances power has been provided in connection with irrigation as a joint or cooperative undertaking between private and local public agencies.

Future irrigation requires construction of large engineeering works such as reservoirs, extensive canal systems, and pumping facilities. Because of the size, scope, and multiple-purpose character of many projects, and to provide a comprehensive program, Federal participation is believed to be desirable. In many instances there is general agreement as to the responsible agency, but in a number of cases conflicts of interest as between public and private responsibility either have appeared or are likely to appear. Most of the conflicts concern hydroelectric power sites.

Approximately 80 percent of the present hydroelectric capacity in the basin is owned and operated by private utilities. They supply more than 95 percent of the area load. The existing utility plants are ordinarily on headwater tributaries using high heads, and with little storage capacity. With the completion of Federal plans calling for multiple-purpose reservoirs on principal tributaries near the foothill line, additional headwater power projects could be constructed, with little effect on downstream improvements for other purposes.

Large multiple-purpose reservoirs at the edge of the foothills would provide sufficient storage to impound upstream power discharges for irrigation and other uses downstream. Private utilities are developing certain headwater power sites and are contemplating the use of others. Such sites are particularly valuable for peak-load use because of the

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high and nearly constant heads. Other power sites may be related to conservation storage upstream.

Building single-purpose upstream power projects has been proposed in some cases as a Federal undertaking, particularly where reregulation is provided by Federal reservoirs. The power available would be used to firm the power output at main reservoir plants, and for irrigation pumping. In addition to the power benefits, carry-over of water stored in some upstream reservoirs from wet to dry years would tend to increase the firm irrigation supply downstream. These upstream reservoirs in a few cases would be the only source of water for irrigable lands in mountain or foothills areas.

In cases where there are conflicts between plans for Federal construction of such projects and plans for construction by private interests, the following points should be considered:

(a) The desirability of maintaining competing sources of power supply in the region, and the physical requirements of the competing systems.

(b) Relative incidental benefits to irrigation in the main valley from upstream power provided by public or private dams.

(c) The relation of the proposed project to other facilities in a program. For instance, where a given agency has built a key project, such as a storage or regulating reservoir required to make possible the best use of downstream or upstream power sites, it would seem logical for the same agency to develop such power sites. Because of the close operational relationship among some past private developments, a single license has been considered applicable to the storage project and the upstream or downstream sites.

(d) The relationship of the proposed project to the general objectives of the Federal river basin program.

(e) The degree of fuel conservation brought about. Either private or Federal use of a given hydroelectric site is, in general, equally effective in conserving fuel resources.

(f) Payment from power revenues for irrigation, taking into account any policy changes concerning reimbursement.

(g) The ultimate efficiency in use of the site under plans proposed by private interests as compared to the State or Federal Government.

In addition to the field of power, there also is a definite place for participation by private enterprise in all other phases of water resources use and control. These include especially the abatement of pollution (as by manufacturing industry) and in watershed management. Proper watershed treatment cannot be achieved without material assistance from land owners and operators.

Conclusions

Private citizens as individuals or as groups have played an important role in the past development of water resources. However, responsibility for future activity must rest more heavily with public agencies. The construction of the great multiple-purpose projects and interbasin diversions are clearly undertakings for Federal or State initiation. However, local public agencies and private groups appear to have places in future development of irrigation, hydroelectric power, watershed management, recreation, and pollution control. Future concern by local agencies and private initiative will relate to those local features which can be undertaken without conflict with multiple-purpose use or national power policy. This does not exclude local participation in essential parts of major undertakings.

The principal issue in further planning for this basin concerns the extent to which Federal and private agencies should participate in the electric power production in headwater areas. In these areas about 4.6 million kilowatts of hydroelectric generating capacity can ultimately be added.

From the more limited point of view of conserving energy resources, a decision might be reached in terms of the likelihood that private corporations would undertake specific projects under license at an earlier date than Federal agencies dependent on congressional appropriations. There is no certainty as to what the answer would be, for it would unquestionably be influenced by the extent to which Federal agencies came forward with sound plans. In general and over the Nation as a whole, production of hydroelectric power in recent years has proceeded more rapidly as a part of multiple-purpose river basin programs than was characteristic of the single-purpose private development era. This has not been the case generally in the Central Valley.

But there are broader considerations of the public interest which must be taken into account. They include the part which power will play in a well-rounded, multiple-purpose basin program offering irrigation benefits. Irrigation would not be financially feasible without the assistance of low-cost power for pumping. They also include consideration of the future importance of such projects as

components in the Federal wholesale power marketing system. Among other things this may afford local units of government, cooperatives, and private systems an alternative source of power if they believe it will better serve the public interest.

In general, unless there are strong public interest considerations to the contrary, including the relative efficiency of opposing plans, use of potential power sites rendered practicable by Federal reregulating or storage reservoir projects should be considered as integral parts of multiple-purpose projects for purposes of planning, construction, and operation. Where private agencies have constructed essential storage or reregulating reservoir projects for downstream power development, the construction at undeveloped power sites should be undertaken as integral parts of private projects, unless there are strong public interest considerations to the contrary. The latter may include the relative efficiency of opposing plans.

3. *Desirability or Handicap of Acreage Limitation Laws in Irrigation Developments.*

The Problem

The application of acreage limitation to farm units served by irrigation developments within the Central Valley.

The Situation

A basic policy of reclamation law has been the promotion of family-size farms. In that spirit, policy expressed in the 1902 Reclamation Act limits irrigable land holdings on projects to 160 acres for any one land owner. This has been construed to permit 320 irrigable acres to be held jointly by man and wife. The law also does not preclude combined farming endeavor by any number of owners, members of a family or otherwise, so long as each owns no more than the acreage limit for any one owner. In effect, therefore, farms considerably larger than 160 irrigated acres may be operated as units under reclamation law.

However, a family-size farm in reality does not always necessarily have to be as large as 160 acres. Soil, climate, market conditions, and other factors vary from place to place; certain crops or types of agriculture are better adapted to one locality than another. Most farms in the Central Valley have less than 160 irrigated acres, and the owners' families dependent on them maintain a reasonable standard of living. Therefore, the discussion below relates to family-size farms, whatever acreage that should be in a given area, rather than to a predetermined size or a given number of irrigated acres.

National policy has long recognized that family-size, owner-operated farms contribute greatly to the economic, social, and political stability of the country. They are, therefore, in the public interest. This has been stated or implied in various legislative acts, and is an important concept in current agricultural programs. Unlike other business enterprises where land is required merely as a site, in agriculture land is site, production plant, and home.

As the total area of farm or potential farm land is limited, opportunities to engage in agriculture are likewise limited. This limitation is intensified to the extent that individual holdings are low in number and large in size. Fortunately, except in local areas, this has not created any real problem in this country. But it will become a problem unless additional increments to our population can find a livelihood in nonagricultural pursuits.

A high efficiency of production has been a policy in agricultural programs in the United States. In the past the family-size farm was not entirely compatible with the most efficient production per worker. Most of the early power machinery for agriculture favored the large operator. Currently, however, farm machinery is being designed more and more for the family-size farm, thus contributing to more equal production efficiency. The family-size farm today is an efficient unit for agricultural production.

Within the Central Valley, where new lands are brought into cultivation and developed as farm units through Federal irrigation works, no particular problems will arise if the acreage limitation provisions of reclamation law are applied. The pattern of land holdings in the newly developed areas will be one of family-size farm units.

However, the principal irrigation development will provide supplemental water to existing irrigated farms rather than bring in new lands. This presents a problem of the application of acreage limitation provisions. The pattern of land holdings is already established in areas to be provided with supplemental water. Approximately 1 million acres of irrigable land in the San Joaquin Valley which can be served from the Central Valley Project and some future projects are in holdings exceeding 160 acres.

Approximately 265,000 of this million acres are reported to be held by three companies, and around 650,000 of the million are in 34 holdings of more than 5,000 acres each.

The concentration of such large areas of land in the hands of a few owners, and the resultant limitation on opportunities for owner-operated, family-size farms and attendant social benefits, are generally recognized to be not in the public interest. But the question to be faced is whether or not the acreage limitation of reclamation law is the solution. Contract arrangements for the sale of water were not concluded prior to project construction. If the large owners do not wish to comply with acreage limitations, and supplemental water is not made available to them, it is possible that they will make up their water deficit by pump irrigation, using water derived from the supplemental surface irrigation. On the other hand such pumping may be definitely limited by ground water shortages.

Application of reclamation law in those Central Valley areas where additional supplemental water supplies have already been developed thus is faced with difficulties. Other means of attaining objectives may have to be considered. The Tenant Purchase Program of the Department of Agriculture can be applied to financing the division of all or parts of surplus holdings which might be offered for sale. State legislation limiting the size of irrigated land holdings, especially by corporations, might be considered.

If developed water is to be made available to acreages above the legal limitation, the public interest should be protected by preventing any windfall or speculative advantage accruing to the owner. This could be done by making an additional charge for those increments of water received in addition to the acreage limitation base. Or the additional water can be charged for at a rate which would repay the Federal irrigation investment with interest.

A problem relating to ground water may develop in connection with application of the acreage limitation. With surface water supplies, the delivery of water to excess lands can be restricted without undue difficulty, but such is not the case with water used for ground water replenishment. Recent contracts between the Bureau of Reclamation and districts along the Friant-Kern Canal have permitted Central Valley Project water which is supplied to nonexcess lands and which unavoidably reached the underground strata of excess lands to be pumped by the owner of those lands.

Conclusions

The policy choice in this instance is not whether the family-size farm is desirable. That is considered an appropriate and just national objective, especially as the virtue of mechanization is now modified by the adaptation of farm machinery to family farm use. The promotion of family-size farms embodied in the reclamation law is in the national interest. No particular difficulties are expected in applying the acreage limitation law to new lands that may be developed by irrigation in the Central Valley. Furthermore most family-operated farms in the Central Valley today have less than 160 irrigated acres.

The policy choice rather relates to the rigid application of acreage limitation to already irrigated lands for which supplemental water becomes available through projects under construction. An unusual situation prevails at the present time in the Central Valley. Because of the location of irrigable land, and established water rights, some supplemental water supplies, as in the Kern River area, can be used only on certain large holdings. If strict acreage limitation immediately is insisted upon, one of two eventualities appears likely. Land purchase or new legislation will be required for the division of the large holdings, or the water will be wasted. Where water is in such short supply and great demand, waste of water cannot be countenanced.

The difficulties could have been avoided by insistence upon the signing of contracts before construction commenced. Since that was not done in this case the general recommendations of the Commission for this situation should be considered for the large holdings which stand to benefit from supplemental water. In this, the ultimate objective would be the creation of family-size farms within the holdings. For the time being, however, in order to make the best use of land resources and water in these areas, the water could be made available to entire units insofar as consistent with good irrigation practice.

If this is done, the public interest should be protected by preventing windfall or speculative values accruing to owners of land holding units in excess of family size. Such owners should be required to pay water charges to prevent such windfall or speculative advantages. Nontransferable utility-type contracts for such water should be for a period of years, subject to renewal or revision at the end of the period.

One consideration in renewal would be the local

need for additional farms. If such need exists, this would be taken into account when the time came to renew contracts. Other Federal programs, especially tenant purchase loans, should be geared to take advantage of opportunities to purchase from large holdings and create new farms that may be needed. Meanwhile, stimulus should be provided in every way possible for meeting the problem at the State level.

4. *Extent of Federal Government Concern with Pollution Control*

The Problem

The extent to which the Federal Government should be concerned with pollution control.

The Situation

Pollution can affect many water uses in the basin adversely. These include public water supply, irrigation, industrial water supply, recreation, navigation, hydroelectric power, commercial fishing, and wildlife. Approximately 60 percent of the water supply for irrigation comes from natural or regulated stream flow and the remaining 40 percent from 32,000 wells.

Control of both bacterial and mineral quality of these waters is important to agriculture. Crops produced in the Central Valley are so widely distributed that the use of contaminated water to irrigate vegetables and fruits, particularly if they are to be eaten raw, constitutes a health hazard to inhabitants of many cities and towns in the United States. High concentrations of certain mineral substances such as sodium and boron are harmful to plant growth and soils.

The worst pollution conditions occur in the Sacramento River immediately downstream from Sacramento, and in the San Joaquin River near Stockton. It is caused primarily by discharge of food-processing wastes. During the peak of the canning season the organic wastes from this processing industry create a drain on the oxygen supply of these streams.

Available data indicate that at least 73 new sewage and industrial waste treatment plants are needed, and that at least 55 existing treatment plants in the valley need improvements. The cost is roughly estimated at 30 million dollars.

In 1949 California revised existing water pollution laws and passed new legislation establishing a State Water Pollution Control Board and nine regional boards to coordinate the actions of the various State agencies and political subdivisions. Under the terms of this legislation State and local health officials are still empowered to order abatement of water pollution which creates a public health hazard.

Control of pollution that is not related to health hazards is vested in the nine regional boards, of which one has jurisdiction within the basin. These boards are empowered to make and enforce rulings as to water conditions to be maintained in all instances of water pollution, existing or threatened. The State Water Pollution Control Board advises regional boards, undertakes State-wide planning with the cooperation of regional boards, directs research, administers the State Water Pollution Control Fund, and acts as an appeal board.

The Water Pollution Control Act of 1948 has established a pattern of Federal cooperation with State water pollution control agencies. Assistance can be provided through technical advice, research on use and reuse of water, and loans for construction of pollution control facilities.

Conclusions

Because of the importance of water pollution control in connection with the maximum utilization of the water resources of the basin, the Federal Government should maintain an active interest in water pollution control. It is thought that for the Central Valley, California State agencies are generally capable of assuming the main responsibility for pollution control. However, the relation of State jurisdiction to Federal lands, like national parks, should be taken account of in agreements on this responsibility.

Pollution control activities by the Federal Government, accordingly, should fully test the effectiveness of cooperation with the State water pollution control agencies, as provided in the 1948 Water Pollution Control Act, through adequate provision for loans for treatment facilities.

5. *The Need for a Pooled Account in Power Planning and Administration*

The Problem

The pooling of costs and revenues of Federal power projects in a single account for purposes of power planning and administration.

The Situation

Power plants constructed in the Central Valley by the Bureau of Reclamation are considered as units in the Central Valley Project. Additional power facilities proposed by the Bureau are considered by it to be extensions of that project. For purposes of financial analysis and for rate making, the costs and revenues from all units in the plan would be combined into a single account.

For power plants at reservoir projects under Army control, the power will be marketed by the Secretary of the Interior under terms of the 1944 Flood Control Act.[3] That act provides that rate schedules will be drawn with regard for recovering the cost of producing and transmitting electric energy. This method is considered applicable generally on a project-by-project basis.

Power from both Bureau of Reclamation and Corps of Engineers projects will be marketed through a regional transmission network which makes segregation of power as to source impracticable. Establishment of rates on a nonuniform basis, as might result from separate consideration of the projects and their financial requirements, would be undesirable and would make accounting very difficult. Accomplishment of other phases of power planning and administration, such as the scheduling of new plants to supply load growth, budgeting of funds for operation and maintenance, and providing for modification or extension of facilities, will be facilitated if Federal hydroelectric projects are treated as parts of a single system in accordance with the regular practice of all utility systems.

Conclusions

For Federal hydroelectric projects constructed in the Central Valley, costs and revenues should be combined in a single account for rate making and other purposes.

6. *The Use of Power Revenues, Including the Interest Component, in Financing Irrigation Developments*

The Problem

The use of power revenues, including the interest component,[4] to pay for reimbursable irrigation costs.

[3] Act of December 22, 1944, § 5, 58 Stat. 887, 890, 16 U. S. C. 825s.

[4] By law interest must be included in the power rate for power produced by facilities on any Federal irrigation project. According to opinions of the Solicitor of the Department of the Interior, under present law, the interest component is assignable to the repayment of that part of the estimated project cost allocable to irrigation in the same project, and beyond the ability of the water users to pay.

The Situation

A repayment schedule was proposed by the Bureau of Reclamation for the Central Valley Project including the recommended but not yet authorized unit on the North Fork Kings River.[5] The total investment cost allocated to irrigation under this schedule is 286 million dollars, which would be repaid without interest. Of this 61 million dollars would be repaid by the water users. There would remain 225 million dollars which would be repaid in part from municipal water revenues ($18 million) and in part from power revenues ($207 million). This 207 million dollars would be provided as follows: 82 million dollars from the interest component on the power investment to be credited between 1945 and 1991, the period of amortization of the power investment; 125 million dollars from net power revenues (average 5.2 million dollars annually) after the completion of amortization on the power investment, to be paid between 1991 and 2015.[6] Repayment would be completed by 2015.

The calculations of repayment are based on production before 2015 of about 138 billion kilowatt hours of firm energy at 5.1 mills per kilowatt-hour, 20 billion kilowatt-hours of nonfirm energy at 3.3 mills per kilowatt-hour, and 40 billion kilowatt-hours of pumping power at 2.5 mills per kilowatt-hour.

The use of the interest component and power revenues for repayment of irrigation costs in the Central Valley presents a different problem from that encountered in the Columbia Basin. The prospective power development is much smaller, and the need for irrigation subsidy relative to the power investment is much higher. Thus, while the interest component would be large enough to care for all possible irrigation development in the Columbia Basin, this would not be the case in the Central Valley. There the interest component would have to be used during the power amortization period and the net power revenues thereafter for an additional 20 years to complete repayment of irrigation facilities.

[5] H. Doc. No. 537, 81st Cong., 2d sess. (1950).

[6] All years fiscal.

Assuming complete amortization of the power investment in 1991, and firm power sales amounting to about 2 billion kilowatt-hours per year, about 2.5 mills per kilowatt-hour, or roughly 50 percent of the 5.1-mill rate, would be required for an additional 20 years to meet the 125-million-dollar irrigation repayment. Presumably, therefore, the firm power rate after 1991 could be about 2.6 mills if no power revenues were used to repay irrigation work.[7] Power consumers in the Columbia Basin, however, would be under no such obligation.

It is to be noted further that a 5.1-mill firm energy rate, while much higher than rates possible in the Pacific Northwest, is not high for California. Sale of all energy producible from the Central Valley Project units, including the North Fork Kings River development,[8] can be considered certain at about the 5.1-mill rate.

Conclusions

The component of the firm energy rate from authorized and proposed Central Valley Federal power plants, after the investment in power facilities has been completely amortized, necessary to repay the project costs allocated to irrigation facilities, would be a significant part of the rate including the interest component. This would have elements of inequity when compared with the requirements in basins better endowed with low-cost hydroelectric resources.

However, in the interest of clarifying the issues, simplifying accounting procedure, and placing all forms of water development on a similar basis for planning, a change in Federal reimbursement policy is recommended, as suggested by the Commission.[9]

It is recommended that for the Central Valley, as elsewhere: (1) Payment should be required from direct beneficiaries of water projects, consonant with their ability to pay and in proportion to their share of benefits. For irrigation water users, as for power users, this might take the form of regular water rates. (2) Every effort should be made to identify all local beneficiaries of irrigation, as well as of other purposes. Responsible beneficiaries, from whom contributions may be sought, include:

(*a*) Water users, or their legally recognized governmental unit, such as an irrigation district.

(*b*) The State and its subdivisions, including counties or municipalities in the project area; and commercial interests, either directly or through a legally recognized governmental unit, such as a conservancy district.

7. *Reimbursability of Allocations for Fish and Wildlife and Recreation*

The Problem

Under what circumstances, if any, should costs incurred to provide for fish, wildlife, and recreation be considered nonreimbursable?

The Situation

Each year agricultural and industrial expansion brings about a further alteration in the valley's fish and wildlife habitat. Concurrently, interest in hunting and fishing is increasing. Hunting and fishing license sales in California have shown an unprecedented increase in the past decade. If California's population continues to increase, and economic activity continues at a relatively high level, the demand for recreation will also increase. Hunting and fishing are among California's most popular forms of outdoor recreation. To meet the growing demands for these sports, fish and game resources must be increased.

Similarly, participation in active recreational pursuits such as swimming and boating is increasing, but available facilities fall far short of the demand. Whenever a new reservoir is created, therefore, the demand for its use by recreationists is immediate and insistent. This problem has become especially acute where bodies of water suitable for recreation are limited.

The situation at Millerton Lake, behind Friant Dam, is illustrative. For 4 years the lake has been open to the public for boating, fishing, picnicking, and swimming. In spite of the unfortunate lack of facilities and the large drawdown, the lake attracts a yearly attendance of some 400,000 persons. Since 1945, only $40,000 has been spent on facilities.

According to the National Park Service, which presently administers the area, about 1.2 million dollars of public funds for physical improvements and $176,000 of private funds for concessions are still needed to bring the area up to acceptable standards.

A widespread recognition has grown recently as

[7] The above discussion assumes operation, maintenance, and replacement costs at approximately the same level used in the schedule mentioned above.

[8] As noted in H. Doc. 537, 81st Cong., 2d sess. (1950).

[9] See vol. 1, pp. 83–86.

to the need for providing the maximum possible facilities to permit adequate recreational use, including fish and game, in connection with Federal water projects. Although the need is recognized, a generally accepted method for financing the required improvements has not been devised.

The Forest Service during the 1930's constructed small dams at the lower end of many alpine lakes in the high Sierras with fixed small outlets to assure a minimum continuous flow in the streams draining the lakes and to prevent the drying of the streams during the late summer, as often happened. Sportsmen's organizations in the foothill communities did the work at many lakes under Forest Service supervision.

The question of financing fish and wildlife and recreational facilities in conjunction with Federal water projects involves three general situations:

(*a*) Costs are sometimes incurred to prevent loss and damage to fish and wildlife resources and possibly in some cases recreational values. An example of this is the Coleman Fisheries Station, constructed by the Bureau of Reclamation at a cost of 1.6 million dollars, one of the functions of which is to reduce salmon losses occasioned by construction of Shasta Dam.

(*b*) Benefits are sometimes obtained from enhancement of fish and wildlife and recreational values. In some instances such benefits will accrue incidentally from the construction of a project. An example is the case of Monticello Reservoir (Solano Project) in which the potential value of the fishery in the reservoir is greater than the fishery damage caused by the project. Another example is the improvement of upland game environment, as for pheasants, when an area is brought under irrigation. In other cases, however, it will be necessary to provide additional facilities in order to realize the benefits, as at Millerton Lake, discussed above, or at Folsom Reservoir. Frequently, the total benefits will exceed the cost of the additional facilities, in which case it might be found that a portion of the benefits could be considered attributable to the reservoir itself.

(*c*) Recreation in some instances may be established as one of the major project functions. There are no examples of Federal expenditures on this basis in the Central Valley, but in the adjoining Russian River Basin, a project has been authorized for construction by the Corps of Engineers which would be operated largely for recreation.

Conclusions

In the first situation, where costs are incurred in preventing losses to fish and wildlife, the Bureau of Reclamation under present law is able to consider them nonreimbursable. The Corps of Engineers has no legally defined responsibility in this regard, but its general practice has been to consider them regular project costs. If such costs are incurred on behalf of a flood control or navigation project, they would, in effect, be nonreimbursable, but if an allocation is made to irrigation or power, a portion of the fish and wildlife cost would become reimbursable.

There appears to be both logic and equity in considering the cost of preventing fish and wildlife losses as legitimate reimbursable project costs. Fish and wildlife might be considered an existing value or facility, similar to a farm or a road, for which compensation or replacement is necessary. However, in some cases it may not be physically possible to maintain fish and wildlife. In other cases the cost may far exceed the values that would be preserved. Judgment might be used in such instances in determining how far to go, and it may be necessary sometimes to consider the losses simply as a project detriment, to be subtracted from benefits in determining economic justification.

In the second situation, where fish and wildlife and recreational values are enhanced, and the prospective benefits equal or exceed the cost of the special facilities, their addition to the project may be considered justifiable. Any excess in the total amount of such benefits over the costs of the special facilities would be reasonably allocable to the joint costs of the reservoir or other works on the same basis as allocations to irrigation, power, flood control, and other purposes served by the joint facilities. The reimbursement of such allocations of cost for recreation and for fish and wildlife, with respect to both special and joint facilities, should be placed on the same basis as the reimbursement of costs allocated to comparable purposes. Inasmuch as the recreation and fish and wildlife benefits accrue to individuals within a wide segment of the population, it would be in accord with present practice to treat the entire allocation to such purposes as nonreimbursable.

If present policies, however, were modified to bring about reasonable and practicable reimbursement from identifiable beneficiaries, then return of a reasonable portion of the recreation and fish and wildlife allocations likewise might be sought. A

policy of free public access to public facilities would seem desirable, with reimbursement sought through devices such as increased concession fees, leases for appropriate private development, and the like.

Two special circumstances may be noted about allocations to fish and wildlife and recreation: (1) Although recreational opportunities at multiple-purpose reservoirs in the Central Valley are of less than national significance, certain of the facilities can be built, and most of them operated, by State, county, or local interests. Reservoirs in or adjacent to a national forest are exceptions, as the Forest Service would be the logical agency to manage those facilities; (2) the benefits from fish and wildlife and recreation are difficult to estimate; consequently, it is important that the benefit evaluations and especially allocations of joint costs be realistic.

In the third situation, establishment of recreation as a major project function, no proposals have been made to consider recreation for any Central Valley project. If such a situation should arise, it would probably be at the specific request of a locality and would be of particular benefit to that area, in which case the appropriate costs should be reimbursable.

Summary

(1) If fish and wildlife and recreational facilities are to be incorporated in plans for water programs, an accepted method of financing should be adopted.

(2) Despite certain current legislation permitting nonreimbursable allocations for costs incurred to prevent loss and damage to fish and wildlife, it would appear more logical and equitable to consider such costs as legitimate project costs, to be charged against the primary purposes for which the project was built.

(3) Costs should be allocated to fish and wildlife and recreation for enhancement of those values, including as appropriate both special single-purpose costs and allocation of joint facilities. Reimbursement of such joint allocations should be on the same basis as reimbursement of other single-purpose costs.

(4) States and local interests should assume their appropriate share of the responsibility for the facilities and management of fish and wildlife and recreation which are local in character.

(5) If recreation is established as one of the major project functions at the request of local interests, the costs should be reimbursable.

8. *Reimbursement to the Federal Government for Ground Water*

The Problem

At present the Federal Government is fully or in part repaid by the water users for the cost of irrigation facilities, through contracts with irrigation districts. Present practice cannot apply to water obtained from replenishment of underground storage, where anyone can obtain it by pumping, and under State law, would have a right to it.

The Situation

No method of reimbursement for replenishing ground water supplies made possible by Federal projects has been developed. For example, individual districts purchasing water from the Central Valley Project may find that after water enters the underground strata, it escapes from the district and benefits an adjacent area.

The seriousness of this problem varies with local situations. Generally speaking, water moves very slowly underground. If the contracting district is of reasonable size and lies over a ground water basin that is reasonably confined, the chances are that only relatively small quantities of water will escape. The amount of escape can be partially controlled by installing wells near the district boundaries, and this is presently practiced in a few areas. An individual district that is losing water on one side also may find that it is gaining water from another.

Under California law, the use of ground water is subject to the doctrine of correlative rights, which recognizes equal rights on the part of owners of overlying lands to the reasonable use of the water in the common underground basin. When the supply is insufficient for all, each is entitled to a fair and just proportion, which the court has the power to determine. Thus a means of controlling the excessive use of ground water exists.

However, such an apportionment of ground water has been made in only a limited number of cases in California, and in no known cases in the Central Valley. So far the proposed solution to overpumping in the Central Valley has been to import additional water for additional surface use and ground water replenishment, and in that way eliminate the overdraft. Present indications are that the ultimate water needs of the basin as a whole can be met by full development of the avail-

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able water resources within the basin and possibly, if necessary, through importations from the north coastal streams of California.

Problems have arisen as to how much water should be released from reservoirs in order to satisfy prior water rights which are dependent on ground water replenishment from the stream channel. The Solano Project is an example of this. Such problems often lead to considerable controversy because of the difficulty of determining how much water the ground water reservoir previously received from the stream, and the extent of ground water replenishment after the project is built. This is essentially a technical problem which must be met on an individual basis in local areas.

Conclusions

An appropriate solution of this problem might be through a Federal Government contract with the State or a legal subdivision of the State, such as a conservancy district, which can collect special ad valorem taxes, and turn them over to the Federal Government in payment for ground water recharge.

B. Conflicts in Beneficial Use

1. *Conflicts of Fishery, Wildlife, and Recreational Interests with Other Water Developments*

The Problem

Can fishery, wildlife, and recreational interests be made compatible with full use of water resources, and what principles should prevail in resolving conflicts?

The Situation

Water projects in the valley affect valuable fish and wildlife habitat. These projects are harmful where favorable habitat and spawning grounds are destroyed, when runs of anadromous fishes are prevented from reaching their spawning grounds, where fish and fish eggs are lost in irrigation and power diversions, and when the entire flows of rivers are diverted from their natural channels. They are harmful where some wildlife habitats are inundated, where marshes are drained, where drastic fluctuations in water level preclude the growth of aquatic foods for waterfowl, and where water exchanges damage or destroy existing limited waterfowl wintering habitat.

Water projects can be beneficial when they maintain larger summer flows in the natural stream channels and reduce water temperature downstream from the reservoirs. Fish may thrive under such conditions. Releases during critical periods can also benefit fish greatly. The fishery values of reservoirs themselves may or may not be equal in value to the stream habitat inundated by the reservoirs. Water projects can be beneficial by providing needed water to waterfowl refuge and management areas, by allocating some reservoir capacity to use for fish and wildlife, by manipulating water levels for their benefit, by planting appropriate plots and strips of food and cover for wildlife, by fencing select areas from livestock, and taking other desirable measures.

One of the important problems to be solved in maintaining fish and wildlife resources is that of providing water for their use. In many localities both reservoir releases to stream channels for fish and water for waterfowl areas can be provided from existing and proposed water projects without undue cost and without seriously jeopardizing other project functions. Elsewhere, particularly in the San Joaquin Valley where water supplies are limited, adequate water for fish and wildlife often can be provided only at great cost or by reducing irrigation or power benefits.

Furthermore, the California water code declares it "to be the established policy of the State that the use of water for domestic purposes is the highest use of water and that the next highest is for irrigation" (sec. 106). Any rights acquired for recreation and fish and wildlife will therefore have lower priority than irrigation requirements, and in cases of extreme water shortage the amount of water available to them may be curtailed.

No commonly accepted criteria have been developed for determining the extent to which water should be allocated to fish and wildlife in competition with other uses. Monetary evaluations of the relative worth of water for fish and wildlife as compared with irrigation are unsatisfactory, primarily because of the difficulty in making the evaluations on a comparable basis.

The problem of maintaining permanent pools for recreation purposes has appeared within the last few years. Past discussions between recreation and conservation interests suggest that serious conflict will not develop on reservoir projects where cyclic storage is the rule or where a minimum pool is to be

maintained for power production. However, a potential conflict is developing on certain reservoir projects (Pine Flat and Isabella in particular) where only seasonal storage is contemplated, and the reservoir will be emptied practically every year and sometimes will remain empty for extended periods. Agricultural interests desire to utilize the full reservoir capacity and all of the water supply for irrigation, on the grounds that one-half of the project cost was paid by the State and that they pay one-half of the cost of upkeep and operation. Recreation interests on the other hand desire the maintenance of a permanent pool.

Fishery interests have objected to the proposed Table Mountain Dam because of potential damage to salmon. If the dam were constructed, salmon would be excluded from some of the best spawning grounds in the upper Sacramento Basin. The State director of natural resources has also suggested that approval of the Yuba River projects be withheld until the Corps of Engineers has proven its interest and ability to care for migratory fish. The fish ladder on the Daguerre Dam is inadequate, and thus far no provision has been made to correct it. The State has also pointed out that rocky spillways like those at Keswick Dam should be avoided.

A frequent conflict in water development programs is that of marsh drainage and its effect on migratory waterfowl. Extensive areas of marshland have been reclaimed for agriculture. Much of the San Joaquin Valley and the rice-growing areas of the Sacramento Valley was formerly marshlands. Recently, in connection with the Yolo-Solano Project, some consideration was given to draining a portion of the Suisun marshes. The marsh area consists of about 43,000 acres, 10,000 of which are in State-owned wildlife-management areas. No definite recommendations for drainage of any of this marsh area have been advanced.

The problem of preserving fish and wildlife resources in many cases involves more than installing protective devices or modifying operational criteria on Federal water projects. For example, many small salmon migrating down the Sacramento River after the spawning season are lost through unscreened diversions. The responsibility of construction agencies to take appropriate measures for maintaining fishery values is generally recognized, but the fishery interests have an equal responsibility for seeing that the fish thus saved are not later destroyed or damaged through other circumstances. The same general principle applies to wildlife.

Conclusions

(1) If the fish and wildlife resources of the basin are to be safeguarded and perpetuated, steps must be taken to prevent harmful effects and to improve conditions where feasible, in order to offset adverse effects.

(2) Water control projects should, insofar as possible, be planned and operated in such a way as to provide maximum benefits for fish, wildlife, and recreational uses.

(3) Where construction projects would conflict with important fishery, wildlife, or recreation interests, the projects should be deferred as long as feasible and appropriate investigations made of possible alternative sites.

(4) State and local interests should recognize their responsibility, along with the Federal Government, to see that maximum fishery, waterfowl, and recreational values are obtained from water projects, and that fish and wildlife habitat is protected.

(5) Where conflicts between fishery or recreation use and other types of use cannot be resolved, the decision should be made on the basis of greatest beneficial use to the public.

2. *Principles for Planning and Construction of Facilities in Areas Previously Dedicated to Scenic Values*

The Problem

Where previously accepted scenic values, like those of national parks, are in conflict with use of water resources for other purposes, what principles should prevail in resolving such conflicts?

The Situation

Central Valley water projects are gradually pressing upon areas that because of their scenic or recreation values have been set aside for public enjoyment.

The problem of encroachment on scenic areas was an important issue some years ago in connection with the construction of the Hetch Hetchy Project within Yosemite National Park. The Hetch Hetchy Valley was held by many to have scenic values equal to Yosemite Valley, yet scenic values were held to be a lesser use, and the Hetch Hetchy facilities were constructed. Each year hundreds of thousands of people visit Yosemite Valley. If the Hetch Hetchy Valley had not been used for

reservoir purposes it could have afforded relief for the present unsatisfactory conditions in Yosemite.

Recently proposals have been made for the study and possible use of the power resources in Kings Canyon National Park. The Department of the Interior, in carrying out the law [10] and intent of Congress is opposed to encroachment by water projects in that park.

The preservation of primitive country for enjoyment of wilderness recreation is an established policy of the Forest Service in administering the national forests. Some of the better known of these wilderness areas are Kings River, Upper San Joaquin, Emigrant Basin, Desolation Valley, and South Warner Mountains.

Two threats to this program are presently beyond the control of the Forest Service or the Secretary of Agriculture. First, since those areas are in lands withdrawn from the public domain for national forest purposes, they are subject to mineral location under the mining laws. Second, water impoundments may be planned for national forest lands, including these wilderness areas.

Conclusions

A resolution of conflict between park and wilderness areas on the one hand and proposed water projects on the other is desirable. All factors involved at any location where a conflict develops should be studied. The study should include full consideration of alternative project locations, alternative opportunities for equal recreation and scenic attractions, and the possibility that reservoirs may not impair but may actually increase the recreational value of an area.

In general, the following principles are considered applicable to the Central Valley:

(1) Where the area has unique scenic, inspirational, or scientific values, it should not be adversely affected.

(2) Developments in conflict with scenic areas of a lesser order should be deferred as long as equally feasible alternative projects are at hand for the same use.

(3) The presence of a large and growing population, and the general physical attractiveness of the State for visitors, create needs which give an importance to social benefits of park and wilderness areas beyond that in most other regions.

(4) Mining laws should be revised to prevent mineral entry on public lands when such entry will be used for purposes that would destroy the public or scenic values of an area.

(5) Final determination of ultimate use should be on the basis of highest beneficial use.

[10] Act of March 4, 1940, 54 Stat. 41, 16 U. S. C. 80.

3. *Inundation of Facilities of Established Enterprises*

The Problem

Factors to be considered where proposed reservoirs would inundate valuable lands or established improvements.

The Situation

This problem arises in most water resources programs throughout the country. The Central Valley is no exception. However, the problem thus far has not caused serious difficulty in this region. The number of people involved is not great and their relocation usually is relatively simple. Some cases have been deferred for future reconsideration.

A typical case of the latter kind is illustrated by the authorized multiple-purpose Iron Canyon (Table Mountain) Project on the Sacramento River downstream from Shasta Dam. The reservoir would inundate a large area of agricultural land. Local interests are strongly opposed on the grounds that land inundation would reduce income to the area and at the same time increase taxes on adjacent lands. In view of this opposition, together with opposition from fishing interests, investigations were made to determine whether a combination of smaller reservoirs on tributary streams could be economically substituted for storage at the Iron Canyon site. It was found that the cost of equivalent storage on the tributaries would be considerably greater than the cost of Iron Canyon Reservoir, and would not be justified. However, a leveed bypass in upper Butte Basin would provide a considerable portion of the flood protection which would be provided by Iron Canyon Reservoir. This project now has been authorized for construction. As a result the Iron Canyon Project has been deferred.

Other examples of this problem are on the Tuolumne and Stanislaus Rivers, where reservoirs have been built by local irrigation districts for irrigation and power. On the basis of increased demands for water and power it appears that much greater reservoir storage capacities are justified on these streams than are now provided by the Don

Pedro and Melones Reservoirs. However, the most economical sites for such additional storage are at or very near the sites of the existing projects, and the authorized New Don Pedro and New Melones Reservoirs would inundate and render totally useless the existing dams.

It should be noted that the New Don Pedro Project is primarily a local interest project, with the Federal Government contributing financially on the basis of the flood control benefits to be provided. Although no express opposition to the inundation of these established enterprises has developed, the situation clearly points out the necessity for a thorough consideration of the positive and negative benefits involved.

In the investigation of reservoir sites on streams in the Central Valley other similar situations have arisen. The authorized New Hogan Project on the Calaveras River involves the same considerations as the New Don Pedro and New Melones Projects, although in this case the existing project is a single-purpose flood control reservoir built by Stockton. The proposed Monticello Reservoir on Putah Creek would inundate agricultural land and is objected to by some local interests for this reason. In some cases mineral resources have been involved in the consideration of reservoir sites, but these cases have not been very important. In the majority of reservoirs proposed for ultimate construction the lands to be inundated are relatively unimproved.

Reservoir projects sometimes have an adverse effect on land transportation facilities. Relocation of railroad lines may require costly bridges or less desirable alinement with increases in distance. Highway facilities also may present difficult problems. For example, the Terminus Reservoir will affect the Sequoia Park approach road. The new road will be much longer, and will have much more curvature and a lower design speed than the present road.

The San Luis Reservoir would flood part of State Route 10, a principal commercial route between San Joaquin Valley and lower San Francisco Bay area. This highway has two lanes but must be expanded soon. Grading for multilane construction on its original location would be a minor item, whereas relocation skirting the reservoir requires expensive support on hillsides or costly fills on the edge of the reservoir. The latter is characteristic of most forced relocations.

Thus an existing highway within a reservoir site occupies the location most favorable for present and future traffic needs. Relocation involves an alternative position less advantageous in obtaining desirable alinement and gradient standards, and adequate construction and maintenance provisions. In such cases, the State division of highways holds that wherever a State highway is affected by a water resources project the highway should be replaced by one of equal utility at no cost to the highway department. However, such replacement does not reimburse the highway agency for other costs added by relocation to future highway expansion.

Even though full compensation, including maintenance, could be arranged, the problem remains as to whether it is good economy to provide for reconstruction of the road to ultimate standards simultaneously with the relocation.

Land-managing agencies, such as the Forest Service, need to keep abreast of plans for water projects so that they may coordinate their transportation plans with those of the water-developing agencies. A coordinated road development program to serve all foreseeable needs such as recreation, timber access, power development, fire control, and the like is in the public interest.

Conclusions

The problems associated with the inundation of lands and improvements by reservoir impoundment in the Central Valley indicate the need for:

(1) As realistic an appraisal of the values of inundated properties as is possible. Such appraisals should take full account of the earning or producing power of lands and improvements.

(2) A sound estimate of the benefits from the project which would compensate for the losses to local activities.

(3) Attention to the desires and views of locally affected interests.

(4) The dissemination of full information on the objectives and future accomplishments of the project.

(5) Exploration of the desirability of requiring beneficiaries to reimburse local governments for taxes lost as a result of inundated properties.

(6) Recognition of the peculiar problems arising out of the forced relocation of highway and railroad facilities by bringing agencies with responsibilities for transportation facilities into planning for water resources at an early stage.

(7) Through investigation of alternative sites or means of accomplishing project purposes.

If these elements of controversy have been fully

taken into account there should be no serious difficulty in resolving them.

4. *Conflicts between Upstream and Downstream Interests*

The Problem

Resolution of conflicts between upstream and downstream water users.

The Situation

This problem relates principally to the use of the water resources for domestic and irrigation purposes, but also is concerned with the use of water for waste disposal.

In the Central Valley, the principal issue of the conflict has been expressed in terms of reserving water for beneficial use in the areas on which it originates, the so-called counties of origin. The California water code states a policy that a watershed or area in which water originates should not be deprived of the prior right to all of the water reasonably required for beneficial purposes in that area. In effect this code also says that these upstream areas are entitled to an adequate water supply in conformity with the State Water Plan. The accepted principle is that only surplus water can be exported. However, in many cases these areas of origin lie above the most economical reservoir sites, which are generally at the foothill line and which are used before more expensive upstream sites. Irrigation development on the valley floor has been more rapid than in the foothill and mountain areas for this reason, but upstream development also has been retarded because rainfall is greater and the land is sloping.

This foothill area, especially in the Mother Lode country on the west slope of the central Sierras, is particularly concerned. Here highly valuable deciduous fruits and vegetables can be grown in a cooler climate than is found in the valley. Although the Bureau of Reclamation estimated some 350,000 acres in the foothills, of which about 200,000 acres are currently irrigated, the State estimated an ultimate irrigation of some 1.6 million acres requiring over 2.5 million acre-feet of water. The State estimate was made "without test of economic feasibility." Presently irrigated lands in the foothill area obtain water through old placer mining ditches. Future irrigation there will be more costly because new ditches will be needed and reservoirs required to provide hold-over storage.

The recent congressional authorization of the Engle Act [11] tied the upstream Sly Park development to the Folsom Project, and added both units to the Central Valley Project. The Sly Park unit would provide a municipal water supply and irrigation water supply for about 7,350 acres in the foothills east of Folsom. Because the cost of this unit exceeds the repayment ability of the water users,[12] it is proposed to repay part of the cost of the Sly Park unit from Central Valley Project power revenues.

Another illustration is presented in the case of the proposed transfer of water from the Sacramento River Basin to the San Joaquin River Basin under the initial Central Valley Project. Such a transfer was proposed on the basis that the available water supply in the Sacramento Valley exceeds its ultimate requirements, leaving a surplus for the San Joaquin Valley. It was contemplated that Shasta Reservoir would be used partly to meet the needs of the Sacramento Valley but principally for the San Joaquin Valley, and that additional reservoirs would be constructed later to meet the full Sacramento Valley demands. However, recent irrigation development in the Sacramento Valley has been more rapid than was anticipated, and water users in this locality now are of the view that their present full demands should be met from Shasta and other reservoirs before any water is exported. The proposed importation of water from streams outside the basin, such as the Trinity, Klamath, and Eel Rivers, involves problems of the same type.

Conclusions

Procedures for estimating the ultimate beneficial needs of an area and allowing for such ultimate use in determining the amount of water available for export to other areas seem logical. However, such estimates necessarily have limited accuracy and must be accompanied by sound judgment, taking into account local conditions. Moreover, the opportunities for economical use of a limited water supply in either upstream or downstream areas should be weighed carefully in preparing plans for comprehensive use of water resources in the Central Valley.

State and other local interests appropriately can take an active part in these determinations, in view

[11] Act of October 14, 1949, § 2, 63 Stat. 852.

[12] Project benefits, however, are estimated by the Bureau of Reclamation to exceed project costs.

of the water right questions involved and the intrastate character of the problems. Proper attention to the timing of new water projects in accordance with demand also can assist. In attempting to solve these problems by including upstream projects in comprehensive plans, individual justification of each element of the plan should be required.

5. *Extent of Conflicts between and Associated with Domestic, Irrigation, Industrial, and Other Water Uses.*

The Problem

The extent to which various water uses conflict with one another.

The Situation

The high rate of pumping of ground water has lowered the water table in some areas, resulting in increased pumping costs for domestic, irrigation, and industrial ground water supplies. Overpumping of ground water for one use results eventually in an inadequate supply for other uses. Overpumping problems exist, particularly in the southern San Joaquin Valley, and these especially in the area south of the Kaweah River on the east side, and in western Fresno County on the west side. The water table has dropped in some areas approximately 300 feet in the last 30 years, and continues to drop about 10 feet a year.

The use of return irrigation water increases hardness and other dissolved mineral matter in the lower portions of the streams of the basin and thereby impairs the quality of water for domestic and industrial use available from these portions of the streams.

Placer mining and gold dredging operations have an adverse effect on recreational use of streams in the vicinity of mining operations because of sediment washed into the streams. Rivers affected are the upper and central Yuba and American and the lower Feather, Stanislaus, and Tuolumne. Increased turbidity reduces recreation values generally and has an especially adverse effect on sport fishing.

The city of San Francisco diverts a portion of the flow of the Tuolumne River from within the Yosemite National Park for municipal use and claims a right to 400 million gallons a day. The East Bay Municipal Utility District, including Oakland, Berkeley, and adjacent cities and communities, diverts water from the Mokelumne River and claims 200 million gallons per day. As these municipalities grow they are likely to need the full amount of their claims. The requirements of the cities and communities within the basin also are increasing and are likely to conflict with such use.

Use of the Sacramento River in the vicinity of Sacramento and the San Joaquin River at Stockton for the transportation of untreated or inadequately treated waste affects the quality of the downstream water for almost all other uses. Using coliform organisms as an index of pollution, surveys of these streams have shown excessive sewage organisms over 12 miles below these cities. Unless adequate waste treatment is provided this problem may become critical.

Conclusions

(1) Ground water resources in the basin should be protected from overdraft by State regulation and by the application of conservation measures. Research aimed at water reclamation, reuse, and ground water replenishment should be encouraged.

(2) Control of water pollution resulting from the discharge of inadequately treated municipal and industrial wastes, including placer mining debris, should proceed as rapidly as possible.

(3) The conflict between irrigation and domestic and industrial water use which results from water quality impairment in the lower streams as a consequence of return irrigation water is believed to be of only minor importance. While water quality for domestic and industrial use is made less satisfactory, it can be corrected by water treatment. Benefits derived from irrigation far exceed any increase in water treatment costs which are made necessary by irrigation usage.

6. *Placer Mining Activities in Relation to Water Resources Development*

The Problem

Measures, if any, required to control placer mining activities, and extent to which mining interests should participate financially in control works.

The Situation

The discovery of gold in California was primarily responsible for the early development of the State, and gold mining was a very important activity for many years. Quantities of gold existed in alluvial

deposits, or placers, and hydraulic mining methods were extensively used. The streams of the Central Valley supplied water required in the placer operation, and also carried away the waste gravels after the gold was removed. Huge quantities of debris were thus moved downstream, and were deposited in the channels and irrigation canals. Valley interests obtained injunctions in 1884 which prevented deposition of debris in stream channels because of damage to navigation and farming.

In 1893 Congress created the California Debris Commission, an organization under supervision of the Chief of Engineers, to permit resumption of hydraulic mining under regulated conditions. The functions of the Commission include administration, planning, inspection, and the issuance of permits, as well as construction of debris control projects. Six such projects have been authorized to date and four of these, the Daguerre Dam, Yuba River restraining barrier, Englebright Dam (Yuba River), and North Fork Dam (North Fork, American River) have been constructed. The two remaining authorized projects call for the construction of debris dams on the Middle Fork of the American River and on the Bear River. Because of changed conditions, these latter two projects will be reanalyzed. The four constructed projects are satisfactorily preventing hydraulic mining debris from passing into downstream channels where it would be detrimental to navigation, flood control, and other stream uses.

A problem has arisen as to repayment by mining interests for the services provided by the projects. Originally the legislation provided for collection of a 3-percent tax on the gross proceeds of each mine using the facilities. However, subsequent legislation substituted an annual tax per cubic yard of material mined, such tax to be determined on the basis of the capital cost (without interest) of each dam or other restraining works and the total storage capacity provided.

Hydraulic mining activities in California have materially declined in recent years because of unfavorable economic conditions and because of inadequate water supply. As a result, the amount of debris stored behind the Englebright and North Fork Dams, completed about 1940, is small, and mining interests have repaid very little of the cost of these structures. The projects have limited use for other purposes because of their small capacity and their location. The head created by Englebright Dam is used for power generation by the Pacific Gas & Electric Co. under license from the Federal Power Commission. The State paid one-half of the costs of the Daguerre Dam Project. If other structures are necessary, debris storage can be made a function of some multiple-purpose projects.

In numerous agricultural areas gold has been found in quantity sufficient to warrant dredge mining. In this operation old river wash material is dredged from as deep as 50 feet. In the process boulders and other rock materials are left on the surface, the soil completely disappearing. Great windrows of useless boulders and rock mark the destruction of the basic soil resource. In some cases these rock piles have been partially leveled and planted to fruit trees, but with indifferent success. It is estimated that 57,870 acres of land, of which 36,560 formerly had agricultural value, have been dredged in the basin. Considering the present plans for extending irrigation the once cultivable land lost may be as much as 38,000 acres.[13]

Conclusions

Damage to downstream channels from hydraulic mining activities in the Central Valley no longer is important. A large part of this formerly serious problem has been reduced by State and Federal regulation and by the construction of debris control projects.

However, a problem of recapturing the Federal investment for completed projects exists because of a decline in hydraulic mining operations in recent years. The contract terms practically preclude any solution. Future projects should be based on more realistic repayment arrangements, with mining interests at least sharing the risk of an idle investment. The possibility of combining projects for debris control with projects for other purposes should be fully considered.

The continued operation of gold-mining dredges is destroying some valuable agricultural land. Although the mining companies pay for such land it is questionable that in a region of such potential high agricultural development and productivity, the permanent withdrawal of such land from cropland agriculture uses is desirable land policy. In any event, the companies should be required to return the lands to a productive or beneficial use, including such uses as forest or pasture, where original conditions did not favor cropping. Consideration should be given to the requirement of

[13] Estimate of the U. S. Department of Agriculture.

bonds from the companies to accomplish these purposes.

Consideration also should be given to control of debris which was placed in stream channels by earlier uncontrolled mining operations, and is now moving slowly downstream as part of rivers' bed load.

7. *Mining Claims on Public Lands*

The Problem

Action required to prevent the validation of fraudulent mining claims on public lands.

The Situation

Fraudulent mining claims often are made on public lands. The real purpose of these claims is to acquire recreation sites at cascades, waterfalls, and the like and minor reservoir sites for watering livestock, and to obtain control and eventual land ownership. Legislation also has been sought allowing unrestricted location of claims in water power withdrawals.

The location of mining claims for nonmining purposes, even though such claims later may prove to be invalid, has been erroneously blamed on the mining industry. Because so much of the land in the basin contains some mineral value, it has been possible to push some mining claims through to patent even though the claimant had no interest in the mineral values and later did not use the land for mineral production.

Of 390 entries patented on national forest land in the basin over a 10-year period, only 120 actually produced minerals, and 71 were worked part-time, with little apparent mining interest. The remaining 199 entries can only be classified as fraudulent. They were used as follows: [14]

2—subdivided for summer homes.
29—timber cut, no further use.
25—commercial (resorts, stores, gas stations, etc.).
26—summer residences.
9—agricultural.
72—no use, some timber cut, property for sale.
36—miscellaneous (none associated with mining).

The area covered by the above entries varied from 20 to 1,968 acres; the total for all uses was 59,000 acres.

In addition there were 265,000 acres of "live" but unpatented mineral claims in the national forests of the basin, amounting to 3.4 percent of the total national forest area.

Of the claims patented in other years than the 390 discussed above, the following disposition is recorded: [14]

Type of development	Total number of entries	Entries worked after patent
Gold claims:		
Lode	158	89
Placer	216	79
Copper	7	4
Industrial minerals	46	13
Feldspar	4	0
Borax	4	0
Building stone	5	0
Limestone	10	3
Clay	10	0

The gold claims produced an average of about $53 worth per claim. In one year (1939), the gold production per acre was $5.48.

Conclusions

Inasmuch as provision is made in other laws for acquiring or leasing public lands for a number of purposes, there is no reason for misuse of the mining laws to obtain land for other purposes. Mining laws require revision in order to prevent such abuse and to promote sound resources use in the basin and in other parts of the Nation. Revisions in the laws also are necessary to protect and encourage sound and legitimate mineral development, using modern techniques in such manner as to be consistent with the best use of all natural resources.

8. *Extent to Which Flood Plain Zoning Is Practicable*

The Problem

The practicability of flood plain zoning in the valley to prevent flood damage.

The Situation [15]

Flood plain zoning is a measure for preventing flood damage through control of land use in areas

[14] Source: U. S. Forest Service.

[15] For a more extended discussion of flood plain zoning problems and possibilities see *Flood Plain Zoning*, California State Planning Board, 1942, 43 pp.

subject to flood. Its application may range through a wide variety of regulations, depending on the degree of the hazard and the probable use which might be made of the hazardous area if unrestricted. Minimum zoning regulations require only a notice of the flood danger. Where the hazard is great, zoning regulations may be applied to exclude buildings for residential or other uses, and all structures susceptible to flood damage. In some cases, zoning regulations may prescribe methods of building construction, and limitations on occupancy and use.

As the zoning principle is based on preserving the health, safety, and welfare of a community, its legality turns on the police powers of a local governmental unit, to preserve the welfare of its citizens. Zoning must be defined in such reasonable terms as may be necessary for that purpose in each locality where it is applied.

The primary advantage of flood plain zoning is its low initial cost as compared to the cost of positive flood protection methods. It also has the advantage of preventing slum types of building in areas where the recognized flood hazard precludes construction of a more substantial nature. Also it may be found of value to preserve areas for planned industrial or other higher type of use at the time such uses together with more positive flood protection become economically warranted.

An important use of zoning regulations is to prevent encroachments on stream channels and floodways. The selection of flood control capacity in a reservoir is based in part on the maximum release the downstream channels can carry with safety. A diversion dam or other obstruction could serve to decrease the channel capacity and impair the reservoir operation. Floodways riverward of a levee and providing local flood protection should remain unobstructed to carry the flood flows for which the levee heights were designed. Only flood easements are obtained in the majority of cases, and the right to plan structures in the floodway is not precluded unless clearly made a condition of the easement.

Fee-simple ownership of the floodway lands would prevent encroachments. Even under fee-simple ownership by a local agency, laxity or local pressure for a conflicting improvement may allow obstructions to be placed in a floodway. A requirement for establishing and enforcing local zoning regulations could be imposed as a condition of local cooperation in Federal water projects.

There are also possible losses from flood plain zoning. Among such losses are those due to exclusion of more intensive uses which, even after allowing for occasional damage or destruction by floods, may still yield a greater return than the most profitable use under zoning restrictions. The area which would seem a logical place for flood plain zoning restrictions is the Tulare Lake bed. Here periodic flooding from the Kings, Tule, Kaweah, and Kern Rivers has caused severe losses of agricultural crops and property. Nevertheless, the soil is so productive that farming is profitable in spite of the flood losses.

In cases where the most suitable use under zoning restrictions is not profitable to private enterprise, public purchase may be necessary where institutional obstacles stand in the way of profitable alternative uses; for example, where the area which should be zoned is suitable for agriculture but has been dedicated to urban development. Costs of administering the zoning laws must also be considered.

It is possible to evaluate the benefits and costs of a zoning program for comparison with the alternative of providing flood protection. The choice between the two methods of preventing flood damages then turns on the relative economic advantages with due regard for related intangible considerations. Zoning, unless combined with a program for evacuation by purchase, restricts future uses and will be most effective alone in a relatively unsettled area. Under certain conditions the combination of limited zoning regulations with partial flood protection might prove the most satisfactory solution of a flood problem.

The inadvisability of zoning Tulare Lake bed was mentioned above. It has been found worth while progressively to dike off large areas of the old lake bed and finally to provide measures for complete flood control. Another area which might be considered for application of flood plain zoning is along the American River east of Sacramento. Release for draw-down of Folsom Reservoir will cause periodic overflow in this area because of the limited natural channel capacity at that point. In this case, however, the demand for residential and industrial expansion at Sacramento will probably establish the advisability of protecting the overflow area by levees in order to permit its development and use for those purposes.

Conclusions

Flood plain zoning has possibilities in the valley as a means to prevent encroachment on stream channels and improved floodways. Other possi-

bilities for its use to prevent flood damages might be found, but in all such cases the desirability of employing zoning restrictions should be thoroughly established on the basis of their economic feasibility as compared with alternative measures.

9. *Conflict between Navigation Developments and Other Water Uses*

The Problem

The extent to which navigation conflicts with other water uses, and resolution of such conflicts.

The Situation

Some reaches of the Sacramento and San Joaquin Rivers have been extensively used for navigation, and many improvements for this purpose have been authorized from time to time. A ship channel for oceangoing vessels has been constructed to Stockton. A similar channel to Sacramento is under construction.

Most present navigation is within tidal waters and requires no extra water for operation. However, an authorized shallow draft project on the Sacramento River above Sacramento involves the operation of Shasta Reservoir to provide a minimum flow of 5,000 cubic feet a second for navigation purposes, and in the Central Valley Project about 18 million dollars has been allocated to navigation. A considerable portion of the water required in the Sacramento River for navigation can also be used to satisfy downstream requirements for irrigation and salinity repulsion. Comparatively little water is released exclusively for navigation.

Nevertheless, such water as is released for this purpose results in some reduction in the supply available for irrigation and municipal use. In view of this conflict, and of the greater total benefits which would result from using this water for irrigation, studies are now being made to determine if it is financially feasible for the irrigation and municipal water supply components of the Central Valley Project to carry the portion of the cost presently allocated to navigation. However, navigation could be continued without water loss to irrigation if a slack water channel were provided.

Federal water policy in the Western States has changed somewhat in recent years. It now recognizes domestic supplies and irrigation as higher uses than navigation. This policy was first stated in the Flood Control Act of 1944,[16] and is in general conformance with California water law.

One navigation project now under construction, the Sacramento Deep Water Ship Channel, may adversely affect salinity control in the Sacramento-San Joaquin Delta. Although the effect from the increased volume of the tidal prism caused by the new channel would be minor, studies have been undertaken to determine the advisability of compensating for the increased tidal prism by reclaiming inundated land in the delta region.

Another problem associated with navigation is the additional cost of bridges across the channels. These bridges must either be high enough to permit river traffic to pass under them or must be provided with movable spans. The cost of modifying existing bridges to provide for passage of boats is taken into account in comparing project costs and benefits and determining economic justification, but the increased cost of future bridges usually is not given full consideration. On the inland waterway above the junction of the San Joaquin and Sacramento Rivers, 41 bridges represent a total investment of over 17 million dollars, with about 4 million dollars of this necessary to obtain navigation clearance.

Conclusions

The conflict between navigation and other beneficial uses of water is secondary in the Central Valley. The conflicts which do arise can be resolved on the basis of determinations of relative benefits and costs, and in accordance with existing Federal and State water policies. Navigation, furthermore, is not entirely incompatible with maximum development of irrigation.

Closer coordination with local highway agencies would be desirable in planning navigation improvements so that the increased cost of future crossings of navigable waterways may be taken into account to the maximum practicable extent.

C. The Character of Development

1. *Basic Data Essential to Future Plans*

The Problem

The data essential for efficient planning, construction, and operation of water projects in the valley.

[16] Act of December 22, 1944, § 1, 58 Stat. 887.

The Situation

A realistic judgment on essential basic data needed in the Central Valley Basin must take into account the following phases: (1) requirements for preliminary investigations, (2) requirements for purposes of general survey investigations (general coverage), (3) data requisite for definite project investigations (specific coverage), and (4) data for construction and operation (which can appropriately be gathered in the course of those activities).

Data already available for the first and second phases have permitted the drafting of a comprehensive plan for physical development in the Central Valley from which initial units have been selected. Likewise, data have been generally adequate for the detailed planning and construction of existing projects, although additional data on surface water conditions will be necessary for other projects as they are developed. Ground water information is less adequate.

In general, the Central Valley is more adequately supplied with basic data than many other sections of the country. The long interest of the State in water programs has resulted in the accumulation of much information. However, to develop adequate plans for future specific projects the present program of data collection should be continued and expanded to insure that data will be available when needed.

The Subcommittees on Hydrology and on Sedimentation of the Federal Inter-Agency River Basin Committee have made a survey of the desires of various action agencies for additional data for all purposes in certain general areas, and have estimated the adequacy of existing measuring facilities. The results of this survey for the Central Valley are shown below:

Type of data:	*Adequacy of existing measuring facilities*[1] *(range of percent)*
Precipitation	41– 60
Evaporation	21–100
Snow courses	61–100
Ground water	6– 40
Stream gaging	41– 60
Chemical water quality	21– 60
Sediment load	0– 20
Reservoir sediment survey	41– 80

[1] Measured in terms of percentage of the estimated total required facilities for all purposes.

Topographic maps are available for nearly the entire Central Valley Basin, but many do not conform to modern standards. However, the present and proposed 10-year mapping program under way by the Geological Survey in cooperation with California and the mapping program of the Forest Service meet most needs of the basin. Adequate geological maps and information are available for only a small part of the basin.

Some sanitation studies have been made, particularly by State agencies. With the increasing population and industrial growth more extensive studies will be required.

Soil surveys and land classification surveys are available for practically all of the existing or potential agricultural land in the basin, but generally on a reconnaissance basis. More detailed surveys either are being made or will be required in specific areas as studies of potential projects progress. A number of agencies are already engaged in research on land management problems, and this work should be maintained and increased to meet situations which are likely to become more critical in the future.

A complete study of underground water storage possibilities of the upper San Joaquin Basin should be undertaken, covering the capacity of the gravels near the ground surface, as well as the deep aquifers. These aquifers should be studied with a view to replenishment, either locally or if necessary at some distance, and their source discovered.

Ground water recharge is a very important aspect of water use in the Central Valley. More information is needed on most efficient methods of adding to ground water supplies. Associated with ground water recharge is the problem of leaching of alkali salt accumulations. More needs to be known as to the best means of accomplishing recharge.

Maximum use of irrigation water requires more research on the time and rate of application of water for different crops, and on varying soil conditions, including drainage characteristics. Drainage conditions are of particular interest in relation to the Solano Project. It is possible that more precise criteria can be developed as a guide to farmers in the valley by more detailed study of those significant factors which, collectively, determine the degree of water requirement. In addition to the crop and soil, these factors would include such things as solar radiation, humidity, and temperature. Research of this type has been undertaken for some of the valuable orchard areas in California. The potential practical value of such guides to farmers, and the possible savings in water, warrant extensive study of this subject.

Although many data are available to guide watershed management programs, additional information is needed to meet special problems. For example, more information is needed about the best rotation and tillage practices to conserve crop residues and reduce runoff and erosion on the dry-farm grain lands of the basin.

Investigations of forest influences have been conducted on only a few of the combinations of climate, topography, and soil in the basin. These studies need to be extended and reinforced by studies of the effects of timber cutting and grazing on water resources. Studies also are needed to determine the best methods of converting brush lands to grazing.

Basic information on fish and wildlife has been collected for a number of years by both State and Federal agencies, but much remains to be learned, particularly on such subjects as the life cycle of the salmon, and the possibilities of maintaining fish life in fluctuating reservoirs. If fish and wildlife are to be preserved, more information is needed.

Conclusions

Basic data are more adequate in the Central Valley than in many other basins of the country. However, present programs for collection and interpretation can be profitably increased, so as to meet the needs of future stages of development. Basic data on the extent of the underground storage available for irrigation and other uses are needed for planning extensions to the irrigation system, and replenishing the supply.

Data should include the area and depth of the various sub-basins for underground storage and their boundaries, the quality of water of each, the movement of water in them, as well as the location and depth of any subsurface control. Among the other data worthy of particular attention in this basin are those relating to methods of applying irrigation water, and economic data indicating needed water resources program adjustments to social and economic trends.

Of prime importance in the Central Valley is more definite information on the loss of water through evaporation from various water surfaces—reservoirs, canals, and laterals. Such information is necessary for a sound approach to all problems of conserving the water. Also involved is the amount of transpiration from riparian water-consuming vegetation. These data are of critical concern in the valley.

2. *The Proper Rate for Future Construction of Facilities To Provide Water for Supplemental Irrigation, and New Land Development*

The Problem

Factors to be considered in planning the rate of development of additional Federal irrigation works.

The Situation

There are important regional considerations involved in arriving at a desirable rate for irrigation developments in the Central Valley Basin. Agriculture in the basin is of an intensive character, is highly developed, and represents a very large capital investment. Because rainfall is limited, irrigation is the primary foundation of the agriculture of the valley. This foundation must be protected not only to sustain agriculture, but also because agriculture is the most important element in the economy of the region. To the extent that it is dependent on diminishing supplies of ground water, the present agriculture of the basin is in jeopardy. This dependence on ground water is extensive, particularly in the San Joaquin Valley, and supplemental supplies of surface water are a necessity.

The regional situation justifies immediate developments to provide additional quantities of water to relieve the pressure on ground water supplies, to make more efficient use of the land resources already developed, and thus to protect the agricultural economy of the basin.

The need for bringing additional land under irrigation is less pressing than is the need for supplemental water. There is a large demand for farms and farming opportunities which will need to be met, to the extent feasible, in the years ahead. This demand is more intense in or near the Central Valley than in most other parts of the country. The Central Valley supplies large quantities of specialty crops (fruits and vegetables) to other regions. Moreover, California is deficient in dairy and meat products, and any further expansion of the dairy and livestock industries within the region will be dependent on irrigation.

The rate of additional irrigation development should not be based on agricultural considerations alone. Consideration should also be given to the fact that other uses for the water might result in greater benefits.

Conclusions

(1) The agriculture of the Central Valley depends on an adequate supply of irrigation water. Present supplies of surface water need to be augmented in order to relieve the pressure on ground water resources and to make more efficient use of the land resources already developed. Projects which would provide supplemental supplies to existing farming areas should, generally speaking, take priority over new land developments and should proceed rapidly.

(2) The large increase in population in and adjacent to the Central Valley has created heavy demands for land and farming opportunities. Regional needs for both farms and such foods as meat and dairy products justify further extension of irrigated land, possibly to the limit of the irrigable area in the Central Valley.

3. *Ground Water Replenishment*

The Problem

The extent to which problems associated with ground water replenishment affect water resources development in the Central Valley.

The Situation

Both ground water and surface water supplies are used extensively in the basin. Approximately 40 percent of the land now irrigated is supplied by water pumped from subsurface supplies, some for their total supply, and others for a supplemental supply when their rights to surface water are exhausted. This latter condition exists to some extent throughout the valley but diminishes toward the southern end of the San Joaquin Valley.

Replenishment of the underground water in general has been through natural means—the sinking of winter rains into the ground, percolation from stream beds, canals, and ditches, and percolation by irrigation and waste water. During recent years there has been some "spreading" of water during the nonirrigation season to replenish the underground reservoir. This has been done especially in the Kings River area, where all of the winter water is stored underground. In this storage most evaporation losses are avoided, the water is recovered easily, and the demand on summer surface supplies by those farms using the underground reservoirs reduced.

During the period from 1921–39 the depth to the underground water surface in the Tulare Basin lowered by 25 or more feet over about one-half of the area. In some localities in the Tulare Basin the water surface was lowered more than 100 feet. In other parts of the basin water levels have been lowered as much as 10 feet per year. Water levels of 200 to 500 feet below the surface are not uncommon, on the west side of the San Joaquin, and wells of 1,000 to 2,500 feet are needed. The total overdraft in the basin as a whole has been estimated to average 1.9 million acre-feet a year. Thus, over a period of 20 years an immense storage space, possibly enough for more than 40 million acre-feet of water, has been made available.

Ground water cannot be considered competitive with surface water. The two forms must supplement each other. The need for water is so great in the basin that full economical use must be made of both sources of supply, and the relative degree to which each should be used will depend on the necessity of the widest use of the limited water resource.

Evaporation is definitely a limiting factor that must be considered in connection with surface storage in an area of high evaporation losses. Where reservoirs must hold water over from wet periods to dry as in the Central Valley, where the deficient period is seven or more years, evaporation loss becomes a major consideration. Even with an evaporation estimate of about 1 million acre-feet a year, during the 10-year period required to fill and hold the water to provide for periods of drought, the loss would be 10 million acre-feet or more, or a half year's supply for the whole valley.

The capitalized value of the water lost by evaporation may well be large and indicates that serious thought should be given to any feasible means of preventing such loss. One means of reducing the loss is through use of underground reservoirs.

The ground water storage capacity in the basin within economical pumping distance is at least equal to and may exceed the total potential surface storage capacity available in the basin. In those parts of the basin where good aquifers exist the underground reservoirs are the best storage because there are no evaporation losses from them. However, water removed from the underground basins must be replaced. If it is not replaced the supply will eventually be depleted, or the ground water level will be lowered to such an extent that it is not economically feasible to continue pumping. In

areas where this has occurred, as in several localities of the San Joaquin, irrigated farming has failed.

The maintenance of ground water as a firm source of supply depends on obtaining, over a period of years, as much replenishment as there is withdrawal. Various means of replenishment are available. Water can be stored temporarily in surface reservoirs, and then later released to the stream channels for underground storage where the ground will absorb it. For example, water stored in Friant Reservoir is now being released from the Madera Canal into various stream channels and sloughs for ground water replenishment. In this way, these channels, which previously served as sources of recharge only during the winter months when natural flow was available, are now made to function continuously, using water stored in Friant Reservoir.

It is the practice of the Kern County Land Co., which controls the use of a major portion of the Kern River supply, to use surface water in conjunction with ground water supplies. If it finds that in one area ground water is becoming relatively high compared to another area, a greater portion of the surface supply is diverted to the latter area, in order to build up the ground water storage. This shifting of water may become desirable in other areas.

The use of artificial percolation areas is common in some areas, particularly in southern California. Such areas have been used to a certain extent in the Central Valley, even though the opportunities are not so favorable. The method is being given further consideration.

The technical problems associated with ground water replenishment are important to the future of the Central Valley. Study of the problem is now under way, but the program should be expandcd substantially. There are very few data on the full capacity of the underground reservoir, its depth, or any barriers that might divide the basin into subbasins. Little is known about the possibilities in the Sacramento or on west side San Joaquin. The whole underground situation needs study, as the full utilization of these storage possibilities may have a profound influence on the conservation of the water resources and the best and maximum utilization of the land.

There have been differences of opinion as to the relative degree to which ground water and surface supplies should be used. In one case (Solano Project) some local interests were of the view that the proposed reservoir was too large and that it should be reduced in size and greater use made of ground water. In another case (Cache Creek) local interests are in disagreement as to the extent to which surface reservoirs should be operated for surface irrigation as opposed to ground water replenishment. These are local problems and must be solved individually on the basis of local conditions which vary widely throughout the basin. To meet the ultimate water needs of the valley and the San Francisco Bay area, maximum use must be made of both surface and ground water.

Some deep pumping has been developed, taking water from great depths, especially in the western part of the basin south of Bakersfield. This deep pumping has tapped some aquifers which either are trapped or originate in distant areas. The importance of this supply and the manner of its replenishment are not now known.

Conclusions

Ground water resources are used independently and in conjunction with surface water supplies in the Central Valley to a much greater extent than in many other regions. Both ground water and surface water resources must be developed and utilized to the maximum feasible extent in order to meet the probable ultimate water needs of the basin.

The use of the storage capacity of underground reservoirs is one of the important conservation possibilities in the valley. Potential reservoir evaporation adds a cogent reason for as complete use of underground storage as is compatible with comprehensive multiple-purpose development. The possibility of replenishment should be explored more fully as soon as possible, and full knowledge should be obtained as to all the characteristics and limitations of underground storage possibilities. Such knowledge should be available in planning for the full use and conservation of water resources.

These studies also should include the possibilities of assuring the movement of water from the basin to remove toxic salts.

A study should also be made of the value of the deep aquifers as a water supply.

All of these studies are proposed by the Geological Survey, and they should receive every assistance to the end that the studies can be completed within a few years.

4. *Land Treatment Programs in Plans for Water Resources Development*

The Problem

Erosion control measures, forestry activities, and related land treatment measures essential to complete water resources development of the valley.

The Situation

Land treatment is lagging far behind other types of water resources development in the Central Valley. Land treatment programs are proceeding at a slower pace in the Central Valley than in most other parts of the country. For example, while soil conservation districts have been organized to include over three-fourths of the farms and ranches of the Nation as a whole, only about 10 percent of the farms and ranches of the Central Valley are included in soil conservation districts. This is true even though soil productivity is deteriorating on over half of the 7 million acres of cultivated land.

Improvements in the manner of distributing and applying water are needed in many irrigated areas. These would provide protection against soil deterioration and would contribute to more efficient use of water.

Of almost equal concern is the situation on the 8 million acres of brush and open range lands. Public domain lands and many private range lands have been so overgrazed in the San Joaquin that dust storms in dry years have stopped traffic on some major highways, and sand deposits have blocked some side roads. The lower slopes and foothill valleys of the west side of both the Sacramento and San Joaquin have been destructively grazed.

In the Paskenta district gullies have added greatly to the sediments which farmers must remove from ditches. At flood times the sediment is flushed into the Sacramento. Recently, fire is being used annually on about 80,000 acres of grazing land scattered throughout the basin in an effort to convert the cover to grass. Soils, particularly the thin ones, will suffer severely from this effort.

In many high mountain meadows, overgrazing has caused serious gully erosion. This destroys the value of these excellent grazing areas, since worthless brush often replaces the lush grasses as the water table is lowered. Great quantities of eroded material from these meadows are poured into the stream channels.

The Central Valley area has a deer herd now numbering about 600,000 animals. In certain areas, these animals are in direct competition with livestock for available feed on the range. There are at present seven areas [17] where big-game grazing is creating watershed problems. Although steps have been taken toward better game management, the number of areas affected may increase until direct measures for reducing herds are adopted.

Logging practices on the 4 million acres of commercial timber stands in the national forests are generally better than on the 3 million acres of nonpublic land, but on both too little attention is currently paid to methods that would reduce erosion. Skidways and roads are a primary source of damaging erosion, and practically no efforts are being made to prevent or heal the scars. Current practices on national forest timber sales require the logger to restore the cut-over land to as nearly normal condition as possible upon completion of the logging operation. Local control is not so effective on the private lands, of which only about 25 percent is considered adequate from a watershed protection standpoint.

Forest fires have resulted in damage to the water resources and to water improvements. In one instance several years ago a 17,000-acre fire in the Upper San Joaquin disabled a powerhouse until the sediment and debris at the intake and in the tunnel could be sluiced downstream.

Nearly 600,000 acres of forest land at present require planting, of which about a third should be reforested to restore good watershed conditions. About half of this total is on public lands. Some 250,000 acres of privately owned watershed lands are thought to be in a critical condition because they are destructively logged and badly burned. A smaller acreage of lands needing attention is that in old mine workings, especially those ruined by placer mining. These now virtually worthless lands are so located as to be a menace to good water conditions.

One objective of watershed management in the water-producing areas of the basin is to provide protection to soils and channels so as to minimize surface runoff and erosion on slopes and flood peaks in the streams. Another objective is to manage the timber, chaparral, and grasslands in such way that they will yield the maximum amounts of usable and regulated water. Further research is needed to show how much safe water yield can be increased by watershed management practices.

[17] E. g., adjacent to Yosemite, at the southern end of the Coast Range, and in the Yuba River and Modoc areas.

None of the watershed management programs in prospect in the water-producing areas at present includes practices to increase water yields or to reduce water losses. Few land use measures have been put into effect specifically to increase the accretion of ground water.

Many of the roads, especially the minor ones, are contributors to poor water conditions. Because of their design, they are a source of considerable sediment pollution, and often are a source of damaging sediments.

Conclusions

Land treatment programs in the Central Valley are lagging behind other forms of water resources conservation. A basin-wide watershed treatment program is needed to maintain the full productivity of the soil resources as well as to contribute to more stable stream flow, reduce sedimentation, and provide for more efficient use of water.

Such a program would include adjustments in land use in accordance with the capabilities of the land; the application of conservation measures; more adequate range and forest management; better forest fire control; an effective program of wildlife management; adoption of a watershed management plan to insure adequate cover on depleted lands and higher water yields; greater attention to care of cut banks, care of slopes, drainage, and other aspects of road construction; and the public acquisition and proper management of some 250,000 acres of watershed lands which because of location, character of topography and soil, and past damage are a liability to the water resources of the basin. A reduction in watershed damage can be obtained by making water resources developments dependent upon State and local participation in the restoration and maintenance of good watershed conditions. State and local interests should also take definite action to permit the reduction of the deer herd to the safe carrying capacity of the forage, and to maintain the game in proper balance with its environment.

5. *Rate of Construction and Integrated Operation of Electric Power Facilities*

The Problem

The proper rate of future power development, and the extent to which it is desirable to integrate and coordinate the operation of electric power generation and transmission facilities and to provide adequate interconnections with the transmission facilities of adjacent areas.

The Situation

Local interests have developed a highly integrated electric power system. This system is composed of many hydroelectric and fuel-electric generating plants, a transmission network, and distribution facilities. Hydroelectric plants presently provide approximately two-thirds of the total installed capacity in the area. Steam-electric plants, which supply the remaining capacity, are used principally to firm the hydroelectric capacity during dry periods. Most hydroelectric plants are single-purpose projects.

During the last 30 years, a number of hydroelectric plants have been constructed in connection with dual-purpose or multiple-purpose projects. The power output of such plants is usually subordinated to other purposes. The first such hydroelectric plant was completed in 1922 at the Don Pedro Storage Dam on Tuolumne River. The reservoir is operated by local interests primarily for irrigation purposes.

The Federal Government is now engaged in constructing and operating a number of projects which are major elements in a comprehensive plan for the further control, conservation, and use of the basin's water resources. Hydroelectric power will be generated at most multiple-purpose reservoirs.

The demand for electric energy for industrial use, irrigation pumping, and other purposes is increasing rapidly. Preliminary estimates of load indicate that the peak demand on systems in the area will increase from the 2.2 million kilowatts reached in 1949 to about 5.7 million kilowatts by 1970. Additional generating capacity will be required as needs increase. National security considerations also require an adequate power supply for industries and defense installations.

To conserve fuel resources, which may be in particularly short supply in times of national emergency, it is desirable that as much as possible of the future power supply be provided by hydroelectric installations. Because the river flows do not sustain a high hydroelectric output, part of the future supply must be provided by steam-electric plants, to permit most economical operation of the power system.

Integration and operation of all major power facilities, both Federal and non-Federal, in a single

system is desirable for reasons of national defense as well as regional development provided the private systems cooperate fully in accomplishing the objective of Federal power policy. The coordinated operation of facilities would take advantage of diversities in types of load and plant outputs, thereby firming plant capacities.

The technique of coordinated operation of a region-wide power pool, involving the hydraulic and power facilities of 10 different agencies—Federal and non-Federal—has been successfully developed in the Pacific Northwest in both peace and war. In general, the basic principles involved in the Northwest Power Pool operations would be applicable in the Central Valley.

Coordination for the Central Valley would have to provide for flood control, irrigation, power, fish and wildlife, and related purposes. It also should provide for established water rights, contractual commitments of various kinds insofar as releases of water are concerned, and for power service to preferential customers from Federal projects through wheeling [18] or other arrangements. The plan should be flexible and capable of being readily adjusted to meet changing conditions and requirements.

Conclusions

(1) The rapidly growing load in the area and considerations of national defense require additional generating capacity in advance of actual need.

(2) To the extent practicable, consistent with the maintenance of the proper ratio of steam to hydro for the most economical system operation, future additions of capacity in the area should be provided by hydroelectric plants for both conservation and national security.

(3) The power generation and transmission facilities of the valley and adjoining areas should be integrated and operated as a unified system, including both Federal and non-Federal facilities under contracts assuring public and cooperative systems a preferential right to Federal power supplies and low rates for irrigation pumping.

(4) A coordinated basin-wide plan of operation of a Central Valley Power Pool, including interconnections with adjacent areas, should be prepared with full consideration of all operating requirements of hydraulic facilities for purposes other than power.

[18] Transmission over its lines by one agency of electric energy produced by another agency.

6. *Facilities for Future National Defense Needs*

The Problem

The place of national defense in plans for future water resources development in the Central Valley.

The Situation

Many new industries were developed in California during World War II which are of continuing importance to national defense. Principal among them are the aircraft, shipbuilding, and related industries. It is expected that the growth and expansion of industry will continue, particularly in southern California and the San Francisco Bay area.

Although the majority of these industries are outside the Central Valley, water resources development in the valley is directly related to their operation and therefore to national defense for the following reasons:

(*a*) Hydroelectric power which Central Valley projects can furnish is needed by strategic industries in the San Francisco Bay area.

(*b*) Water supplies are needed in the bay area for domestic and industrial use. These can best be supplied from the Central Valley.

(*c*) Full irrigation development in the Central Valley would contribute to greater self-sufficiency in the regional food supply and thereby free transportation facilities for other vital uses.

(*d*) Navigation can provide supplementary transportation of defense materials, food, and the products of mines and forests.

(*e*) Flood control reduces damages to established municipal, agricultural, and industrial facilities in the valley, and thereby promotes stability of production.

Conclusions

(1) Because of the vital importance of Central Valley water projects to strategic industry, food supply, and domestic water in the San Francisco Bay area, the program should proceed promptly, with account being taken of the bay area's needs.

Attention should be given to the possibility of decentralizing industrial concentrations in the bay region, making use of sites as well as resources within the valley. Future water projects, wherever possible, should be so designed as to encourage such decentralization, particularly for new construction.

Waterway improvements in particular are significant in such encouragement.

(2) Attention should be given to the danger of sabotage or destruction of water supplies from the Central Valley to the bay area; preventive measures should be taken promptly.

(3) Attention should be given to the possible power needs of the Los Angeles industrial area, and the relation of Central Valley resources to them.

(4) Because of the national interest in these matters, Federal agencies concerned with water development should consider it their obligation to assist in planning for strategic needs.

7. *Uniform Policy on Providing Recreation Facilities in Reservoir Areas*

The Problem

Should recreation be considered an objective in Federal reservoir developments, and if so, should there be a uniform policy in providing recreation facilities?

The Situation

There is a definite need for additional outdoor recreational use of Federal multiple-purpose reservoirs. Experience at Shasta and Millerton Lakes and other reservoirs clearly indicates that recreational use will be made of such reservoirs, despite lack of adequate facilities and the objectionable drawdown of reservoir levels. These recreation values would be enhanced if plans were made for the fullest possible use of the recreational opportunities. As the recreational use in general is of less than national significance, investments in such facilities should be made to a large extent by State and local interests. One of the interests of the Federal Government in recreation is to avoid undue conflicts with other project functions. Under most circumstances it should provide basic facilities like land, roads, and water supply.

At present there is lack of uniformity in legislation pertaining to recreation at Federal reservoirs. The Corps of Engineers has authority to construct, operate, and maintain recreation facilities or to permit such activities at its reservoir projects. The Bureau of Reclamation does not have such general authority. This inconsistency is particularly noticeable in the Central Valley, where both the Corps and the Bureau are building water projects.

Conclusions

There is a need for additional recreation facilities in the Central Valley. This could be met in part by appropriate developments at Federal multiple-purpose reservoirs, including acquiring desirable land adjacent to the reservoirs. Most improvements can be provided by local interests. Their installation would be facilitated if recreation were recognized as an important objective of Federal water programs in the authorizing legislation. Uniform legislation applying to construction agencies should be adopted.

8. *Extent to Which Fish and Wildlife Programs Should Be Included in Planning for Water Resources Development*

The Problem

The extent to which basin-wide investigations of means of maintaining and enhancing fish and wildlife resources should be included in planning for water resources use.

The Situation

Fish and waterfowl, as well as some other forms of wildlife, constitute a resource of economic and recreational value. Maintenance and enhancement of this resource is intimately related to the construction of multiple-purpose projects. Reservoirs and dams may be so constructed and managed as either to maintain and enhance this resource or unnecessarily impair or destroy it.

Until recently it appears to have been the general practice to attempt to integrate the fish and wildlife program into multiple-purpose projects after project construction had begun. However, to be effective, integration should be undertaken from the earliest possible stage in the planning process. To be effective it is essential, also, that the construction agency be furnished reliable basic data on all phases of fish and wildlife, including habits and essential environment. This would permit preparing plans for the proper sequence of dam construction, types of fish ladders to be used, and spillways of proper design. Because such data were not available, State approval of the construction of both Iron Canyon and Table Mountain Dams has been withheld, and approval of work on the Yuba River is held in abeyance.

Some of these studies are in progress.

Unscreened pumping plants and canals along the Sacramento River divert small salmon in numbers during downstream migration from the river to irrigated land. State laws designed to prevent this appear to be ineffective.

Wildfowl habitats in the Sacramento and San Joaquin Valleys have been lost as agriculture has taken over large areas of former feeding and resting areas. If the species formerly using these areas are to be maintained in quantity, wildfowl refuges and shooting areas are needed. To satisfy this need, over 1,000 second-feet of water will be required for the purpose. Plans for water use should therefore take into account these requirements. Provision of waterfowl refuges and shooting areas on the Pacific flyway can help to alleviate crop depredations that result from restricted and inadequate habitat. These depredations are estimated to have reached a peak of a million dollars in 1943. Feeding areas, provided later, have reduced this damage.

The State is prepared to establish additional waterfowl management areas but because of objections in some farming areas it appears to be difficult to agree upon sites.

Conclusions

The adverse effects of water projects on fish and wildlife resources in the Central Valley heretofore have been considered generally on a project-by-project basis as individual problems have arisen. A more logical procedure would be the development of a comprehensive plan for the preservation and enhancement of fish and wildlife values which would be developed as part of a comprehensive multiple-purpose water resources program for the basin.

9. *Measures for Mosquito Control*

The Problem

The effect of proposed water regulation and use programs on the mosquito problem.

The Situation

The development of water control and use programs in the Central Valley Basin has been extensive during the past half century. Current development and planning are for an increased rate in this development.

Important as is the elimination or control of mosquitoes in connection with water projects, measures to accomplish this frequently have been undertaken only after completion of the projects. By that time, mosquitoes may have become a nuisance and a danger.

Measures to destroy mosquitoes and their breeding places are available. If this knowledge is applied and adequate controls incorporated in the original plans for the project, many of the problems that now arise after the project is built will be less serious or will not occur at all.

Water surfaces which may create mosquito habitat in the valley have increased continuously during the last two decades. During the critical water years 1927–34 an average of a little less than 3 million acres were irrigated annually in the Central Valley. This is only 45 percent of the total irrigable area of the basin. The average annual increase during the next decade amounted to about 67,000 acres per year. The presently authorized Federal Central Valley Project, excepting the American River service area, includes water supplies sufficient for about 550,000 acres of new land and 500,000 acres in need of supplemental supply. This development is expected to be nearly complete by June 30, 1956, and is scheduled for completion at the rate of about 80,000 acres (maximum) a year.

Mosquito control measures are not keeping pace with water control and use programs.

The 32 organized mosquito abatement agencies within the basin derive their income from taxes, but they are not prepared financially to cope with an ever-growing increase in mosquito control requirements. They now serve a little more than 10 million acres or about 27 percent of the area contained within the drainage basin.

Conclusion

The need for mosquito control should receive early recognition in Central Valley water planning. Adequate participation by specialists in this field in the planning, design, construction, and operation of water control projects of any size should be provided. It is essential first to know precisely what should be done to protect public health in the area, and then to take necessary preventive measures.

10. *Extent to Which Engineering and Design of Major Works Should Take Account of All Probable Future Water Needs*

The Problem

The extent to which dams and other major engineering works should be designed to meet future water needs.

The Situation

Estimates of future water requirements for irrigation, domestic and industrial supply, power, and other purposes recently have been revised upward. Moreover, additional flood protection has been found warranted in many suburban areas as a result of population increases.

The correct procedure for considering these future needs is first to estimate them on the most realistic basis possible, and then to provide for them in the planning, design, and construction stages in accordance with best engineering and economic practices. Some of the particular problems which have been encountered in the Central Valley are:

Two-step versus one-step construction of dams.—The question here is: Where it is known that a reservoir site ultimately should be built to its practicable limit, but need for its full capability does not presently exist, should a low dam be constructed initially with provisions for future raising, or should the dam be built to ultimate height? The question arose, for example, in connection with the Folsom Project on American River, where it was concluded that provision of the maximum practicable capacity of 1 million acre-feet in one step would be the most economical procedure. Two-step construction also was considered for the Table Mountain and Monticello Projects. The Hetch Hetchy Dam on the Tuolumne River was constructed by San Francisco in two steps, the initial reservoir capacity being 206,000 acre-feet, and the ultimate capacity 360,000 acre-feet.

Installation of penstocks and other features for probable future power generation in dams presently under construction.—Such action is logical engineering practice. Penstocks are being provided, for example, at the Pine Flat Dam for future power installation.

Provision for future irrigation needs.—Should special irrigation outlets be provided at reservoirs under construction for future needs, or should these facilities await the need, at which time their installation would be much more costly? Irrigation outlets are being provided at all multiple-purpose projects designed for future irrigation demands. However, a special outlet for a future high level canal from Folsom Reservoir was considered, but for economic reasons was not incorporated.

Design of flood control works.—To what extent should the design of levees take into account future upstream reservoir storage? Such coordinated design is good engineering practice. An example occurs in the Cache Creek flood control project, where levees will be designed to provide needed local flood protection in conjunction with a future upstream reservoir at the Indian Valley site, or some alternative.

Use of adjacent reservoir sites.—What consideration should be given in the design of dams and reservoirs to prevent foreclosure of future use of adjacent sites? This problem was encountered in the Iron Canyon Project where the dam site was moved downstream after project authorization, so as not to preclude use of the original site (Table Mountain) for a much larger storage capacity than presently is authorized.

Conclusions

The design of major engineering works for the development of the water resources of the Central Valley, as in all river basins, should give full consideration to all probable future water needs and provide the most economical and practicable methods for meeting those needs. The problems involved are primarily in the fields of engineering and economics. In the valley such consideration is especially important because all available forecasts suggest an almost certain need for full development of water resources in the basin for all purposes. Water may eventually even have to be imported from other basins. Plans of the several agencies indicate an awareness of these needs. However, more complete data should be made available, particularly on economic trends and strategic industrial needs, so as to permit planning with the desired accuracy.

11. *Interbasin Diversions of Water into and out of the Central Valley*

The Problem

The extent to which interbasin diversions of water into and out of the Central Valley may be required as a part of the ultimate plan.

The Situation

Two studies have been made of the possible annual net use of water in the Central Valley: one by the State, included in the report on the State Water Plan; the other by the Bureau of Reclamation, presented in its report.[19] They are abstracted as follows:

Type of use	Bureau of Reclamation	State
	Acre-feet	*Acre-feet*
Irrigation	16, 600, 000	19, 287, 000
Domestic, industrial, and miscellaneous uses	550, 000	.....
Salinity control	2, 400, 000	2, 390, 000
Export to San Francisco Bay	450, 000	1, 075, 000
Total [1]	20, 000, 000	22, 752, 000

[1] Totals do not include evaporation losses.

The average annual runoff into the Central Valley Basin over the 40-year period 1904–43 was 33 million acre-feet. However, not all of this water can be conserved for beneficial purposes. Much of it occurs in occasional years of extremely large flow. It would not be possible to provide sufficient storage capacity in the Central Valley, either surface or ground water storage, to hold over all of these large flows from wet periods to dry periods. The critical water supply period in the Central Valley was the 7-year period 1927–34, in which the average annual runoff was 18.4 million acre-feet. Rainfall data indicate this to be the driest period during the 100 years for which records are available. Most water supply studies for the basin as a whole are predicated on meeting the assumed demands during a period such as 1927–34, although in certain areas, other base periods are used.

The Bureau of Reclamation on the one hand, and the State engineer on the other, propose to meet the estimated ultimate Central Valley demands in the following manner: [20]

	Annual averages in acre-feet	
	Bureau of Reclamation [1]	State of California [1]
Estimated available supply		
Natural runoff	18, 400, 000	20, 900, 000
Draft from carry-over storage (surface and underground)	2, 400, 000	2, 274, 000
Trinity River importation	700, 000	700, 000
Total	21, 500, 000	23, 874, 000
Estimated use and losses		
Net use of water	20, 000, 000	22, 752, 000
Evaporation losses	900, 000	1, 122, 000
Unavoidable waste to the ocean	600, 000	.....
Total	21, 500, 000	23, 874, 000

[1] Data from the Bureau of Reclamation are for 1927–1934. The period covered by the State is not known. See discussion of California State Engineer in S. Doc. 113, 81st Cong., 1st sess.

The foregoing figures would indicate that the ultimate demands of the Central Valley could be met with the available supply in the basin, plus the importation of 700,000 acre-feet. However, events and additional data gathered during the past few years suggest that the estimates of ultimate water needs presented above may be low. It now appears that more water will be required in the San Francisco Bay area than previously estimated,[21] and the additional water will have to be obtained from either the Central Valley or the north coastal streams of California.

Technical studies reveal that the requirement for outflow for salinity control also will be significantly greater. During recent years there has been successful development of irrigation on lands which previously were considered uneconomical for irri-

[19] S. Doc. 113, 81st Cong., 1st sess. (1949).

[20] S. Doc. 113, 81st Cong., 1st sess., pp. 326, 329.

[21] Particularly in the Bureau of Reclamation estimates.

gation. The extent to which these factors might increase the ultimate water requirements of the basin is difficult to foresee, but the total increase might amount to several million acre-feet of water annually.

Should these larger demands materialize, there are several possibilities for obtaining the additional water. One method would be to make further use of the water within the Central Valley itself. Additional water would be available for conservation; however, since the previous estimates assumed all of the runoff during the 1927–34 period would be utilized, the only way to conserve additional water would be to provide additional storage and to carry the water from preceding wet years into the critical dry period. For a 7-year carry-over, it would take 7 acre-feet of additional storage capacity to obtain 1 acre-foot of additional yield. If large amounts of additional storage capacity were provided, the carry-over period might be extended to 12 or 17 years, which would require even greater amounts of storage capacity per acre-foot of yield. This storage might be obtained either by construction of additional surface reservoirs or by further use of ground water capacity. Either method would be quite costly and would be increasingly expensive as additional storage was provided.

Another method of conserving water would be to construct a barrier across the northern end of the San Francisco Bay. This would prevent salt water intrusion into the delta area, and thereby reduce the required outflow of fresh water for salinity control. This possibility has received much attention during the past 30 years. It was rejected as not being an economically feasible alternative for the salinity control outflows now being provided. The potentialities of water conservation by means of the salt water barrier depend on a number of factors.

For example, it is certain that even with such a barrier, some fresh water releases would have to be made into San Francisco Bay to provide for the passage of ships, to pass fish, and to permit outflows of saline irrigation return water. Furthermore, such a barrier would create a fresh-water lake, the evaporation from which would be large. Thus the feasibility of a salt water barrier depends on comparing the cost of the barrier with the net amount of water which could be saved.

A third possibility of additional water is through importations of surplus supplies from adjacent basins. The north coastal streams of California are the nearest and most likely source of such water. They include principally the Klamath, Trinity, Eel, and Russian Rivers. The runoff of the first three of these rivers, and to a lesser extent of the Russian River, is far greater than the ultimate water needs within the basins for domestic, industrial, and irrigation purposes. However, these rivers are quite valuable for their fishery and recreational resources, and diversions would reduce their power potentialities.

A diversion from the upper Trinity River was included in the California State Water Plan and also the Bureau of Reclamation's plan for the Central Valley. The California Legislature recently removed the Trinity Diversion from the State Water Plan. Other interests within the basin have attempted to restore it to the State Water Plan but so far have been unsuccessful.

Under present tentative plans of the Bureau of Reclamation, approximately 700,000 acre-feet annually would be diverted from the upper Trinity River into the Central Valley Basin, in addition to which 120,000 acre-feet would be released down the channel of the Trinity River for fish, recreation, and other purposes. This downstream release, together with the large tributary inflows below the diversion point, is considered by the Bureau of Reclamation to be more than sufficient to meet all conceivable ultimate demands in the Trinity River Basin. The Trinity Diversion is being considered by the Bureau because it offers a relatively inexpensive source of both water and power.

Another possible interbasin diversion is from the Russian River. Estimates by the Corps of Engineers indicate that 86,000 acre-feet over and above the needs of the Russian River Basin could be diverted to the northern San Francisco Bay area for irrigation and municipal and industrial demands. Such a diversion would reduce the required diversions from Central Valley to the San Francisco Bay area.

A number of other plans for diversion from the Klamath, lower Trinity, and Eel Rivers into the Central Valley or to the San Francisco Bay area have been considered by various agencies over a period of many years. The extent to which these might be undertaken is difficult to forecast. On the Klamath River, below the mouth of the Shasta

River, the construction of dams is prohibited by a State referendum of 1924. This action was sponsored primarily by sportsmen who wish to preserve the stream for fishing, and it could be repealed only through another referendum. Whether or not additional diversions from these streams would be justified also depends on the ultimate demands which actually materialize in the Central Valley Basin and the San Francisco Bay area.

There is further question on the desirability of conserving water on these streams and making additional water available to help meet the ultimate water needs of southern California through a series of reservoirs, tunnels, canals, and exchanges of water. Such an arrangement might even replace some of the Colorado River water now used or contemplated for use in southern California. In the latter eventuality it may be necessary to consider not only the north coastal streams of California as sources of supply, but also those of southern Oregon and possibly the Columbia River. All of these possibilities are being considered, but it probably will be many years before firm conclusions are reached.

Conclusions

The upper Trinity River diversion into the Central Valley is a proposed addition to the Bureau of Reclamation plan. The export of water from the basin to the San Francisco Bay area is a part of the Central Valley Project. Additional importations could be made from the northern coastal streams of California into the Central Valley and the San Francisco Bay area, but studies as to the need for and economic feasibility of such projects are only in the preliminary stages. Such diversions, however, are likely to be expensive. There are no immediate demands which cannot be taken care of within the basin. Diversions from other basins therefore are a matter of long-term interest, but they should not be ignored in comprehensive water planning for the basin.

12. *Integrated Planning, Construction, and Operation of Facilities for Water Use in the Central Valley*

The Problem

The extent to which planning, constructing, and operating water use projects should be coordinated.

The Situation

Different criteria govern consideration of planning, construction, and operation.

Planning.—Planning for regulation and use of water resources in the Central Valley involves both regional and basin-wide problems. The problems are many and varied, often requiring specialized, technical study, and concern numerous Federal, State, and private agencies. In many cases the benefits from a particular project are realized in localities some distance from the site, and many specific areas are benefited by more than one project. Moreover, multiple-purpose projects provide services and benefits of more than one type. Thus, planning activities must be coordinated on an intraproject as well as on an interproject basis.

Many problems of an entirely local nature also exist. In some cases local water problems are so important as to make certain projects almost independent of basin-wide programs.

In the Central Valley, coordination and integration of the planning activities of the various Federal, State, and local agencies have been maintained to interchange basic data, furnish mutual assistance in the case of specialized studies, and inform each responsible agency on progress, investigations, and planning.

Generally, such coordination of effort has been informal, and special steps are taken for closer cooperation as the need arises. For example, a joint committee was formed to consider the proper power capacity to be provided in the Folsom Project on the American River. This committee was composed of representatives of the Corps of Engineers, the Bureau of Reclamation, and the Federal Power Commission as well as the California State Engineer. In the past, such procedures have insured generally satisfactory coordination among these agencies on regional matters. Difficulties and inconsistencies at the regional level are usually caused by differences in policies, arising from differences in legislative authority.

Coordination in the planning stage has been lacking between the construction agencies and the land-management agencies. As a result no consideration is given to such matters as requiring State or other public agencies to undertake proper watershed management measures, or reducing the rate of watershed damage.

Coordination between water project construction and highway agencies also appears to be imperfect. The programs of water projects are not specifically

made available to highway agencies long enough in advance to permit integration with the regular highway construction program. The Bureau of Public Roads reports that much wasted effort in highway planning has resulted. Where programs are known in advance, present practice does not permit water development agencies to pay for highway relocation until construction of the water project begins. The State cannot undertake highway work near the site until the project is under way, which sometimes means a delay of several years.

Construction.—The construction of Federal projects in the Central Valley has raised several problems in coordination. The timing and sequence of construction of various units of a comprehensive plan must be given consideration on a basin-wide basis, but this is more properly a problem of the planning phase. The rate of construction progress is largely dependent on congressional appropriations, and to that extent is beyond the control of the constructing agencies. Federal agencies, however, have not always agreed on the assignment of responsibility for constructing major projects, as on the Kings or the Calaveras Rivers.

The Folsom Project, where the Corps of Engineers is constructing the dam and the Bureau of Reclamation is authorized to construct the power facilities, is an example of the need for coordination in appropriations. Numerous conferences between these two agencies have been necessary to insure orderly economical prosecution of the work. To this end the Corps and the Bureau are considering including in one contract the powerhouse substructure excavation and concrete work for the main dam. They are parts of the same structure, and they should be built concurrently.

Operation.—Various projects for control and use of water in the valley will require coordinated operation for maximum benefits. For flood control, such coordinated operation is normally required from November through June. However, during this period the flood control operation may require accurate and rapid decisions as to reservoir releases.

Irrigation also requires coordination seasonally, usually from April through October. Because of the transfer of waters from one basin to another, coordination is required. The time element is not so critical for the irrigation operations as for flood control. Irrigation releases can be predetermined, permitting operation more or less in accordance with fixed schedules. In irrigation operations the type of crop in the local service area is an important consideration. Releases may be used for replenishment of ground water supplies as well as for surface application.

For most efficient hydroelectric power operation, the outputs of existing and proposed Federal and non-Federal plants should be physically integrated into a common system. Therefore, a closely coordinated operation of reservoirs which release water to downstream power plants will be necessary, on a daily or hourly basis, throughout the year. Some coordination with steam-electric plant facilities in the system will also be required.

Other project purposes which must be given attention include fish and wildlife, recreation, domestic and industrial water supplies, pollution, navigation, and salinity repulsion. Although some coordination is required for these functions, they are of a more local character. Most interproject coordination in such cases would be limited to a few projects within a sub-basin.

Intraproject coordination is necessary to achieve maximum benefits from multiple-purpose projects. Shasta and Millerton Lakes, for example, are being operated in the joint interest of irrigation, power, and flood control, as well as other functions.

Independent operation, at least for some years, is thought to be advisable for certain purely local projects, some of which are single-purpose flood control reservoirs, and some multiple-purpose projects. Examples are the existing and authorized flood control reservoirs on the Merced County streams and the authorized Solano Project on Putah Creek. It is also quite likely that an irrigation and flood control project in the Cache Creek drainage would be operated independently of other units in the Central Valley for an initial period. Eventually, however, full development of the Solano and Cache Creek areas will require additional water supplies which can best be obtained through coordinated operation of these with other Central Valley projects.

Conclusions

Complete coordination and integration of the planning activities of all interested Federal, State, and local agencies in the Central Valley should be attained. This is necessary to insure full use of available data and specialized personnel, to avoid duplication of effort, and to give all concerned full opportunity to participate in planning. It is necessary more particularly to assure the best use of resources for all purposes.

Construction activities should be coordinated at the regional level. But the proper timing of construction or installation of the various elements of a program is determined to an important extent by the timing and amounts of appropriations. Greater attention should be given to coordination in this phase.

Coordination in operating water control projects in the Central Valley is necessary if maximum benefits are to be realized. This coordination is required not only among the various projects but also among the several purposes of a particular project. Coordination of operation will require close cooperation among all agencies, including local interests. Certain local services can be supplied best by independent operation, and where practicable, they should be so undertaken.

In view of the complexity of the program in the Central Valley, the many agencies concerned, and the need for close coordination, a more formal and responsible coordinating procedure is indicated. A river basin commission should be established. It should consist of representatives from each of the responsible Federal agencies, and provision should be made for full State and local participation in planning, construction, and operation. This is in accordance with the Commission's recommendations in volume 1.

D. Program Procedures

1. *Irrigation Repayment Contract Principles*

The Problem

The time of repayment contract negotiation for irrigation services provided by Central Valley reservoirs in relation to construction of those reservoirs.

The Situation

The Corps of Engineers and the Bureau of Reclamation have been authorized to construct a number of multiple-purpose reservoirs in the Central Valley. Some of these are in operation and others are under construction. The projects of the Bureau were authorized under reclamation law and the projects of the Corps were authorized by the Flood Control Act of 1944.[22] All of these projects require that local interests using irrigation water from the reservoirs repay a proportionate share of the project cost, but problems have arisen in connection with the making of repayment arrangements for this irrigation service.

These problems stem from the question as to whether existing reclamation law applies directly to projects constructed under flood control law, and from the broader question as to whether reclamation law should apply to any reservoir project in the Central Valley.

Conflicting interpretations of these acts with respect to repayment policy have resulted in confusion. Should the repayment policy for use of irrigation water be the same whether the project is built by the Bureau of Reclamation or the Corps of Engineers? The unsettled question of whether local irrigation interests are required to contract for conservation use of the reservoirs with the Secretary of the Army or the Secretary of the Interior adds to the confusion.

Cogent arguments can be presented for either side of the question as to whether or not reclamation law should apply to all projects in the Central Valley. Those favoring the application of reclamation law cite the need for consistency throughout the valley, as the Bureau of Reclamation has made and is making repayment arrangements for irrigation water provided at projects authorized under this law. Those opposing the application of this law claim that the provisions regarding acreage limitations are not applicable in an area where irrigation has been practiced locally for many years, where water rights are established by State law, and where most of the water to be provided by Federal projects is of a supplemental nature. They further cite the fact that the water from some projects will be used on lands already fully developed, and will be conveyed there by means of existing diversion dams and canals.

There likewise are two points of view on the negotiation of contracts before construction. Many believe that irrigation repayment contracts should be negotiated prior to construction of a project on the grounds that otherwise it is very difficult to consummate any agreement for reimbursing the Federal Government as required by law, particularly where no works are necessary to convey the stored water. However, in some instances such prior contracts would not be necessary, provided advance arrangements for acquiring water rights to the unappropriated waters are made with the State of California.

Proponents of prior negotiation call attention to the fact that it is impossible to operate the reser-

[22] Act of December 22, 1944, § 10, 58 Stat. 887, 891.

voirs without incidentally providing significant irrigation benefits, and that therefore local irrigators are inclined to delay negotiations with the idea of receiving benefits without cost.

Others believe that repayment contracts need not be made prior to construction. The principal argument in support of this stand is that the flood control to be provided by the projects is urgently needed and should not be delayed. They also contend that these projects are very much desired by local interests and that proper arrangements could be made for them to pay their equitable share of the project cost, as indicated by offers received, but that the difficulty stems from the larger question of the applicability of reclamation law rather than from evasive tactics.

An excellent example of the difficulties encountered because of the present situation is afforded by the Pine Flat Project on the Kings River. The 1944 Flood Control Act [23] authorized this project for construction by the Corps of Engineers, and provided that the Secretary of the Army should make the necessary arrangements for compensation for conservation use of the reservoir. Subsequently, the Secretary of the Interior was directed by the President to negotiate irrigation repayment contracts for the use of water from this reservoir. The project is under construction and will be operated initially for flood control only, until such time as contracts are obtained, although incidental and automatic irrigation benefits estimated at from 10 to 25 percent of the benefits under a multiple-purpose operation would result from flood control operation.

The area which will use irrigation water stored in Pine Flat Reservoir comprises numerous irrigation districts and private irrigation companies. This area is intensively irrigated, and a relatively large portion of the total runoff of Kings River is now used by direct surface application and by pumping from the underground reservoir. The Bureau of Reclamation, in accordance with the Presidential directive cited above, is currently attempting to obtain a repayment contract for the irrigation use of Pine Flat Reservoir, but is meeting with serious difficulty primarily because of the objection of local interests to application of reclamation law.

Irrigation contract negotiations are especially difficult on Kings River because irrigation canals are already constructed to use water from the reservoir. Similar difficulties may appear in other areas where canals already are available, such as on Kaweah, Kern, and Tule Rivers, and on Cache Creek.

Problems may also arise elsewhere, but probably will not be so difficult because new canals will be required. They will give greater control over the use of water and therefore more opportunity to enforce the provisions of reclamation law. It is pertinent to note, in order to avoid the implication that the difficulty has been concerned entirely with projects of the Corps of Engineers, that the Bureau in the past has had some difficulties in making repayment arrangements with certain local irrigation districts for water from its own Central Valley Project. However, it is now thought that contracts will be completed for all Central Valley Project water in advance of completed construction.

Conclusions

The differences in basic laws under which Federal reservoirs are constructed in the Central Valley lead to serious inconsistencies and difficulties in the negotiation of repayment contracts for water conservation features. Two basic policy problems are involved:

(1) Should land limitation and antispeculation provisions of reclamation law apply to all lands receiving regulation and conservation benefits from federally constructed reservoirs whether such benefits are a primary objective of construction, or incidental to operation for other primary purposes and largely supplemental water supply for distribution facilities already available?

(2) What means are there to enforce negotiation of repayment contracts?

It is suggested that the following procedure be made obligatory, by legislation or other means needed to establish it:

The same policy should apply to all projects having irrigation benefits, whatever the construction agency.

Contracts should be negotiated prior to construction where important irrigation benefits accrue from a project. However, this should not be so interpreted as to preclude the construction of a project in which very minor irrigation benefits are incidental to construction for other purposes, and where contracts cannot be negotiated.

Where there are important irrigation benefits every effort should be made to secure agreement or contracts with the State or local interests in which reimbursement for surface and ground water benefits will be considered together.

[23] *Ibid.*

In cases where supplemental water may be supplied to areas already under irrigation but where some existing farms exceed the acreage limitations of reclamation law, provision can be made to supply those farms with an equitable share of water under utility-type contracts, as recommended generally by this Commission.[24]

2. *Acquisition of Property in Reservoir Areas*

The Problem

Hardships caused by land and property acquisition for reservoir purposes and means of alleviation.

The Situation

As in other basins, a delay occurs under present procedures between authorization of a Federal reservoir project and beginning of property acquisition in the reservoir area. This normally results either from lack of appropriations or deferral of the acquisition program by the construction agency, especially when the construction period is long. When the land acquisition program is undertaken, it is usually completed as rapidly as possible in order to clear the reservoir area for its intended use.

These procedures can produce adverse results, their extent depending on the current economic situation in the locality. Where land is at a premium, the adoption of a project will result in price inflation on reservoir lands due to speculative activity. This will increase with time as the actual acquisition of project lands is deferred. Speculative building and minor improvement will also take place in order further to inflate the land prices. These conditions operate to increase project cost.

Under depressed conditions, hardships are imposed on property owners in the reservoir area in two principal ways:

After project authorization and pending Federal acquisition, the property in the reservoir area is generally unsalable because it has no future use other than for flowage and if purchased it usually is for speculative purposes. Secondly, upon initiation of the acquisition program the accelerated purchasing of reservoir property immediately throws the majority of the original owners into the market for replacement of their former holdings.

The first type of hardship is particularly severe on a property owner who, due to financial circumstances, may be forced to sell his holdings. The lack of a normal market in view of the impending reservoir construction could result in his receiving a greatly reduced price and consequent financial loss. Also, with impending dislocation, a property owner is deterred from making improvements which might afford him a better return on his investment.

When the property owners are bought out, the majority will desire to relocate in the same general vicinity on holdings where they can carry on their accustomed endeavors. In an agricultural area, for example, farmers would normally prefer to buy farms of about the same type and quality as their previous farms, so as to use the knowledge they possess. Although owners receive a fair price for their holdings they are furnished no assistance in relocating. The suddenly engendered competition in the local market may increase prices to where some of them will be unable to relocate and those who do may suffer serious loss due to the higher price they are forced to pay for equal or inferior properties. The knowledge of the difficulties with which they will be faced in relocating has caused owners of property in proposed reservoir areas to oppose the adoption of many worthwhile reservoir projects.

These conditions apply mainly to the upper Sacramento Valley. For the Central Valley as a whole, the problem cannot be considered serious.

Where relocation of an entire urban community is required, it is usually carried out as a part of the Federal project. Even in such cases hardships are encountered by the affected residents because they are divorced from normal service facilities, stores, schools, and churches during the time removal and relocation are in progress. Any delay in the process results in prolonging upset conditions.

One case in the valley is the Isabella Project, which is under construction on the Kern River. The reservoir will inundate the towns of Kernville and Isabella as well as agricultural lands. Isabella will be abandoned as a town, but Kernville will reestablish itself about 8 miles upstream. This entails a troublesome problem in the relocation of roads, power lines, and telephone lines to serve the new community, in addition to the acquisition of the properties and improvements which will be inundated. The problem is complicated by inadequate appropriations to permit satisfactory relocation in a relatively short period.

[24] See volume 1, p. 174.

Conclusions

Present procedures for property acquisition in flowage areas of authorized reservoirs result in hardships to the affected property owners, excess costs to the Federal Government, and delays and opposition to the Federal program. The procedures could be improved both from the standpoint of the property owners and the Federal Government if sufficient funds were available to initiate an orderly program of land acquisition as soon as practicable after project authorization and all property owners were assured of Federal assistance in resettlement. Such a program would provide a ready and fair market for property where the owners desire an immediate sale, and assistance in expeditious relocation would remove many of the objections now encountered.

An orderly acquisition program immediately undertaken upon project authorization would also provide time for acquisition and resettlement prior to flooding of the reservoir area, without sudden disturbance of the property owners and inflation of the market for surrounding property. The program could be implemented by creation of a revolving fund for use by each Federal construction agency in land acquisition and a grant of authority and funds to appropriate Federal agencies to assist the affected property owners in resettlement. Repayment of appropriations from the revolving fund might be from appropriations for project construction. This revolving fund also could be used to aid in the relocation of roads, and promote the efficiency of State highway organizations in meeting their responsibilities in the project area.

Chapter 6

Elements of a Plan for Full Development

The Central Valley Basin is best considered in the light of its relations to the larger region of which it is a part. The valley dominates the State in several important ways, particularly through the amount and central location of its water resources. Further use of those resources can be planned efficiently only in terms of the potentialities, functions, and needs of California as a whole.

Considered in this manner, the use of valley water resources assumes an important, if not an indispensable place among water resources programs in the United States. The already large population of the State, its environmental attractiveness, its first-rank strategic location, the presence of important defense industries in the San Francisco and Los Angeles areas, and the State's dominant position as a producer of minerals, forest products, fishery products, and specialized agricultural commodities combine in raising California to a commanding position in the national economy.

California always will be faced with difficult problems because of inadequate water supplies in the most densely settled sections of the State. California's future therefore rests upon ingenuity and effort in bringing water to ever-demanding lands and cities. Basin plans, because they concern the heart of the State's water sources and the center of long-range distribution systems, give some important clues as to California's future. They are, of necessity, complex plans. They must be adapted to the already intensive development, and thread their way among the maze of established water rights, peculiarities of land holding and social structure, jurisdictional interests of localities, State, private, and Federal agencies, and conflicting views on acceptable objectives of national policy.

The elements of a plan here presented do not represent a final answer to all known problems nor a reconciliation of all conflicts recognized. There is, however, much of the future of California in them.

Ultimate Objectives of the Plan

A wide variety of elements enter into consideration of water resources developments in the Central Valley Basin. Nearly all of the purposes toward which they are directed enter Central Valley plans. Foremost among them, however, are irrigation, electric power generation, urban water supply, and flood control.

Irrigation

Irrigation agriculture is the basic economic activity of the Central Valley and will continue to hold an important place, although increasing industrial development in the adjacent San Francisco and Los Angeles areas, and to a lesser extent in the Central Valley itself, is exerting an influence on the area.

The long-range objective in the Central Valley is the full economic use of all irrigable lands in the basin. It would be desirable to increase the self-sufficiency of the area, particularly in milk and meat products, which presently are deficient. The Central Valley also raises many specialty crops, for which there is a relatively limited growing area throughout the Nation.

Irrigation expansion includes three major phases: (*a*) maintenance and improvement of irrigation agriculture with supplemental water, especially in areas where ground water pumping exceeds natural replenishment, (*b*) increase of crop production by converting presently dry-farmed lands to irrigated lands, by which crop yields can be increased several

times, and (*c*) bringing in irrigable uncultivated lands.

Nearly one-half of the more than 4 million acres presently irrigated in the Central Valley is in need of supplemental water, and an additional area of from 3 to 6 million acres awaits life-giving water.

The many uses which can be found for every acre-foot of water, even in irrigation alone, make it imperative to plan the most efficient use possible of the natural water supply of the basin. To this end reduction of every nonconsumptive disappearance of water should be sought. A reduction in evaporation losses through underground storage or other means will be an important consideration in planning.

In addition to the construction activities, as new areas are brought under irrigation, farmers should be provided with technical assistance in land preparation, in laying out irrigation systems, and in planning and applying sound cropping and irrigation practices. In many irrigated areas farmers also need technical help to improve present irrigation practices and make more efficient use of water. In both the new and existing irrigated areas there are needs for long-term credit to permit farmers to finance the installation of new or improved farm irrigation systems. Such measures will help to make the best use of primary facilities to be constructed.

Power

Electric energy in the Central Valley and the adjoining San Francisco Bay area is obtained from a system including both hydroelectric and fuel-electric plants. This combination is essential because the hydroelectric potential is insufficient to meet power needs; characteristics of the stream flow are variable; and storage regulation must be predominantly for irrigation and municipal purposes. Power loads are steadily increasing as industrial activities expand, population increases, and irrigation is extended to new lands.

A balanced program for meeting these power needs will involve the further construction of both hydroelectric and fuel-electric plants. California has been favored with relatively large quantities of oil and gas, which are used to generate power. These reserves are exhaustible, and development of as much hydroelectric power as possible is desirable so as to conserve regional fuel supplies.

Full economic development of potential hydroelectric capacity in the Central Valley should be sought.

Municipal and Industrial Water Supply

The San Francisco Bay area already is using most of its local water resources and is obtaining a large part of its supply from the Central Valley. Steadily increasing demands will have to be met largely from the Central Valley, with possible assistance from some of the northern coastal streams of California. Demands are increasing in the Central Valley itself. Provision for the expanding municipal and industrial needs of this area is therefore an essential element in the Central Valley program.

Flood Control

Under natural conditions, about one-fourth of the main valley floor of the Central Valley was subject to annual or periodic overflow. All but a small portion of this land has been reclaimed through the construction of levees and is used primarily for irrigated farming, but includes considerable areas of urban and industrial land. Many levees can be overtopped or breached during large floods. Tributary valley areas are in many cases unprotected from flood damage.

Flood control reservoirs or storage capacity for flood control provided in multiple-purpose reservoirs will protect downstream areas in the tributary valleys on which they are located and will contribute toward a higher degree of protection on the main valley floor. Additional flood protection is needed in many areas and should be provided to the maximum economic extent, for without adequate flood protection, both the rural and urban economy of the basin can be impaired.

Navigation

A ship channel has been constructed from San Francisco Bay to Stockton, and another is under construction to Sacramento. These are the two principal cities in the Central Valley which can be reached economically by ocean vessels. In addition, the Sacramento River upstream to Red Bluff, the lower reaches of the Feather and Mokelumne Rivers, and the San Joaquin River and its distributaries in the delta have been improved for shallow draft navigation. The improved channels constitute a transportation network and also serve to carry flood flows, as well as irrigation water in transit

from the Sacramento River to the San Joaquin Valley. The most important of these projects are within the tidal influence of the ocean and do not require fresh water for their operation.

Navigation on the Sacramento River above Sacramento involves the operation of Shasta Reservoir to provide certain minimum flows in this reach for navigation purposes. Reservoir releases for irrigation in the summer and tributary inflow during the winter provide sufficient water in the Sacramento River above Sacramento for navigation during a major portion of the year. However, periodically special releases primarily for navigation are required. These will flow out to the ocean unused for irrigation.

The need for water for irrigation and municipal and industrial purposes is much more critical, and its value is higher, than for navigation. Therefore, in the course of time it would appear desirable to eliminate special water releases solely for navigation. This will not necessarily mean the elimination of navigation above Sacramento, since reservoir releases for other purposes, including salinity control and tributary inflow, will be sufficient to maintain navigation depths for a major part of the year. If year-round navigation later is considered desirable and is found to be economically feasible, a slack water navigation channel could be built.

Watershed Management and Sediment Control

Watershed management is an essential element in the water plan for the Central Valley. It is needed in order to prolong the useful life of projects, to provide maximum amounts of usable water, and to conserve and protect the productive capacity of the valley's soil resources. Watershed management, which is partially in effect now for many of the Federal headwater lands, should be intensified, and should be basin-wide, especially in view of the fact that practically every major stream has or is proposed to have on it one or more water developments. Capable, intelligent watershed management should precede the construction of the facilities whose life and functions may be significantly affected by untoward practices or uses within the watershed. At the very least, adequate land treatment programs should be established in significantly affected project areas to proceed concurrently with engineering construction.

Watershed management is not considered a substitute for, but instead insurance for and complement to, downstream water resources development.

Fisheries

Salmon and steelhead trout are desirable resources of the Central Valley, especially for sports fishing. Their maintenance is proposed in the plan for as long a period as is possible by deferring projects on the upper Sacramento River (like Iron Canyon) which would destroy the more valuable spawning beds. In time, it may be possible to work out methods whereby the loss of these spawning grounds would not destroy the resource. For instance, if proper steps are taken, north coastal streams of the State may well supply a better production of anadromous fish than they now do.

However, when the need for water development becomes so acute that a choice must be made between water for the general economy of the basin and fisheries, a decision will have to be made based on a determination of the relative value of the contribution of each to the national and regional economy.

Recreation

The Sierras are the natural playground for the residents of California. Every year an increasing number visit the State parks and forests and national parks, monuments, and forests. Although the mountains with their big trees and interesting geology attract many, people flock to those areas which in addition provide water recreation in various forms. Unfortunately, these developments are not numerous, considering the population and the accessibility of places in the basin. There are so few of these that any new water resources development immediately attracts attention.

Recreation must be an element in the full plan for using the resources of the valley. Recreation facilities should be provided in nearly every water resources reservoir project, some reservoirs operated with due regard to recreational uses and values, and water released into normal stream channels to meet sport-fishing requirements. There should also be provided necessary access to the reservoir area, and sufficient publicly owned land about the lake to enable public control of use and improvements and to obtain full values from the whole reservoir area. Cooperative action of Federal, State, and local agencies will be needed to procure the best form of planning, construction, operation, and maintenance.

Envisioned also as part of the full use of all of the recreational potential is greater provision for

recreational use of the Federal lands. Many opportunities exist which only await adequate funds for facilities and maintenance.

Pollution Abatement and Insect Pest Control

Primary treatment of all raw sewage is needed. This is emphasized by the already dense and still growing population of the central California area, future possibilities of industrial development in the valley, the seasonal nature of natural water flow, and the danger inherent in use of polluted water for irrigating some vegetable and fruit crops.

Some pollution abatement can be obtained by the release of water from reservoirs for other purposes, like prevention of salt water encroachment from San Francisco Bay into the lower reaches of valley streams. Such flow, however, is not thought to be sufficient to remove all hazards from bacterial infection during low water periods. Treatment appropriate to local conditions and downstream water uses of all raw sewage and harmful industrial wastes therefore is an element of a full plan.

Maintenance of adequate mosquito prevention measures also is included.

Unified Planning and Operation

Nearly all reservoirs included in the comprehensive water plans for the Central Valley serve two or more purposes. This is primarily due to the fact that runoff can be predicted accurately, permitting multiple-use of reservoir space without too serious conflict. Operation of these reservoirs on a common stream system must be coordinated with each other and with related canals, flood channels, and power facilities in order to meet the irrigation, flood control, power, and related needs of the basin. Because these reservoirs affect or are affected by the use or treatment of watershed lands or their resources, it is essential that operating plans for water developments include consideration of or provision for the related watershed operations as well.

A fully coordinated plan of operation is essential to the success of a program. Work toward that end should be continued and a suitable organizational arrangement achieved which will assure full attainment of the major objectives. Wasteful confusion, whether caused by conflicting State and Federal statutes or by organizational misunderstandings, is not in the public interest.

The Rate of Development

No detailed guide for the rate of completion of stages in a plan for full development can be presented for any river, since much depends upon events which may not be foreseen. Economic trends, international affairs, and technological discoveries can influence the composition of any development plan in a significant manner. One element of a desirable plan for the Central Valley, therefore, is flexibility and adaptability to future trends. The main objective, namely the greatest public good, should be kept constantly in mind and in the forefront of comprehensive plans.

The major purposes to be served by future water resources developments in the Central Valley are irrigation, flood control, and power. Multiple-purpose projects will be key developments in meeting major objectives. Most potential reservoir projects will serve at least two of the major purposes noted, and many will serve all three.

The construction of multiple-purpose reservoirs therefore is fundamental to future plans for each of the individual functions to be served. Consequently, the question of rate of development and stages in the plan cannot easily be separated by function; the several functions are inextricably tied together in the multiple-purpose reservoir projects.

All available evidence points to the need for additional electric energy in the Central Valley and adjoining San Francisco Bay area which can be met by construction of power facilities in conjunction with multiple-purpose water projects.

The need for additional irrigation water is also great. The initial features of the Central Valley Project were intended primarily to meet the first of these needs, particularly to replenish ground water in the San Joaquin Valley. However, the project has been long in building, because of its magnitude and delays occasioned by World War II. In the 13 years since it was started, additional needs for supplemental water have developed. Furthermore, there is an insistent demand within the basin for water for new irrigation, which should be met insofar as is compatible with: (a) a program of providing needed increments of agricultural products in the region or in the Nation as a whole; (b) demonstrated need within the region for additional agricultural products, farm employment opportunities, and balance of urban and industrial development; and (c) an accepted basin-wide plan for most efficient use of water.

Flood control is urgently needed in certain areas, and a higher degree of flood protection is required in other areas. Most of the basin area subject to flood damage already has received a certain degree of protection, but the rapid economic growth in recent years has increased the need for flood control.

Municipal and industrial water is critically needed in a few limited areas.

Navigation should be maintained, and extended as need develops, insofar as it does not conflict with uses of water for beneficial purposes of higher priority.

With the foregoing background regarding the water needs by function, it is suggested that in the advancement of the program by all interests concerned, the following criteria be applied to project selection:

1. Preference should be given to those units which are in a position to meet several of the needs through construction of a single facility.

2. Preference should be given to water conservation projects which incorporate power development. It would be desirable not only to eliminate present water supply deficiencies but also to keep the construction of reservoirs (water-conserving features) in appropriate balance with canals (water-consuming features). This will involve construction of reservoirs at least as rapidly as water demands increase, but in cases where irrigation demand promises to develop slowly, the reservoirs could appropriately be constructed ahead of the canals. If reservoir development includes power, it can be operated primarily for that purpose during the interim period while the water demands build up. In that way it can help meet the power needs of the area and conserve fuel resources. Furthermore, the construction of reservoirs ahead of the canals would permit greater flexibility in providing additional irrigation.

3. Effort should be made, as early as possible, to make use of feasible underground storage.

4. A high order of priority also should be given to power developments needed to fill any gap between aggregate power requirements and the amount to be provided through multiple-purpose projects.

5. Consideration should be given to specific projects which will fill critical local needs.

Watershed management programs also should be intensified at an early date throughout the basin. Appropriate land management programs are needed in the headwater areas, in the foothills, and in the valley proper. The general purposes of the several programs would be to conserve the soil resources, to promote better water-flow conditions, and to increase agricultural and forest production. Specific attention should be given in headwater areas to those measures which would increase water yields during periods of low flow and would prevent or control erosion.

High on the list of specific needs in the drainage basins are intensification of forest fire control, reclamation of denuded and depleted land, and better management of forest and range lands, both public and private. Intensification of soil and water conservation practices on the presently irrigated land are needed also to obtain better returns from the amount of water used in agricultural production. Such programs would increase production, raise the efficiency of both water and soil, and reduce losses.

Positive steps must also be taken in water and land programs to maintain the desired level of fish and wildlife production. Such levels can be produced by operations designed to enhance these natural resources through improvement or maintenance of the habitat, and managing the resources in accordance with sound conservation principles.

Further, positive steps in pollution control should not be deferred. Such steps should include not only the maintenance of adequate flows, but a reduction in the various pollution hazards. Associated with this phase of the program is the maintenance of the mosquito control effort.

Provision for growing recreational needs must be kept in step with other development. Provision should be made in water resources projects for all types of recreation practicable at the speed consistent with availability of funds.

Available data should be supplemented by an expansion of resources surveys in practically all fields of effort. More data and research are needed. The availability of maps, all kinds of physical, economic, and social data, and the results of research, are essential to the proper planning and the successful construction and operation of the many projects which are involved in or related to the use and control of the water resources. Additions are needed to the information already available to assure full success of these undertakings.

Stages in Attaining Full Development

The time necessary to reach full development and the rate at which that development should or will occur are virtually impossible to forecast, except for a few years in the immediate future. However, it is possible to see the present and near future needs of the basin. An initial stage of development intended to meet these needs is presented. No attempt is made to itemize future stages by individual features, because sufficient data are not available to make sound selections between alternative plans.

Initial Stage of Development

Based on the data available the projects and programs which are considered appropriate to the initial stage of water resources and related development in the Central Valley Basin are listed below.

TABLE 4.—Initial stages of Central Valley projects and programs

Project or program	Organization	Primary purposes of physical features
UNDER CONSTRUCTION OR IN PROGRESS		
Central Valley Project—initial features	Bureau of Reclamation	Irrigation, flood control, power, municipal and industrial use, navigation, fish and wildlife, recreation.
Central Valley Project—distribution systems	.....	Irrigation.
Folsom Reservoir	Corps of Engineers	Irrigation, flood control, fish and wildlife, recreation, municipal and industrial use.
Folsom Power Plant	Bureau of Reclamation	Power.
Pine Flat Reservoir	.....do	Flood control, irrigation.
Isabella Reservoir	.....do	Do.
Cherry Valley Project	San Francisco	Power, flood control, municipal and industrial use.
Big Creek No. 4 Project	Southern California Edison Co.	Power.
Bear River Project (Mokelumne Reservoir)	Pacific Gas & Electric Co.	Do.
Farmington Reservoir	Corps of Engineers	Flood control.
Merced County group	.....do	Do.
Sacramento deep water channel	.....do	Navigation.
Miscellaneous channel improvements (4 projects).	.....do	
Transmission systems	Department of the Interior	Power.
Partial watershed management and land treatment programs.	Department of Agriculture	
Fish and wildlife facilities for projects above	Fish and Wildlife Service	
Recreation facilities in connection with above projects.	.....	
Pollution control by local agencies	.....	
Collection of basic data	.....	
AUTHORIZED [1]		
Solano Project	.....	Irrigation, municipal and industrial use, recreation.
Butte Basin By-Pass	.....	Flood control.
Sly Park Unit	.....	Irrigation, recreation, municipal, and industrial use.
New Hogan Reservoir	.....	Flood control, irrigation.
Black Butte Reservoir	.....	Irrigation, flood control.
New Melones Reservoir	.....	Irrigation, flood control, power.
Terminus Reservoir	.....	Flood control, irrigation.
Success Reservoir	.....	Flood control, irrigation.
Miscellaneous channel improvements	.....	Flood control.
Bonneville Interconnection	.....	Power.
Waterfowl refuges	.....	Fish and wildlife.

See footnotes at end of table.

Project or program	Organization	Primary purposes of physical features
UNDER INVESTIGATION		
Unselected projects, with 2 million kilowatts of power capacity		
Augmented watershed management and land treatment program		
Comprehensive fish and wildlife management program		
Comprehensive recreational program		
Augmented pollution control program		
Augmented program of basic data collection		

[1] As investigation proceeds, it is possible that some authorized projects may prove to have lower priority in order of construction than some projects now unauthorized, but under investigation.

The facilities included in the initial stage for irrigation are designed to provide water for both supplemental and new irrigation for approximately the following areas:

	Area supplied with water	
	Supplemental	New
	Acres	*Acres*
Projects under construction	1, 400, 000	500, 000
Projects authorized	370, 000	100, 000
Projects under investigation	1, 500, 000	1, 000, 000
Total	3, 270, 000	1, 600, 000

The projects named above would provide an additional installed capacity in the area totaling 1,298,000 kilowatts, of which 200,000 kilowatts would be in the authorized steam-electric plant of the initial Central Valley Project. In addition 188,000 kilowatts are under construction by local private and public agencies, 234,000 kilowatts are in authorized Federal projects. Although the foregoing installations would provide over 1 million kilowatts of additional capacity, it has been estimated that the power load in the region will require more than 3 million kilowatts in new capacity during the next 20 years.

It will therefore be necessary during the initial stage to provide approximately 2 million kilowatts of capacity in addition to that included in the specific projects listed above. This additional capacity could be obtained partially from fuel-electric plants and partially from hydroelectric plants, both single-purpose and multiple-purpose. The undeveloped hydroelectric power possibilities that would be available for both the initial and long-range needs are estimated to be some 4.6 million kilowatts capacity, with potential annual generation of 22.5 billion kilowatt-hours. Further studies will be required for selection of the more favorable of these for early construction.

Operation of reservoirs included in the initial stage for flood control and related channel improvements would provide increased flood control for more than 40 existing urban areas and almost 2 million acres of rural land.

The improvement of watershed conditions is an important element of the initial stage of development in Central Valley. On forest lands this calls for, among other things, an intensified fire control program, reforestation of denuded areas, construction of access roads, and public acquisition of forest lands that cannot be properly managed under private ownership. The proper stocking and rehabilitation of eroding range lands should be accomplished in the initial stages of basin development. The stabilization of upstream drainage ways and small tributaries by structures and vegetative plantings is needed.

At the present rate of adoption of conservation practices on cultivated lands, it will be more than a century before the productivity of these lands will be stabilized. In the meantime great loss of soil resources will have occurred. The adoption of conservation practices on croplands needs to be in-

cluded in the initial stage of development on an intensified scale.

The improvement and rehabilitation, where needed, of farm irrigation systems and privately owned group enterprises should be accomplished in the near future. This calls especially for improved water distribution systems on farms to make better use of water and minimize erosion and salinity losses. Where feasible, adequate drainage of wet areas where water accumulates by seepage or otherwise should be included in the initial development stage. Additional investigation of the possibilities of underground water storage is urgently needed.

Land owners and operators, in order to make the improvement and adjustments needed, will require credit greatly in excess of amounts presently available through Federal credit agencies.

The present fish and wildlife program in the Central Valley includes a number of activities which are in progress by the Fish and Wildlife Service, the California Division of Fish and Game, and other interested groups. Among them is a research program which includes as one of its important elements the study of the life history of salmon and trout. These agencies also should be enabled to investigate the effects of water projects on fish and wildlife and recommend means and measures to propagate them and to prevent losses.

Other programs in which the State and Federal Governments cooperate are wildlife restoration and waterfowl management, the latter including the maintenance of waterfowl habitat, alleviation of crop depredations, and the provision of public shooting grounds. The State and Federal Governments presently operate eight waterfowl areas in the Central Valley with a total area of 31,000 acres, and authorization has been obtained to expand certain of these to provide two new areas, increasing the total area to 70,000 acres. The initial stage for future development in the Central Valley would include a continuation and expansion of these various activities with the objective of developing and maintaining a comprehensive program for conservation and management of fish and wildlife resources at the highest practicable level.

Recreation facilities have been provided at both Shasta and Friant Reservoirs, and plans are being drawn for Folsom, Pine Flat, and Isabella Reservoirs. These recreation facilities in conjunction with water projects will help meet the increasing demand for active recreation pursuits such as swimming, boating, and fishing. The initial stage contemplates continuation of the programs under way and the initiation of similar activities at other reservoir projects as they are undertaken, so as to contribute as fully as possible to the over-all recreation needs.

Pollution control is being undertaken under State and local auspices. A recently enacted State pollution control law will probably result in increased activity toward solving pollution problems. The initial stage contemplates an expansion in this activity to the end that all sewage and other wastes will be sufficiently treated so that they will not unduly contaminate waters used for domestic purposes, irrigation, and recreation. Similarly, it is contemplated that the current mosquito abatement program will be expanded.

The collection of basic data needed to correct present deficiencies should be given high priority in the initial development stage.

Future Stages

The control and use of the water and related resources must be conceived as a continuing process to meet the increasing needs of the basin and of the adjoining areas. The projects and programs of the initial stage, as described in the preceding paragraphs, can be expected to merge into future stages, which will include as one primary objective the construction of the necessary facilities to provide additional irrigation and municipal and industrial water supply.

Power projects, including both multiple-purpose and single-purpose hydroelectric facilities and fuel-electric plants, will be needed in addition to the 3 million kilowatts capacity of the initial stage. Improvements of navigation facilities would be undertaken as required. As more intensive use is made of lands, some increased flood protection through additional reservoirs and channel improvements will be necessary. Programs such as watershed management, land treatment, fish and wildlife, recreation, and pollution control will also be required on a continuing basis through future stages of development.

The Future Region

The progressive development of the remaining unused water and land resources of the Central Valley will permit the continued expansion of the economic and social structure of the area. Agriculture has long been the predominant economic

activity of the basin. The provision of additional water for presently irrigated land will preserve that part of the resources base which is faced with curtailed production because of water shortage. Developments also will make possible expansion of this base.

However, even taking into account the possible new developments, it is not considered likely that irrigation will provide support for more than 700,000 additional people in the Central Valley, including those indirectly dependent on farming activity. This may not be more than 10 percent of the actual population increase in California by the time construction of facilities and settlement have been completed. It is therefore evident that searching attention will have to be directed toward other means of supporting people, particularly in manufacturing.

Industrial development in California has been concentrated largely in the Los Angeles and San Francisco areas, the latter of which is dependent in large measure on the hydroelectric power and the raw materials produced in the Central Valley. Further water resources development in the basin will help to support those areas. It also may be expected that industries will increase in the Central Valley itself. The trend already has started, and from a strategic point of view it should be encouraged.

Through increases in the agricultural and industrial potential of the region, large additions to population can be maintained, provided the planned development is pushed forward speedily. The capacity of the area for population increase is so great that extraordinary measures ultimately may be required if water development is allowed to lag.

On the other hand, if water development proceeds apace, California will assume an even more important role in the economic life of the Nation. California already has passed far beyond the stage of being one of the western "open spaces." Intensive further strengthening of the weakest link in its resources chain—water—is vital in permitting the region to build further, and to avoid possible distress.

Achieving Water Development Objectives

Previous and present investigation of plans for use of water in the valley, starting with those of the State several decades ago and including current Federal and State studies, have given full consideration to the major present and ultimate needs of the area on a basin-wide basis, including principally irrigation, municipal and industrial water, flood control, navigation, and power. Other phases, such as recreation, fish and wildlife, watershed management, and pollution control, have not received the same degree of attention, but there is a growing realization of the importance of these activities, with the result that they are beginning to assume a more appropriate place in planning.

Interagency cooperation in the development of physical plans for the Central Valley generally has been carried on, although there is room for improvement. On some policy matters, equal coordination has not been possible. This has resulted from the fact that the State has opposed certain Federal water resources policies, and the further fact that the Corps of Engineers and Bureau of Reclamation, with the cooperation of other Federal agencies, are engaged in the planning, construction, and operation of similar and adjacent projects on the basis of differing basic legislation.

Although much progress already has been made in the conservation and use of the water resources of the Central Valley Basin, and an extensive program is in progress, there are a number of problems which are tending to prevent most effective development. The following are considered to be important:

1. Conflicting views and interpretations of policies and legislation relating to the distribution of irrigation water from Federal projects need to be resolved. This general problem involves questions such as the application of the acreage limitation provisions of the reclamation law, which Federal agency should negotiate irrigation repayment contracts, and negotiation of repayment contracts in advance of construction.

2. Recreation, fish and wildlife, watershed management, and mosquito and pollution control need to be brought more fully into the comprehensive plans and assigned their proper place in the program.

3. A plan must be devised for integrating the operation of the projects of various agencies both physically and financially.

4. To the end that all elements of the program will advance together, procedures need to be established to permit increasingly effective participation by interested Federal, State, and local public and private groups in the planning, programing, financ-

ing, and operation of water resources facilities. It is particularly desirable that these procedures be so established that they avoid the cumbersome nature of present practice where long delays are often experienced in obtaining effective common action. This is neither good business nor good government. It is further desirable that regional representatives of agencies be delegated more authority for coordination. Assistance toward resolution of these difficulties can be given by the establishment of a river basin commission for this area, as recommended by this Commission.

5. Measures should be taken to keep appropriations of all agencies concerned with the comprehensive development in proper phase. Budgets for all water development purposes within the basin should be considered as a unit.

There are, of course, many other lesser problems which must be faced. The more important problems listed above, and the lesser also, can be solved if all who are affected approach the situation with the objective of developing a comprehensive program in the best interests of all citizens, both in California and in the Nation.

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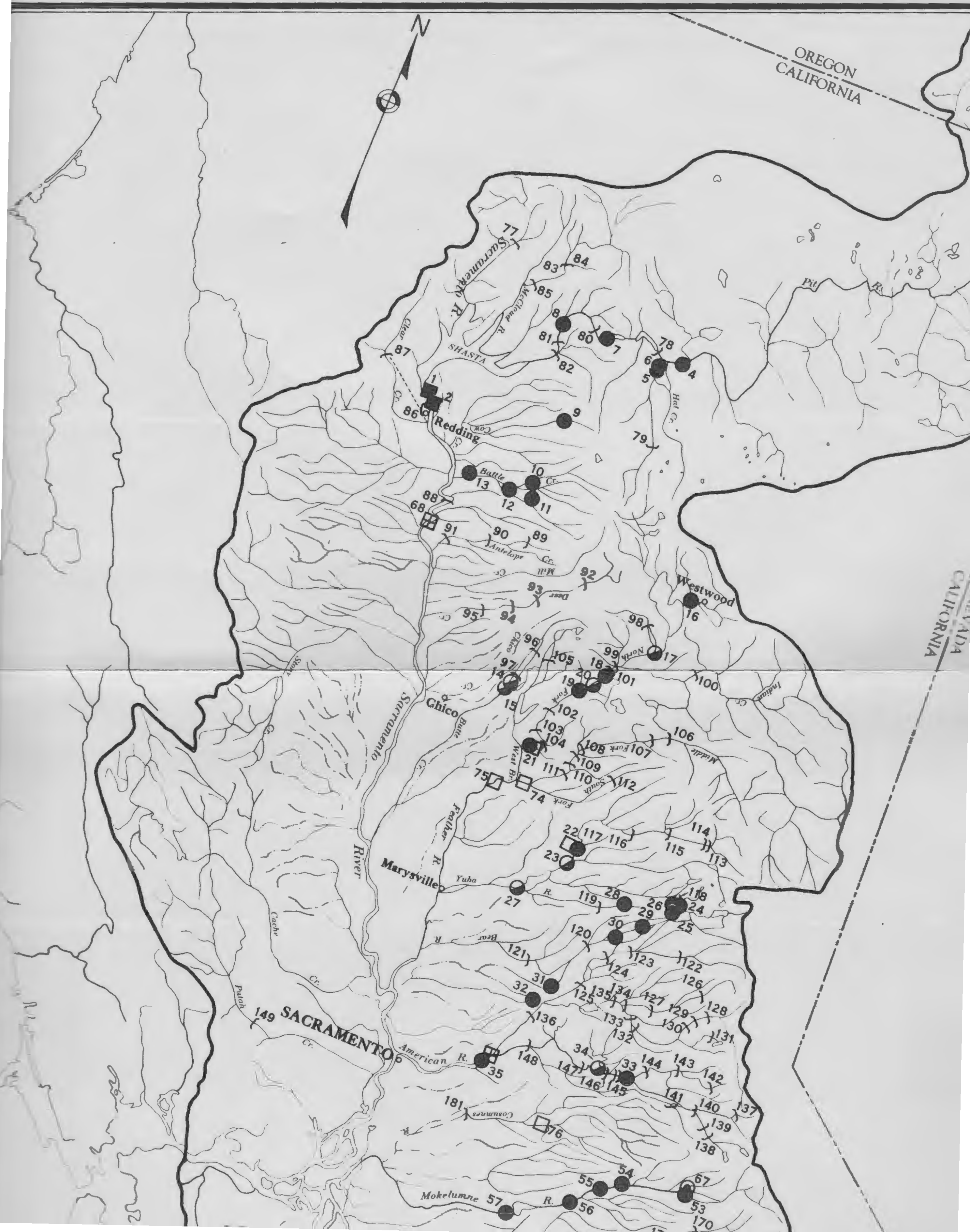
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