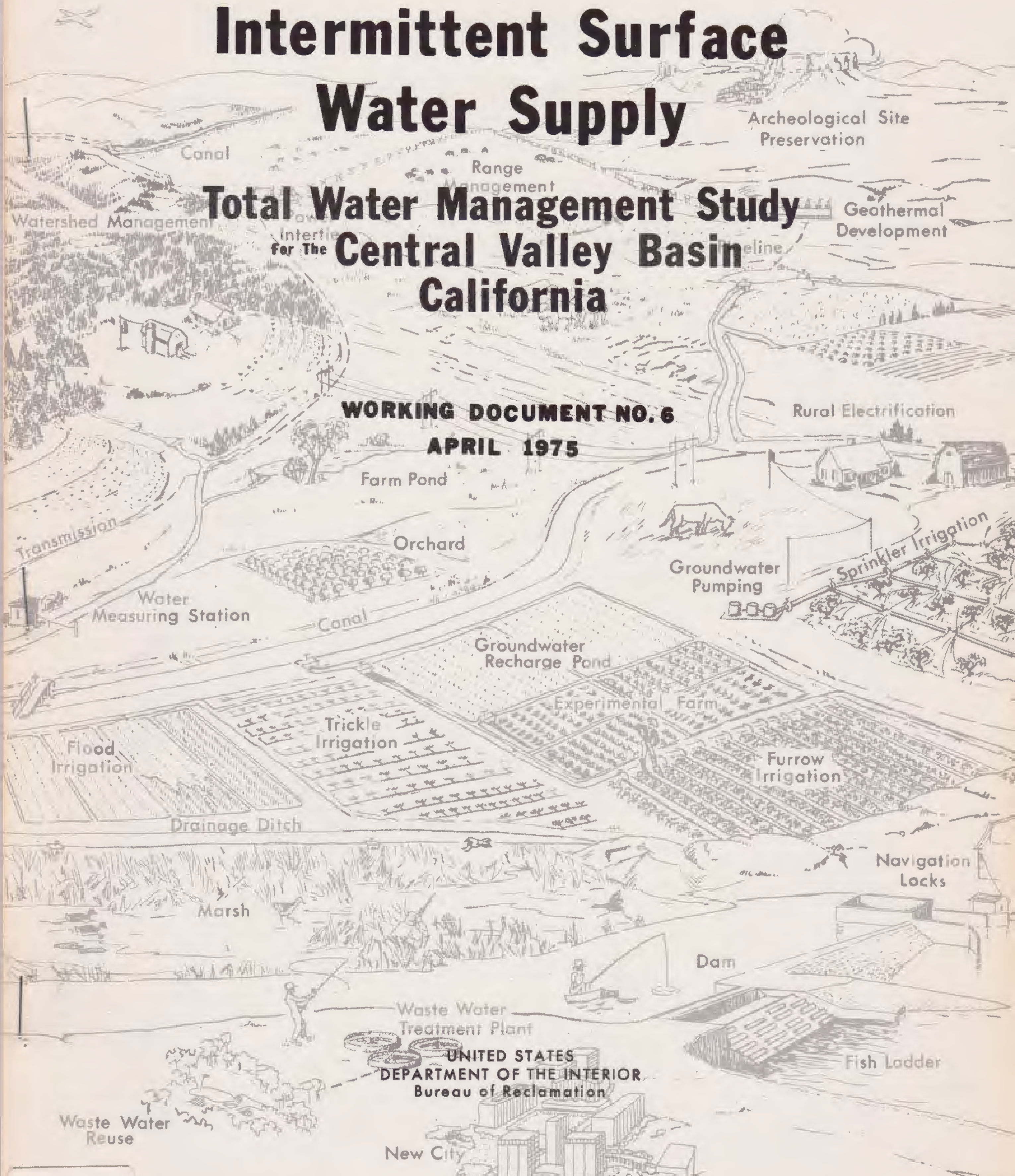
Intermittent Surface Water Supply

Total Water Management Study for The Central Valley Basin California

WORKING DOCUMENT NO. 6

APRIL 1975



UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

TOTAL WATER MANAGEMENT STUDY
FOR THE
CENTRAL VALLEY BASIN, CALIFORNIA

CENTRAL VALLEY PROJECT

INTERMITTENT SURFACE WATER SUPPLY

WORKING DOCUMENT NO. 6

April 1975

THIS REPORT WAS PREPARED PURSUANT TO FEDERAL RECLAMATION LAWS (ACT OF JUNE 17, 1902, 32 STAT. 388 AND ACTS AMENDATORY THEREOF OR SUPPLEMENTARY THERETO). PUBLICATION OF THE FINDINGS AND RECOMMENDATIONS HEREIN SHOULD NOT BE CONSTRUED AS REPRESENTING EITHER THE APPROVAL OR DISAPPROVAL OF THE SECRETARY OF THE INTERIOR. THE PURPOSE OF THIS REPORT IS TO PROVIDE INFORMATION AND ALTERNATIVES FOR FURTHER CONSIDERATION BY THE BUREAU OF RECLAMATION, THE SECRETARY OF THE INTERIOR, AND OTHER FEDERAL AGENCIES.

Bureau of Reclamation

Mid-Pacific Region

CONTENTS

Contents

TABLES

PLATES

INTRODUCTION

Intermittent water, as discussed in this document, is water available only in wet years, which can be controlled by Central Valley Project (CVP) reservoirs, and used the same year to enhance the normal multipurpose functions of the Central Valley Project.

PURPOSE AND SCOPE

This document describes the simulated operation studies which establish the optimum normal multipurpose functions of the Central Valley Project. The operation studies also establish the availability of an intermittent water supply at various locations; the possible uses of such a supply within the Central Valley Project are then examined.

The intermittent water supply could be used for irrigation, for fish, wildlife, and recreation, and for water quality. Emphasis in this document is placed on irrigation use.

The present class 2 water marketing program in the Friant Division is described in order to provide some insight into the possibilities for developing similar programs in other CVP areas. Those areas which are located near existing conveyance facilities and have ground-water recharge potential could benefit from the use of an intermittent surface water supply.

Possibilities in the Tehama-Colusa service area, which seems to possess many of the factors necessary for the success of marketing intermittent water for agricultural use, are explored.

Other multipurpose functions of the Central Valley Project that could benefit from the use of intermittent water supplies are also considered briefly. Maintenance of fish, wildlife, and recreation through Trinity River fish releases is used as an example. Enhancement of minimum water quality conditions in the Sacramento-San Joaquin Delta is another potential use.

CENTRAL VALLEY PROJECT

The Central Valley Project is a series of storage, conveyance, and power facilities in operation, under construction, or planned to make optimum multipurpose use of the water supplies controlled by those facilities.

Introduction

The main storage reservoirs are Shasta, Clair Engle, Whiskeytown, Folsom, Auburn, New Melones, and San Luis. All but Auburn and New Melones are presently in operation.

Project functions are: flood control, power, navigation, recreation, fish and wildlife conservation, water quality, and provision of firm or dependable water supplies for agriculture and municipal and industrial (M&I) uses. The use of water is governed by Federal Reclamation laws and agreements.

The types of services provided by the Central Valley Project vary in time and location, and in many instances, the same water is used for more than one purpose.

A release made from Shasta, for example, to meet a navigation demand can also serve several purposes en route. The water can generate power as it leaves the reservoir, and maintain the fishery in the upper reaches of the Sacramento River. In the river's middle reaches, the same water helps satisfy the navigation flow requirement and then is diverted for export or water quality in the Delta. The return flow reenters the system and becomes available for further project use; possibly to meet a later Delta export requirement or, alternatively, to help maintain Delta outflows.

Shasta and Folsom Lakes are operated, and Auburn Lake and New Melones Reservoirs are to be operated to control floods. Storage space is provided in the reservoirs during the winter and spring months when the danger of flood is present. Releases which are within the capability of the downstream channels are made through the powerplants, outlet works, and spillways. The balance of the inflow is stored until capacity is available in the downstream channels for disposal of floodflows.

In operating the Central Valley Project, each reservoir must meet the demands which can be met only from it. Downstream from the confluence of the Sacramento and American Rivers, there is, however, considerable flexibility in operating to meet the requirements which physically can be served from either the Shasta-Trinity complex or the American River facilities. Service is likely to be from combinations of supplies which can vary from time to time. Delta demands, for example, are commonly met at various times and in varying proportions from the Shasta-Trinity system and from the American River facilities.

Folsom Lake and Auburn Reservoir do not completely control the runoff of the American River to the same degree that Shasta Lake controls the Sacramento River. Accordingly, if maximum use is to be made of American River water, close operational coordination is essential. At times when Folsom has ample water supplies, it can meet an increased share of common requirements, thus relieving the burden on the Shasta-Trinity system. Water can then be stored in the Shasta-Trinity system to be used at a future time and American River water utilized which might otherwise have been lost to the Central Valley Project because of the less-than-adequate control afforded to American River flows by Folsom. This coordination of water operations between the Shasta-Trinity complex and the American River is not without certain limitations. For example, the amount of water that can be brought from the Trinity River to the Sacramento Valley in a given period of time is limited by the capacity of the Clear Creek and Spring Creek Tunnels.

WATER DEMANDS

Demands for water are consumptive or nonconsumptive. Water used for agricultural and M&I purposes is partially consumed. Wildlife uses can also be consumptive in those cases where crops are raised for waterfowl. Within the Sacramento-San Joaquin Delta, the area's natural vegetation consumes a large amount of water. The water required as outflow from the Delta to maintain water quality is lost from the system. Water is also lost through evaporation from the surface of reservoirs and waterways; some seepage losses can accrue to the ground-water basin.

Nonconsumptive uses include recreation in reservoirs and streams, power production, and maintenance of streamflows for fish, navigation, and in-basin water quality requirements. Power releases are subject to reuse downstream after they pass through the powerplant. Fish, navigation, and water quality maintenance flows are usually specified in terms of a flow requirement at a specific point or in a specific reach of stream. Once the flow has passed the specified point or reach, it is subject to reuse. An exception would be water quality releases for Delta outflow, since there are no further CVP multipurpose functions below that point.

WATER SUPPLIES

Runoff in northern California varies widely within a given year and from year to year. The runoff also varies widely from season to season, being highest in the winter and spring, and lowest in the summer and fall months. Many streams in the area are intermittent, having flow only during wet periods of the year.

Variation in flow is common on a weekly, daily, or even hourly basis; for example, during flood periods, runoff can vary widely in very short periods of time.

Because of the great variation in flow over time, regulation through storage is necessary if the water is to be utilized for the project purposes which have high water requirements during those periods of the year when runoff is at a minimum.

The water supplies used to provide project services derive from a combination of three sources--stored water, streamflow, and return flow. The stored water supplies regulated by the reservoirs are the most important. Water is stored during wet periods when inflow to a reservoir exceeds the demands on that reservoir and would otherwise flow to the ocean. The stored water is then released when demands on that reservoir exceed the inflow. In this manner, water which would have passed to the ocean in January, for example, can be saved and used in the following July. Similarly, water stored in a wet year can be used in a subsequent dry year.

The second source of water is the direct use of streamflow as it occurs, when demand and runoff coincide. It is limited, however, because uses frequently are heaviest when runoff is low, and because runoff varies considerably from year to year. Runoff, however, is an important source since watershed areas below project reservoirs are large. At times the runoff or accretions from these areas constitutes a major water supply.

Return flows from project agricultural and M&I uses are the third source of water. To the extent that these uses are reasonably consistent, so also are the return flows from them. Return flows are generally directly related to use timewise, and therefore are greatest when they are most needed. As much as 50 percent of the agricultural supplies and even larger percentages of M&I supplies return to the system. Return flows are an important contribution to water supply, particularly in the downstream reaches of the Sacramento River.

HYDROLOGIC OPERATION STUDIES

SIMULATED OPERATION STUDIES

Simulated operation studies were made to optimize the normal multipurpose functions of the Central Valley Project. The operation studies, made on a monthly basis, considered the inflow and storage in each CVP reservoir in relation to the obligations to be met by the system. The studies similarly established the amount of available intermittent water.

CVP Firm Water Supply

Through the coordinated operation of the Central Valley Project facilities, a firm water supply is provided. This firm supply is the maximum amount of water that can be provided each year on a usable pattern to meet CVP obligations, with allowable deficiencies in critical years. The water supplies provided to CVP service areas in the operation studies are summarized in table 1.

Study Period

The hydrologic study period used in the simulated operation studies for this document is the historic period water year 1922 (Oct. 1921 to Sept. 1922) to water year 1966. It represents a sequence of years which occurred historically and can reasonably be assumed to reoccur.

The water supply for each year of the study period was then modified to represent supplies for two levels of development, the years 1985 and 2015.

Modifications included the effects of additional reservoirs constructed since the historic period or expected to be constructed; and any change occurring or expected to occur in the level of development within a hydrologic basin. Allowances were also made for prior rights by reducing the inflow by an appropriate amount, or by considering the prior right to be an obligation to be recognized in operating the Central Valley Project.

Table 1. Central Valley Project water supply (year 2015 level of development)

	Acre-feet
Coordinated supply available from in-basin Sacramento Valley, American River service area, and Delta exports	9,250,000
Friant Division water supply	1,504,316
Other supply available	652,800
Total supply available	11,407,116

Hydrologic Operation Studies

Criteria

The criteria used in making the simulated operation studies were:

1. **That the** Central Valley Project protect against a recurrence of **a period as severe** as the critical dry period (1928-34).

2. That the CVP reservoirs be operated from full in 1928 to nearly empty in 1934.

3. That deficiencies in agricultural supplies up to 100 percent of one year's supply be tolerated during the critical period.

4. That releases from CVP reservoirs maintain a monthly average of 5,000 cubic feet per second at the navigation control point (NCP) on the Sacramento River during normal years and 4,000 cubic feet per second in critical years.

5. That existing agreements for fish and wildlife requirements below all CVP reservoirs be maintained with permissible deficiencies.

6. That a Delta outflow of 1,800 cubic feet per second maintain the present Federal and State water quality standards.

7. That all in-basin uses be given priority before meeting Delta exports.

Effect of Critical Dry Period

In any year during the historical period 1922-66 which has a water supply above normal, more water is available to utilize for CVP functions than is required for the firm supply. Contracts with existing and potential CVP water users are, for the most part, based on the availability of a maximum water supply which can be guaranteed in normal years. This guaranteed water supply of the Central Valley Project requires focusing on the most severe series of years during the study period. This period, referred to as the critical dry period from 1928 to 1934, contains three normal years (1928-30) and four critical years (1931-34).

At the beginning of a critical dry period such as began in April 1928, all of the main storage reservoirs in the Central Valley Project would be full. At the end of September of the first of those dry years, enough water would be held in storage to ensure the development of the firm yield and dependable capacity in the remaining dry years. The reservoirs would be integrally operated so that, by the end of the critical dry period in December 1934, nearly all of the carryover storage would be used.

With Auburn Reservoir included as an operating storage facility of the Central Valley Project, none of the reservoirs would spill during this period. Any Delta surpluses during the critical dry period would be the large winter accretions originating below a regulatory facility.

Although nearly all of the carryover storage from the CVP reservoirs would be used and there would be no spills during the critical dry period, water could be supplied to meet CVP obligations. The manner in which this water would be supplied would affect the magnitude of the CVP firm water supply.

To moderate the effect of the critical dry period operation, deficiences of 25 percent of one year's agricultural supply are taken, in each of the four critical years. Through scheduling of shipping on the Sacramento River, a saving in navigation releases equivalent to 1,000 cubic feet per second in a month can be realized. No deficiencies are assumed for M&I supplies in the operation studies, but varying degrees of deficiency are accepted for water rights and fishery supplies.

If 25 percent deficiencies in agricultural supplies can be tolerated in critical years, additional water can be furnished in all normal years of the study.

The effect of taking a 25 percent deficiency in irrigation supplies in each of the four critical years is illustrated by the following example:

Water year	Condition	Full supply	Supply, with 25 percent deficiency
1928	Normal	100	116
1929	Normal	100	116
1930	Normal	100	116
1931	Critical	100	88
1932	Critical	100	88
1933	Critical	100	88
1934	Critical	100	88
	Total	700	700

The 116 acre-feet shown in the example could be provided in all years except for the four critical years and for 1924, which is also a critcal year.

INFLOW FORECASTS

Project operation plans are based in part on forecasts of inflow. The amount of water in storage at the end of September can be estimated if the collective storage in CVP reservoirs on April 1 is known, and the inflow expected between April 1 and the end of September can be reasonably forecasted.

To make the forecasts of basin inflow to CVP reservoirs, multipurpose regression equations are used. These equations are based on information for the basin concerning:

1. Water content of snow on the date of forecast at a given number of snow survey stations.

2. Precipitation from July 1 to date of forecast for a given number of stations.

3. Precipitation estimated to occur from date of forecast to June 30.

4. Precipitation from February 1 to June 30 of prior years.

The forecasts utilize these data with the coefficients determined from past historical forecasts. The coefficients are updated as more historical data are available and consequently, as time progresses, the equations become more accurate. These equations are used to provide the Bureau with an estimate of the full natural runoff from April 1, the date of forecast, through July 31. The months of August and September are then extrapolated to determine the inflow for the full season.

The accuracy of the forecasts is largely dependent on the amount of runoff from snowmelt. If a basin has a high degree of spring runoff from snowmelt, the forecast for that basin can be expected to be reasonably accurate. If the basin receives most of its runoff from rainfall, the forecast may be somewhat less reliable.

INTERMITTENT SUPPLIES

Intermittent water in the Central Valley Project, as used in this document, is water which is available only in wet years, can be controlled by CVP reservoirs, and can be used immediately to enhance the normal multipurpose functions of the Central Valley Project.

Hydrologic Operation Studies

The amount of intermittent water available from CVP reservoirs was determined by simulated operation studies for the 1985 and 2015 levels of development.

The quantity of intermittent water available for use in the Sacramento-San Joaquin Delta that could be controlled in Shasta, Folsom, and Auburn is shown on plate 1. In the 1985 level study, in 5 years out of 45 about 1-1/2 million acre-feet is available; in 19 years about 1 million acre-feet is available, with some intermittent water available in 35 years. In the 2015 level study, in one year out of 45 about 1-1/2 million acre-feet is available; in 8 years about 1 million acre-feet is available; and in 20 years some intermittent water is available.

The amount of intermittent water available for use in the Sacramento Valley above the confluence of the Sacramento and American Rivers that could be controlled in Shasta is shown in plate 2. In the 1985 level study, in 16 of the 45 years an intermittent supply in excess of 1/2 million acre-feet would be available, and in 31 years some intermittent supply. In the 2015 level study, in 11 out of 45 years an intermittent supply in excess of 1/2 million acre-feet would be available, with some supply in 20 years.

In establishing the availability of the intermittent supply by April 1 of any year, the information required includes:

1. Storage on April 1.

2. Forecasted inflow for the remainder of the season.

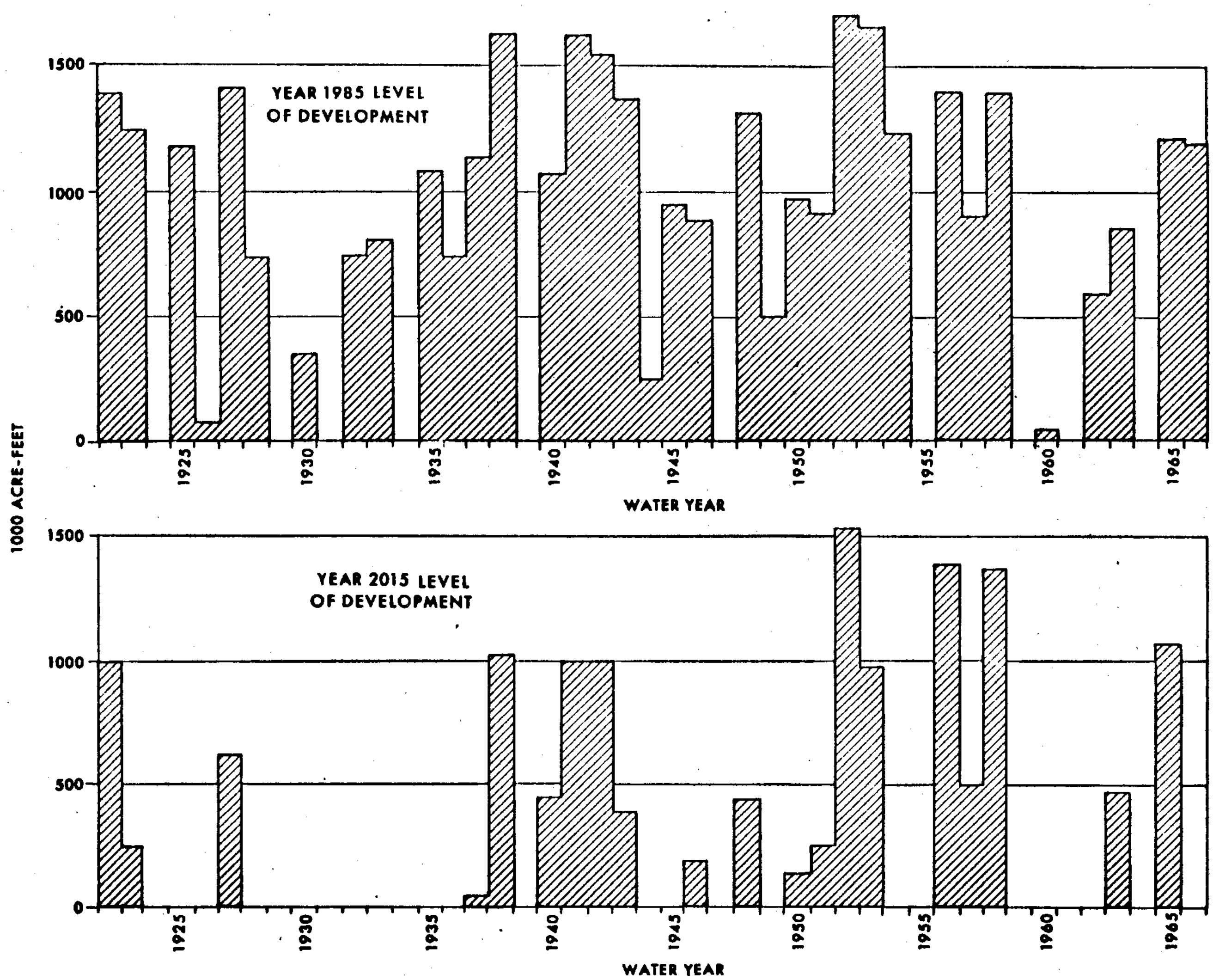
3. Safe-end or minimum carryover storage required at the end of September.

After meeting the requirements for this minimum carryover any additional water in storage could be made available as an intermittent supply in the following year.

Availability of the intermittent supply could be forecasted on April 1, and could be more accurately determined by the end of May.

The intermittent water could be controlled and released on a usable pattern to enhance the multipurpose functions of the Central Valley Project.

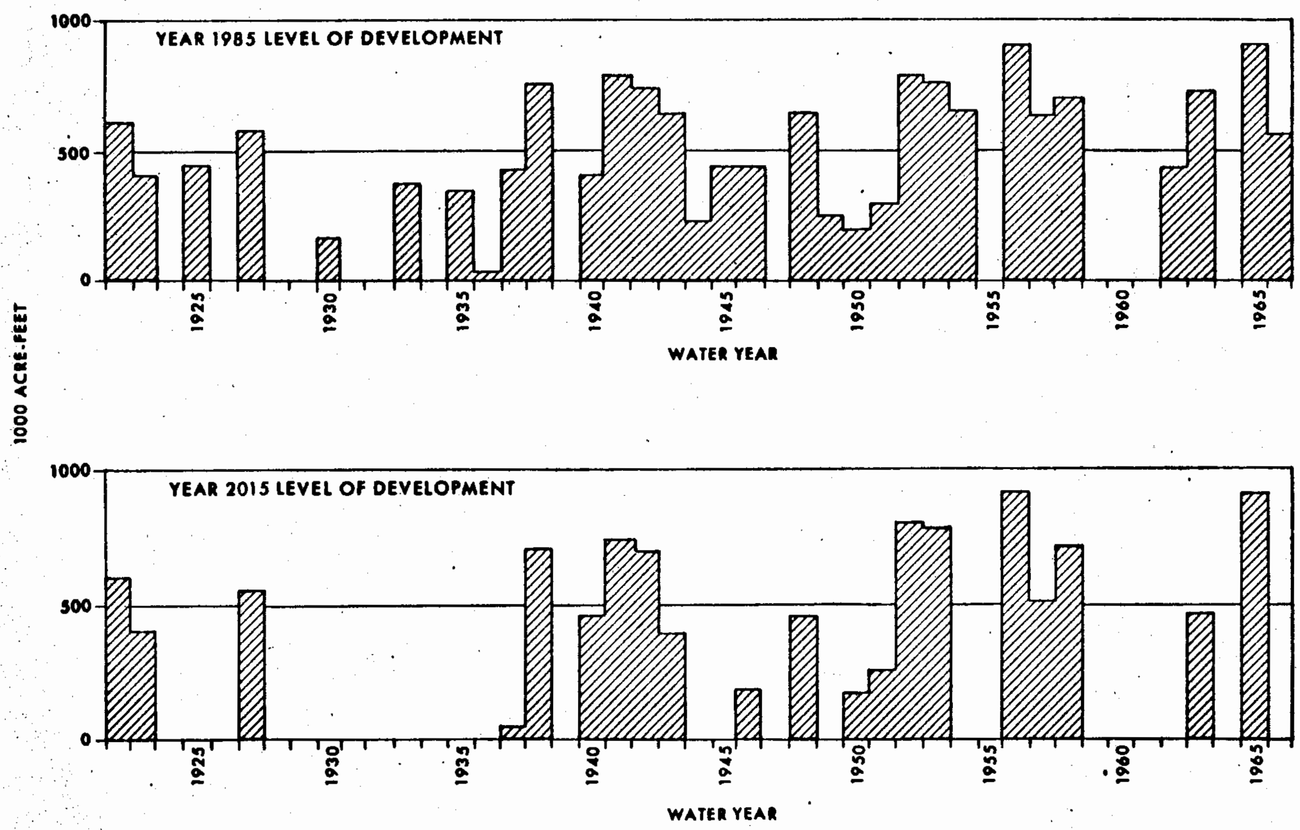
PLATE 1



INTERMITTENT WATER SUPPLY FOR THE DELTA

CENTRAL VALLEY PROJECT

PLATE 2



INTERMITTENT WATER SUPPLY FOR THE SACRAMENTO VALLEY

CENTRAL VALLEY PROJECT

WATER MARKETING IN THE FRIANT DIVISION

An intermittent water supply is presently being utilized in the class 2 marketing program of the Friant Division. Firm and intermittent supplies are delivered from Millerton Lake to the Friant-Kern and Madera Canals.

FRIANT DIVISION

Friant Dam with its reservoir, Millerton Lake, located on the San Joaquin River about 20 miles northeast of Fresno, California, is one of the principal features of the Bureau of Reclamation's Central Valley Project.

Millerton Lake has a gross storage capacity of 520,500 acre-feet, with about 385,000 acre-feet of usable storage space. The reservoir controls flows of the San Joaquin River, with downstream releases to meet water rights requirements above Mendota Pool, and provides conservation storage and diversion into Madera and Friant-Kern Canals. It also provides flat-water recreation opportunities and controls floods consistent with its operations for other functions.

The Friant-Kern Canal carries water southerly from Millerton Lake, serving areas in Fresno, Tulare, Kings, and Kern Counties. The canal is 152 miles long, and has an initial capacity of 4,000 cubic feet per second, terminating at the Kern River about 4 miles west of Bakersfield. At present, 135 structures are used to make deliveries to water customers.

The Madera Canal diverts water northerly from Millerton Lake to lands in Madera County for use by the Madera Irrigation District and Chowchilla Water District. The canal, with an initial capacity of 1,000 cubic feet per second, is 36 miles long and terminates at the Chowchilla River. Eight structures deliver water to the two districts.

The natural runoff in the San Joaquin River basin at Friant Dam averages about 1.8 million acre-feet annually. Annual flows vary from a high of 4.37 million acre-feet in water year 1906 to a low of 445,000 acre-feet in water year 1924. Millerton Lake regulates a portion of the annual surface runoff. Reservoirs of the Southern California Edison Company and Pacific Gas and Electric Company (PG&E) provide additional regulation of surface water.

The Southern California Edison Company has an extensive system of powerplants and storage reservoirs with a total storage capacity of 572,000 acre-feet. PG&E owns and operates Crane Valley Reservoir

(Bass Lake) with 45,000 acre-feet of storage. During heavy rains, these reservoirs greatly reduce potential flooding, and store water for later season releases.

Since the surface reservoirs do not have sufficient capacity to provide carryover storage for the total water supply available from year to year, the underground reservoir or ground-water storage is drawn down during dry years and is recharged during wet years. When the Millerton Lake supply is insufficient to meet the service area demands, ground-water pumping is necessary.

MARKETING PROGRAM

Water Use

San Joaquin River flows and releases from reservoir storage at Millerton Lake furnish an average annual supplemental water supply of 800,000 acre-feet of firm or class 1 water to the Friant Division service area. About 660,000 acre-feet is delivered by the Friant-Kern Canal, and the balance by the Madera Canal.

Class 1 water is available on a dependable basis to meet irrigation and municipal and industrial (M&I) demands, except in very dry years when deficiencies may have to be imposed on the deliveries. In any year of shortage, the Bureau reserves the right to apportion the available supply among those entitled to receive class 1 water. Most of the class 1 water is used by the water and irrigation districts to meet agricultural demands, including domestic use incidental to agricultural needs and stock watering. The cities of Fresno and Orange Cove are furnished small quantities of M&I water. Two users receive a maximum of 350 acre-feet of M&I water directly from Millerton Lake.

Class 2 water, the intermittent supply in excess of class 1 water, is available in most years, with large quantities available in some years, and none in others. The class 2 water marketed in the Friant Division since 1955 is shown on plate 3 and in table 2. The maximum amount of class 2 water marketed was 1,128,341 acre-feet in 1969. The maximum entitlement of all long-term contractors along the Friant and Madera Canals to class 2 water as established in 1974, is 1,402,800 acre-feet as shown in table 3. The average amount of class 2 water marketed since 1955, is 609,901 acre-feet annually, or less than half of the maximum entitlement.

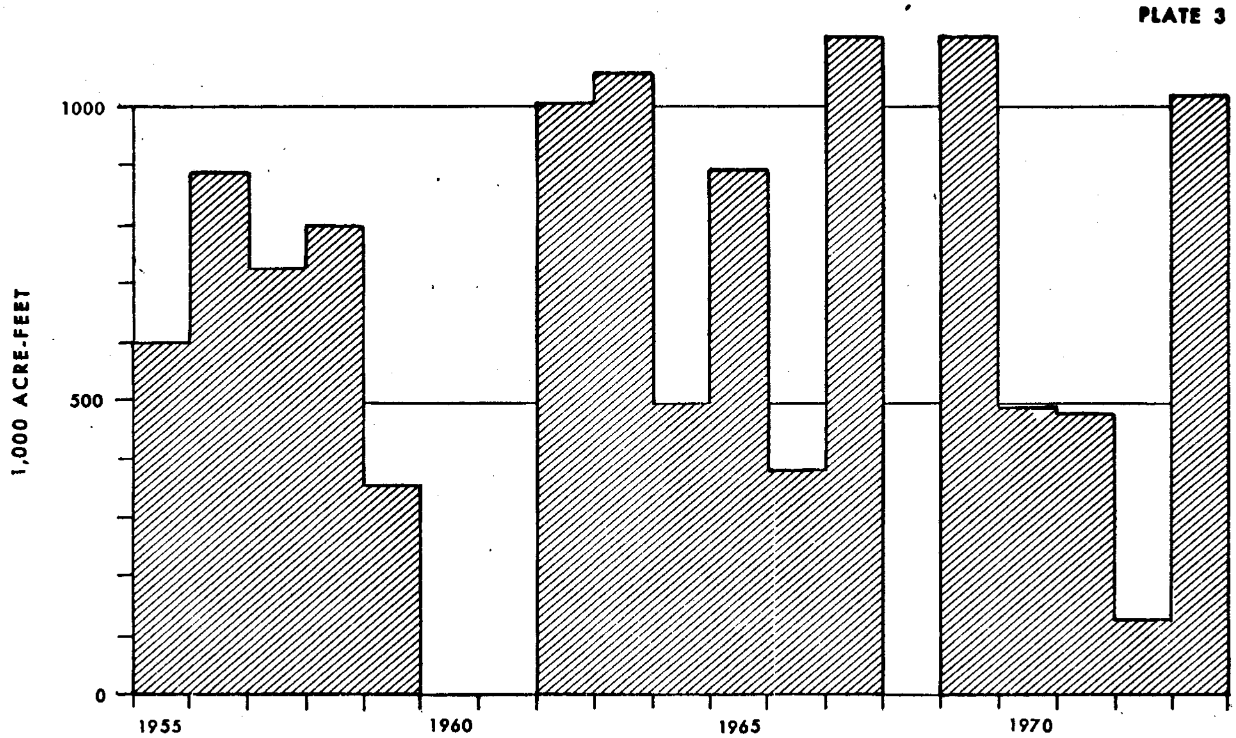
Table 2. Class 2 water marketed, Friant Division[a]

Contract year[b]	Friant-Kern Canal	Madera Canal (acre-feet)	Total
1955	456,402	149,627	606,029
1956	707,294	173,601	880,895
1957	563,461	156,976	720,437
1958	653,507	140,000	793,507
1959	272,870	81,400	354,270
1960	0	0	0
1961	0	0	0
1962	863,552	155,000	1,018,552
1963	870,782	194,000	1,064,782
1964	419,744	74,827	494,571
1965	868,278	22,800	891,078
1966	294,747	85,219	379,966
1967	883,821	241,197	1,125,018
1968	0	0	0
1969	788,032	340,309	1,128,341
1970	390,645	104,340	494,985
1971	358,250	121,100	479,350
1972	118,531	13,840	132,371
1973	814,216	209,750	1,023,966
Total	9,324,132	2,263,986	11,588,118
Average	490,744	119,157	609,901

[a] Marketed to long-term contractors and also through transfer to short-term contractors. Quantities are actual deliveries to districts.

[b] April 1 to March 31.

PLATE 3



CONTRACT YEAR (APRIL 1 TO MARCH 31)

CLASS 2 WATER MARKETED IN FRIANT DIVISION

CENTRAL VALLEY PROJECT

Table 3. Class 2 water entitlements of long-term contractors, Friant Division

Long-term contractor		Class 2 entitlement (acre-feet)
Friant-Kern Canal		
Arvin-Edison W.S.D.		313,000
Delano-Earlimart I.D.		74,500
Exeter I.D.		19,000
Fresno I.D.		75,000
Ivanhoe I.D.		7,900
Lindmore I.D.		22,000
Lower Tule River I.D.		238,000
Porterville I.D.		30,000
Saucelito I.D.		32,800
Shafter-Wasco I.D.		39,600
Southern San Joaquin M.U.D.		50,000
Tulare I.D.		141,000
Gravely Ford[a]		14,000
	Subtotal	1,056,800
Madera Canal		
Chowchilla W.D.		160,000
Madera I.D.		186,000
	Subtotal	346,000
	Total	1,402,800

[a] Being negotiated.

Note: Types of districts are: WSD - water service
ID - irrigation
WD - water
MUD - municipal utility

Class 2 supplemental water is used for direct surface application during years when it is available to meet irrigation demands on pattern. This has relieved, at least in part, the need to pump from the ground-water supply.

In years when the class 2 supply is available in months with little irrigation demand, a large block of water is used to recharge the underground reservoir.

Consolidated Irrigation District, a short-term contractor, acquires surplus water by transfer from a long-term contractor, primarily for ground-water recharge through means of percolation ponds. Surplus water is water in excess of that required to meet water rights demands, operational losses, and the needs of long-term contractors.

Water Contractors

Approximately 26 water user organizations have long-term contracts for supplemental water from Millerton Lake on a firm annual basis. Of these, 22 users have the water delivered to them via the Friant-Kern Canal, 2 from the Madera Canal, and 2 directly from Millerton Lake. These users hold long-term contracts with the United States, indicating that a dependable or firm supplemental water supply will be available for delivery during each irrigation season--except for infrequent water-shortage years.

The class 2 entitlements of long-term contractors are shown on table 3. Another 20 water users have received water from Millerton Lake under short-term or 10-year contracts when surplus water is available. All 20 users have obtained water from Friant-Kern Canal.

Declaration of Available Water

As soon after February 1 as snow survey data are available, a forecast of the anticipated seasonal runoff in the San Joaquin watershed above Friant Dam is developed. The forecast considers such factors as antecedent precipitation, projected subsequent precipitation, and the water content of snow. The forecasts are compared with similar forecasts made by the State of California, the River Forecast Center of the National Weather Service, and Southern California Edision Company.

Before February 15, the water users are furnished with an estimate of the water supply available to them for the water year. By March 1 the water users submit their initial schedules for water desired during the year. These schedules are reviewed to determine if the supply available for the year can be regulated to meet them.

Subsequent runoff forecasts are made monthly as soon as snow survey and precipitation data are available.

Contract Administration

The long-term water service contractors and Bureau representatives meet monthly, February through September. The updated water supply forecasts are furnished the users at these meetings, and any problems in operation of the facilities and delivery of water are discussed.

Revision of runoff forecasts usually changes the delivery schedules. Although the supply may be sufficient to meet class 1 water demands, class 2 schedules can be increased or decreased. Available class 2 water is prorated among the water users in proportion to their contractual entitlements. Water users may adjust their schedules during the year as long as the project facilities can deliver the desired water. To meet emergency conditions, schedule revisions may be requested at any time.

Water users with long-term contracts are, in most cases, required to submit schedules which include both classes of water. If the supply is not adequate to meet all water schedules, class 2 schedules are reduced before class 1 schedules are affected.

The Bureau endeavors to meet the water schedules submitted by long-term contractors. When the runoff forecasts indicate those contract obligations can be satisfied, any water remaining can be marketed to short-term users, or used in other project operations.

The short-term contractors can order water only as it becomes available in amounts greater than the demands for long-term water.

The Bureau advises each contractor of the quantity of class 1 and class 2 water delivered and furnishes a statement of the charges made against funds which were advanced by the contractor for that year's water service.

Policy Statement

A water policy statement is furnished annually to all of the water users. It includes the priorities to use of the Millerton Lake water supply, dates of required water schedules, and rates of water charges. These rates are $3.50 per acre-foot for class 1 and $1.50 per acre-foot for class 2 water. Bureau officials must approve proposed transfers of water between water users, as well as sales of water to other than the long-term contractors. Transfers and sales are subject to these limitations:

1. Water available for transfer or sale must first be offered to agricultural users holding long-term contracts, and at the same price as it would be offered subsequently to water users with a lesser priority.

2. A district cannot sell class 1 water to another district while the seller district has class 2 water available for its use.

3. The sale or transfer of class 1 or class 2 water cannot be approved if the sale or transfer has an adverse effect on either the supply available or delivery rate to other long-term service contractors.

LIMITATIONS

Primarily because of the limited storage capacity available at the Friant damsite, Millerton Lake and the Friant and Madera Canals were designed so that class 2 water could be provided. Physical limitations in the use of class 2 water in the Friant Division service area include timing of supply and demands, possible change in cropping patterns, canal capacities, and percolation ability.

Because of varying weather conditions, and the increasing accuracy of the estimates, Millerton Lake water supply forecasts change from month to month, sometimes considerably. Quantities of water available to water users, especially those relying on a class 2 supply, also change. The water users tend to schedule available class 2 water early in the year, reserving their class 1 water for use during peak summer demands. Should a class 2 user divert scheduled water early in the season and the water supply subsequently be reduced, the class 2 supply would be reduced, with any use that exceeds the adjusted class 2 allotment charged as class 1. When the Millerton Lake available supply is adjusted downward, the class 2 user's supply is reduced.

During wet periods, when the water demands are lower, diversions from Millerton Lake are smaller, and the reservoir fills at a more rapid rate. These conditions and early season storms or snowmelt can require flood control releases to the San Joaquin River with a loss of water.

The total water supply available determines when the users schedule their shares of class 1 and class 2 water. Crops other than the citrus, fruit, and walnut orchards already established in the service area could be affected. If the planned water supply is altered, the crop yields may be reduced.

The Millerton Lake water users prefer to schedule the large portion of their water deliveries during the late spring and summer season. Unless some adjustments are made during the season, canal capacity may be insufficient to meet all water orders. Because of class 1 priority, class 2 users in some years could be denied the use of their water when it might be urgently needed.

Part of the water supply used for direct service percolates to the underground. Some of the class 2 is used specifically for percolation to replenish the underground supply, with recharge limited to the percolation capability of the ponds or channels.

GROUND-WATER INTEGRATION

In many areas of the Central Valley of California, pumping exceeds the safe yield of the ground-water basin, with ground-water overdraft. Conjunctive use of ground water and an intermittent surface supply could alleviate some of the areal overdrafts, and stabilize ground-water levels.

PRESENT OPERATIONS

Most recharge occurs under natural conditions. Artificial recharge of ground-water basins in California began as early as 1911, gained impetus during the 30's, and increased steadily since that time.

Artificial recharge is the intentional replenishment of ground water. Natural stream channels and manmade basins are used extensively to add large volumes of surface water to the ground-water basins.

Very little regional data are published in summary form; most data concern specific agency operations or research on the methodology of artificial recharge. Data for the Sacramento Valley are particularly scarce, with only a few percolation studies concerning channel losses along specific streams. A cooperative study by the U.S. Geological Survey and California Department of Water Resources is now underway in the Sacramento Valley.

Artificial recharge operations in the Central Valley have been confined mainly to the upper San Joaquin Valley--especially in the area from the Chowchilla River to the Tehachapi Mountains, where reported intentional recharge in water year 1973 amounted to 1,390,000 acre-feet. The extent of the recharge activities there can be attributed, at least in part, to the presence and operational flexibility of the CVP facilities. Most of the supply is class 2 water delivered from Millerton Lake by the Madera and Friant-Kern Canals.

POTENTIAL RECHARGE AREAS

Potential areas for integration of ground and surface water supplies are those areas with well systems and CVP conveyance facilities to deliver the surface supply. Areas within the CVP operational area with a potential for artificial recharge of the ground water are:

1. Arbuckle Plain in the Tehama-Colusa Canal area.
2. Cosumnes River--Deer Creek Complex and Dry Creek.
3. Pleasant Valley in the Coalinga Canal area.
4. Millerton Lake service area, where those agencies have expressed a desire for more water to be used for recharge.
5. Gravel pit locations near CVP conveyance facilities.

TEHAMA-COLUSA SERVICE AREA

The Tehama-Colusa service area of the Central Valley Project is one of the areas in which an intermittent or a class 2 water marketing program might advantageously be implemented. This area seems to possess many of the factors necessary for the success of such a program. The area has a need for water; an intermittent water supply appears to be available from Shasta Lake; the Tehama-Colusa Canal can deliver the intermittent supplies, and the present conjunctive use could be increased.

To demonstrate how the projected needs for water in the Tehama-Colusa service area could be satisfied, the availability of surface supplies and ground-water supplies is indicated. Conjunctive use of the supplies within the area is explored in order to increase the use of ground-water resources, lower the requirement for a firm surface water supply, and maintain the planned level of development with the use of a class 2 water supply.

DESCRIPTION

The Tehama-Colusa service area, encompassing some 1,100 square miles, is bounded by the Sacramento River on the east, the Coast Range foothills on the west, Rice Creek near Corning on the north, and Cache Creek Slough near Dunnigan on the south. The Tehama-Colusa Canal is presently under construction. The canal, which extends southerly from Red Bluff Diversion Dam, will be approximately 122 miles long when completed and will serve irrigation needs in Tehama, Glenn, Colusa, and northern Yolo Counties. The initial diversion capacity is 2,300 cubic feet per second.

The principal land use is for agriculture. Of the 239,732 acres within the service area, 235,529 were devoted to agricultural uses in a study made in 1952. Farm delivery requirements were calculated to be about 517,000 acre-feet, or about 3.0 acre-feet per acre for 172,200 acres under full development. The farm delivery requirement is the quantity of water, exclusive of utilizable rainfall, required to bring the crop to maturity. It includes economically unavoidable losses, such as percolation, runoff, and nonbeneficial evapotranspiration.

Ground-Water Conditions

Ground-water safe yield in the Tehama-Colusa service area under present recharge conditions is approximately 130,000 acre-feet annually. Under ultimate project conditions, the safe annual yield is estimated to be about 151,000 acre-feet, or approximately one-fourth of the service area's total water needs.

The area's underground reservoirs have a gross storage capacity for the depth interval of 20 to 200 feet of about 2 million acre-feet. The primary water-bearing materials are unconsolidated continental deposits; consolidated nonwater-bearing sands and shales form the bedrock floor throughout most of the area.

Without exception, the deep wells tap confined aquifers which extend generally westerly beyond the limits of the Tehama-Colusa service area. The shallow water-producing zone is largely confined, with small areas of unconfined or semiconfined ground water in the western part of the Arbuckle plain, the western part of Willow Creek plain, in the Stony Creek flood plain, and the Capay plain. Over 80 percent of the total ground-water yield comes from deep and shallow confined zones; however, because of artesian pressure, water is seldom lifted over 100 feet. Most confined zones are generally below a depth of 100 feet.

Except for isolated areas, static ground-water levels showed no definite large long-term lowering for the period 1947 to 1959. Studies since 1959, made prior to project deliveries from the Colusa Basin Drain, show marked declines and overdraft southwest of Arbuckle; water levels are still declining northwest of Arbuckle. Since 1959 the area west of Artois also shows pumping depressions and declining levels.

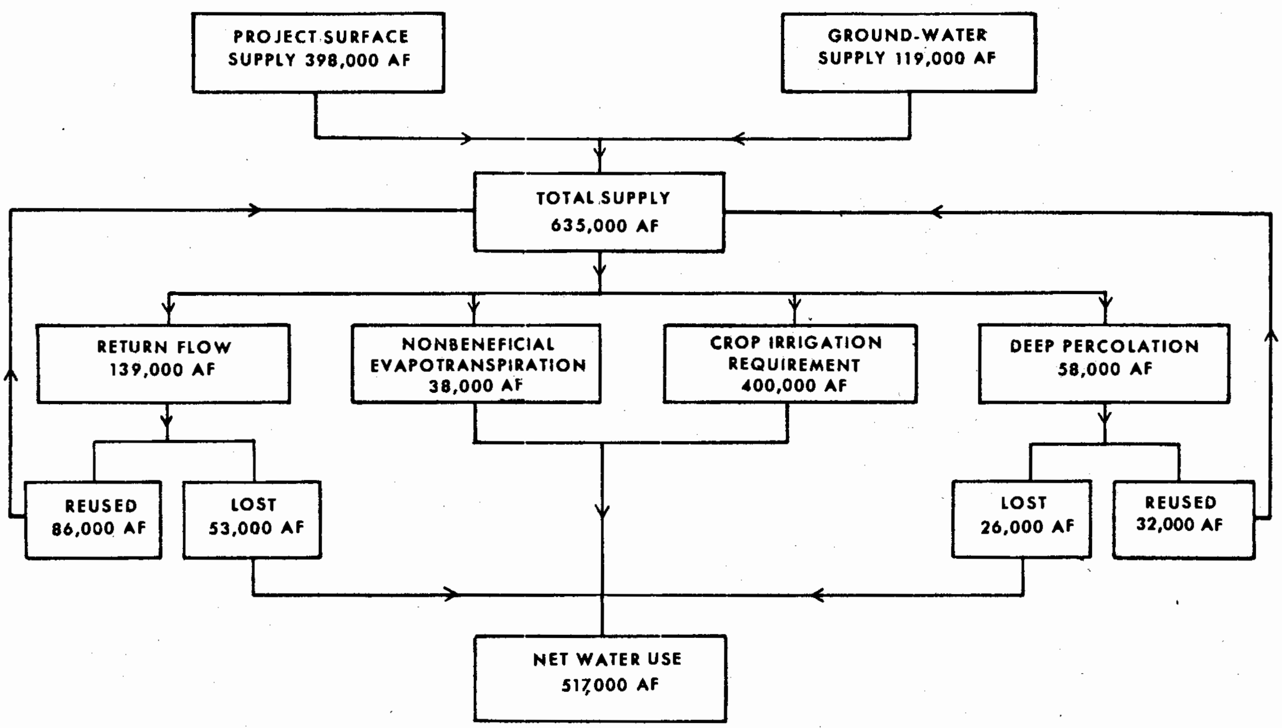
Ground-water recharge occurs primarily from rainfall and to a lesser extent from stream losses within the dissected uplands west of the pumping areas. Nonpressure pumping areas are also recharged from percolation of a portion of the water applied for irrigation. Extreme easterly portions of the Tehama-Colusa area are recharged by underflow from the Sacramento River area.

Increasing ground-water pumpage has caused some problems of mutual well interference, increased pumping lifts, and greater costs because of the deeper drilling required to obtain adequate yields. Pumpage for irrigation in 1959 amounted to about 133,000 acre-feet. In some areas pumpbowl settings were lowered in an attempt to maintain well output, which declined due to pumping interference between wells. Pump lifts range from 25 to over 200 feet, however, they are generally less than 100 feet.

Water Requirements

The annual water balance for a normal year in the Tehama-Colusa service area under ultimate conditions is presented in plate 4.

PLATE 4



ANNUAL WATER BALANCE, NORMAL YEAR
TEHAMA-COLUSA SERVICE AREA
CENTRAL VALLEY PROJECT

The amount of water needed to bring crops in the Tehama-Colusa service area to maturity is about 635,000 acre-feet per year. The total annual requirements, shown by month on plate 5 and table 4, include: 400,000 acre-feet for the crop irrigation requirement, and losses of return flow of 139,000 acre-feet, non-beneficial evapotranspiration from native vegetation of 38,000 acre-feet, and deep percolation of 58,000 acre-feet for a total of 635,000 acre-feet.

Present Water Supplies

The water supply of 635,000 acre-feet per year comes from three sources: surface water supplies delivered from the Tehama-Colusa Canal, ground-water pumping, and return flow.

The project surface supply delivered by the canal is 398,000 acre-feet, including 10 percent losses.

The safe annual yield of ground water in the service area, estimated to be 151,000 acre-feet, includes 119,000 acre-feet of natural recharge and 32,000 acre-feet of percolated irrigation water.

Return flow, the surface runoff that can be recaptured and reused within the service area, will amount to about 86,000 acre-feet per year annually. Monthly distribution of the water supply for the planned normal operation, using the safe ground-water yield, is shown on plate 6 and table 5.

INTERMITTENT WATER SUPPLIES

Supply Available

An intermittent water supply could be made available to the Tehama-Colusa service area from Shasta Lake. The operation study shows that, exclusive of the critical dry period (1928-34), sufficient intermittent water would be available from Shasta Lake to replace ground-water pumping in the service area about half of the time. (See plate 2)

Table 6 illustrates the effect on the ground-water storage if the Central Valley Project were operating at the year 2015 level of development through a period similar to 1922-66, taking no deficiencies in the firm project supply of 320,000 acre-feet.

PLATE 5

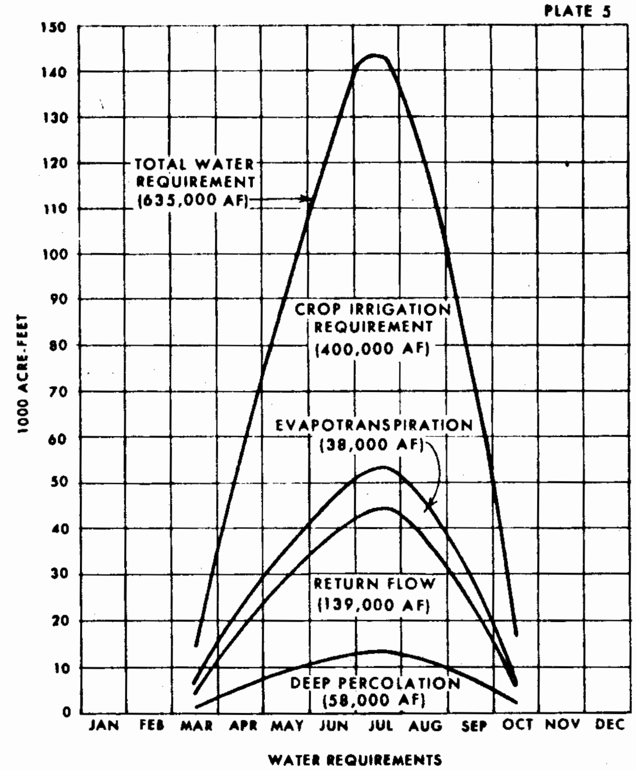
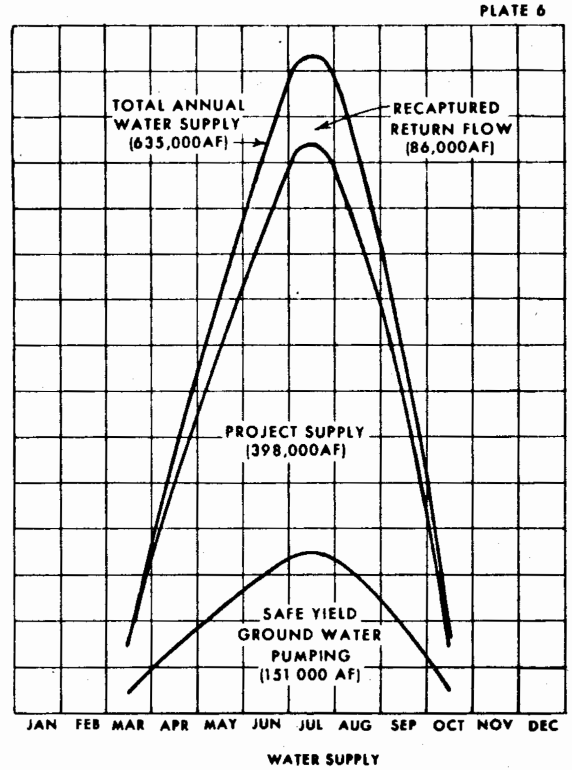


PLATE 6



WATER REQUIREMENTS AND SUPPLIES
PLANNED NORMAL OPERATION
TEHAMA-COLUSA SERVICE AREA
CENTRAL VALLEY PROJECT

Table 4. Water requirements, Tehama-Colusa service area

Month	Crop irrigation requirement	Losses: Return flow	Losses: Nonbeneficial evapo-transpiration	Losses: Deep percolation	Total water requirement
		(1,000 acre-feet)			
January	-	-	-	-	-
February	-	-	-	-	-
March	8	3	1	1	13
April	36	13	3	5	57
May	56	20	5	8	89
June	76	26	7	11	120
July	90	31	9	13	143
August	76	27	7	11	121
September	48	16	5	7	76
October	10	3	1	2	16
November	-	-	-	-	-
December	-	-	-	-	-
Total	400	139	38	58	635

Table 5. Water supplies for planned operation, Tehama-Colusa service area

Month	Project water	Safe yield, ground-water	Return flow	Total water supply
		(1,000 acre-feet)		
January	-	-	-	-
February	-	-	-	-
March	8	3	2	13
April	36	13	8	57
May	56	21	12	89
June	75	29	16	120
July	90	34	19	143
August	75	29	17	121
September	48	18	10	76
October	10	4	2	16
November	-	-	-	-
December	-	-	-	-
Total	398	151	86	635

Table 6. Effect of intermittent water supply on ground-water storage, Tehama-Colusa service area (year 2015 level of development)

Water year	Water supply: Project water: Intermittent	Water supply: Project water: Total	Water supply: Ground water	Ground-water storage: Effect on safe yield	Ground-water storage: Cumulative effect
	(1,000 acre-feet)				
1922	229	549	0	+151	+151
1923	229	549	0	+151	+302
1924	0	320	229	- 78	+224
1925	0	320	229	- 78	+146
1926	0	320	229	- 78	+ 68
1927	229	549	0	+151	+219
1928	0	320	229	- 78	+141
1929	0	320	229	- 78	+ 63
1930	0	320	229	- 78	- 15
1931	0	320	229	- 78	- 93
1932	0	320	229	- 78	-171
1933	0	320	229	- 78	-249
1934	0	320	229	- 78	-327
1935	0	320	229	- 78	-405
1936	0	320	229	- 78	-483
1937	33	353	196	- 45	-528
1938	229	549	0	+151	-377
1939	0	320	229	- 78	-455
1940	229	549	0	+151	-304
1941	229	549	0	+151	-153
1942	229	549	0	+151	- 2
1943	229	549	0	+151	+149
1944	0	320	229	- 78	+ 71
1945	0	320	229	- 78	- 7
1946	181	501	48	+103	+ 96
1947	0	320	229	- 78	+ 18
1948	229	549	0	+151	+169
1949	0	320	229	- 78	+ 91
1950	229	549	0	+151	+242
1951	229	549	0	+151	+393
1952	229	549	0	+151	+544
1953	229	549	0	+151	+695
1954	0	320	229	- 78	+617
1955	0	320	229	- 78	+539
1956	229	549	0	+151	+690
1957	229	549	0	+151	+841
1958	229	549	0	+151	+992
1959	0	320	229	- 78	+914
1960	0	320	229	- 78	+836
1961	0	320	229	- 78	+758
1962	0	320	229	- 78	+680
1963	229	549	0	+151	+831
1964	0	320	229	- 78	+753
1965	229	549	0	+151	+904
1966	0	320	229	- 78	+826

During a period as severe as the 1923-34 critical period, pumping a maximum of 229,000 acre-feet per year would overdraft ground-water supplies by over 1/2 million acre-feet by the end of 1937. It would then take about 6 years using the surface intermittent supply with no ground-water pumping in order to recharge the basin, and thus maintain desirable equilibrium conditions.

Wet Year Operation

In a wet water year, forecasted intermittent supply would be available from Shasta Lake for use in the Tehama-Colusa service area, and no ground water would be pumped. The operation during a wet year is shown in plate 7 and table 7. Of a total surface supply of 549,000 acre-feet per year diverted, 320,000 acre-feet would be a firm or class 1 supply, and 229,000 acre-feet an intermittent or class 2 supply.

The replacement of the entire ground-water supply by surface water is an extreme possibility which is based on the following assumptions:

1. All pumping would cease for the irrigation season.
2. The Tehama-Colusa Canal would have sufficient capacity to meet demands in full from surface supplies.
3. The area's ground-water level would not be so high as to create a drainage problem.
4. Irrigators would maintain pumps and pay energy standby charges during this period of no pumping.
5. A dual distribution system, if required, would be built to distribute water supplies from both the Tehama-Colusa Canal and ground-water pumping.

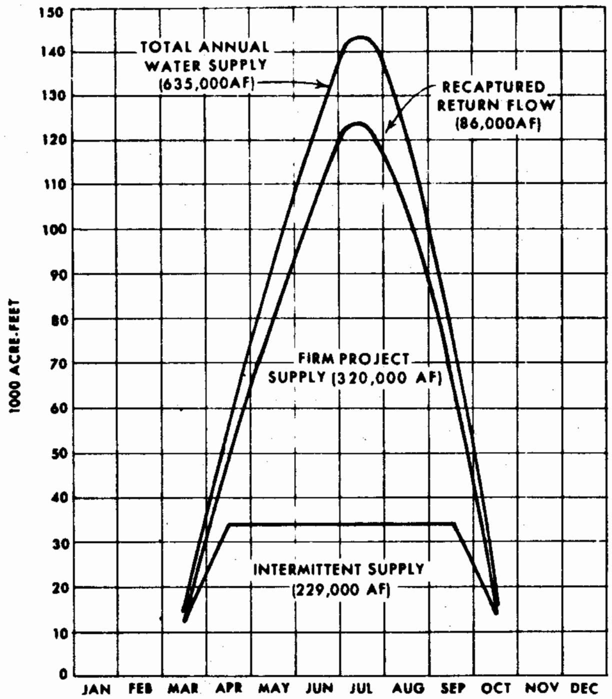
The ground-water table would be recharged by 151,000 acre-feet.

Dry Year Operation

In a dry year, when little or no intermittent surface water supply would be available, the ground-water supply would be used. Without extensive construction of new pumps, a maximum of 34,000 acre-feet could be pumped in the month of July, or about 229,000

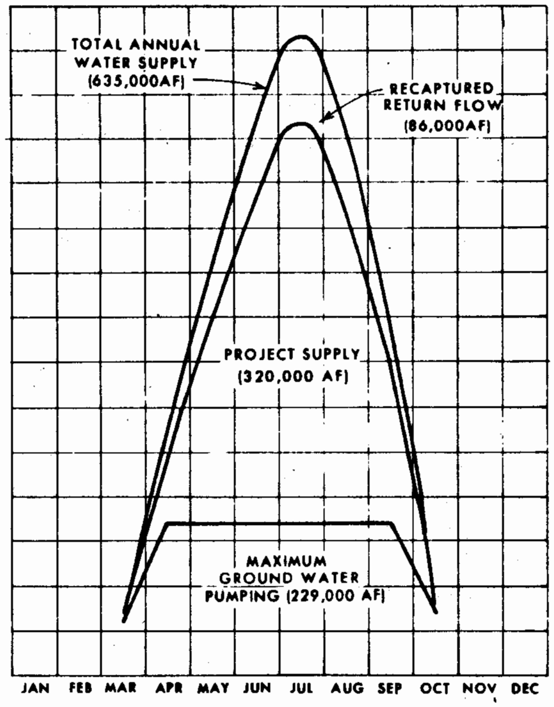
Tehama-Colusa Service Area

PLATE 7



WET YEAR WITH INTERMITTENT SUPPLIES

PLATE 8



DRY YEAR WITH MAXIMUM GROUND WATER PUMPING SUPPLIES

WATER SUPPLIES, WET YEAR AND DRY YEAR, UTILIZING INTERMITTENT WATER

TEHAMA-COLUSA SERVICE AREA

CENTRAL VALLEY PROJECT

Table 7. Water supplies in a wet year, with intermittent water, Tehama-Colusa service area

Month	Project water: Firm	Project water: Intermittent	Ground-water	Return flow	Total water supply	Ground-water recharge
			(1,000 acre-feet)			
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	0	11	0	2	13	+ 3
April	15	34	0	8	57	+13
May	43	34	0	12	89	+21
June	70	34	0	16	120	+29
July	90	34	0	19	143	+34
August	70	34	0	17	121	+29
September	32	34	0	10	76	+18
October	0	14	0	2	16	+ 4
November	-	-	-	-	-	-
December	-	-	-	-	-	-
Total	320	229	0	86	635	+151

Table 8. Water supplies in a dry year, with ground-water overdraft, Tehama-Colusa service area

Month	Project water: Firm	Project water: Intermittent	Ground-water	Return flow	Total water supply	Ground-water overdraft
			(1,000 acre-feet)			
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	0	0	11	2	13	-8
April	15	0	34	8	57	-21
May	43	0	34	12	89	-13
June	70	0	34	16	120	-5
July	90	0	34	19	143	0
August	70	0	34	17	121	-5
September	32	0	34	10	76	-16
October	0	0	14	2	16	-10
November	-	-	-	-	-	-
December	-	-	-	-	-	-
Total	320	0	229	86	635	-78

acre-feet annually. Use of the surface water supply could then be reduced to 320,000 acre-feet per year, with the ground water overdrafted by 78,000 acre-feet.

The monthly operation during a dry year is shown on plate 8 and table 8.

FUTURE CONSIDERATIONS

The expanded conjunctive use program for the Tehama-Colusa service area illustrates one way in which an intermittent water supply could be used to reduce the need for a firm supply.

In this illustration, 229,000 acre-feet of the water supply for the Tehama-Colusa area would be obtained from surface intermittent or class 2 water available in wet years, and from ground-water pumping in dry years.

The many economic factors involved if intermittent water were to be used in the Tehama-Colusa service area have not been evaluated. These include:

1. The charge for intermittent or class 2 water vs. class 1 water.

2. The added costs for

    (a) Pump installations that might lie idle for up to four consecutive years.

    (b) The increase in pump lift during periods of ground-water overdraft.

    (c) The dual distribution system.

    (d) Pumping into a closed system such as pressurized pipeline.

The suggested operational plan would result in a reduction in the requirement for a firm project supply from 398,000 to 320,000 acre-feet annually. This 78,000 acre-feet could be marketed to other potential Bureau customers and thus enhance the normal multipurpose functions of the Central Valley Project. The added costs associated with the use of intermittent water might appropriately be shared by those potential customers.

Tehama-Colusa Service Area

Before an adequate assessment can be made of the suggested alternative uses of intermittent water in this service area or in other areas, economic analyses of those alternatives would be required.

It might be possible in a wet year to reduce the pumping requirement rather than totally eliminating the need for pumping. The saving in firm water supply would be reduced, but such an alternative might be more economically attractive, as there would be less need for dual distribution systems.

Another alternative which has not been examined would be to store the intermittent surface supply in an offstream surface reservoir, and distribute the water to the area of need in dry years. To replace the firm water supply of 78,000 acre-feet, for example, could require a reservoir with a capacity of over 800,000 acre-feet, if the intermittent water were the only source of reservoir inflow and assuming a drought period of 10 years with no inflow.

An intermittent water supply could be used to enhance streamflows for recreation, fish and wildlife. It might also be used in the Sacramento-San Joaquin Delta to enhance the existing water quality.

FISH AND RECREATION

Intermittent water could be released to enhance downstream conditions for reacreation, fish and wildlife. Any flows in excess of the minimum streamflows established by reservoir operating agreements could be used to enhance stream conditions. The Trinity River below Lewiston Dam is one such stream.

Trinity River

Fishery of the Trinity River has declined in recent years. To improve this fishery, the releases needed and the quantity of water which could be made available on an intermittent basis from Clair Engle Lake for release down the Trinity River were examined.

Major functions of the CVP's Trinity River Division are to provide irrigation water, and to generate hydroelectric energy. Other important benefits from project operation include the fishery resources of the Trinity River which are an economic asset to the basin and to the north coast area.

Existing Agreement

The U.S. Bureau of Reclamation and the California Department of Fish and Game on March 27, 1959 entered into a memorandum of operating agreement for streamflow maintenance for the protection, preservation, and enhancement of fish and wildlife, and the recreational resources of the Trinity River as affected by Lewiston and Trinity Dams. The agreement provides that the Bureau release from Lewiston Dam down the natural channel of the Trinity River these quantities of water:

Period	Quantity
January 1 - September 30	150 ft^3/s
October 1 - October 31	200 ft^3/s
November 1 - November 30	250 ft^3/s
December 1 - December 31	200 ft^3/s

This schedule was modified slightly in 1968, but the amount of water required, 120,500 acre-feet per year, was not changed.

During several years of project operations, fish habitat has been degraded, and the number of steelhead and fall-run king salmon returning to the Lewiston area have declined.

Need for Additional Releases

A letter dated October 24, 1973, from the State of California, Department of Fish and Game, to the Bureau suggests that the reason for the decline in fishery resources is that the minimum flows agreed to in 1959 are inadequate to preserve anadromous fish resources at preproject levels and to maintain the character of the river habitat, . . .thus, diminishing one of the beneficial uses of the Trinity River.

In an effort to reverse the declines in steelhead and fall-run king salmon in the Trinity River, Fish and Game has recommended that the Bureau increase minimum releases in the Trinity River to 315,000 acre-feet per year. The initial experimental flow release and monitoring program, to extend for a minimum of 3 years, would include the flow schedule developed by their biologists given in table 9.

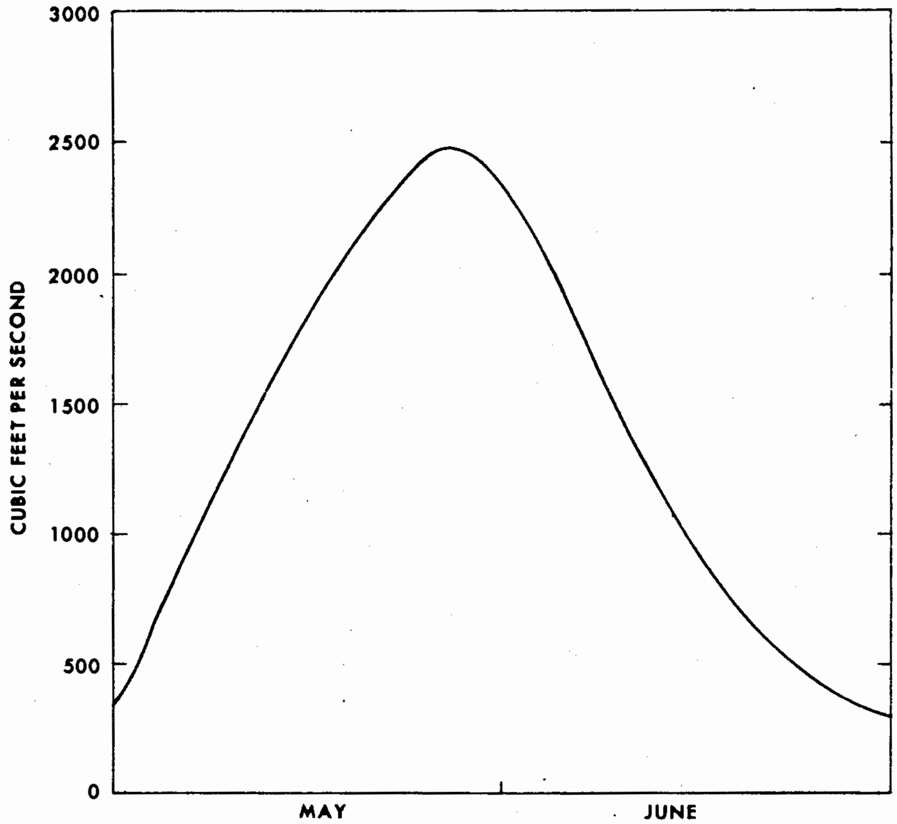
Flows during May and June shown on plate 9 which were recommended by Fish and Game would reduce water temperatures during the middle of the period, simulating the natural snowmelt.

Intermittent Supply Available

Operation studies for the historical period 1922-66 were examined for the year 1985 and 2015 levels of development. The intermittent supply for supplemental releases to the Trinity River would be the amount of water available in excess of necessary storage required at Clair Engle to provide for CVP firm water supply and dependable capacity. Some intermittent supplies would also be available in the form of reservoir spills. These large winter spills would have limited value in that they occur in very wet months and would have to be used as they occur.

The intermittent water that could be controlled in Clair Engle Lake for release to the Trinity River below Lewiston and usable spills are shown on plate 10. In the year 1985 and 2015 levels of development, the intermittent water available is nearly the same. At both levels of development, except for the critical period (1928-34), Clair Engle is operated mainly for power.

PLATE 9



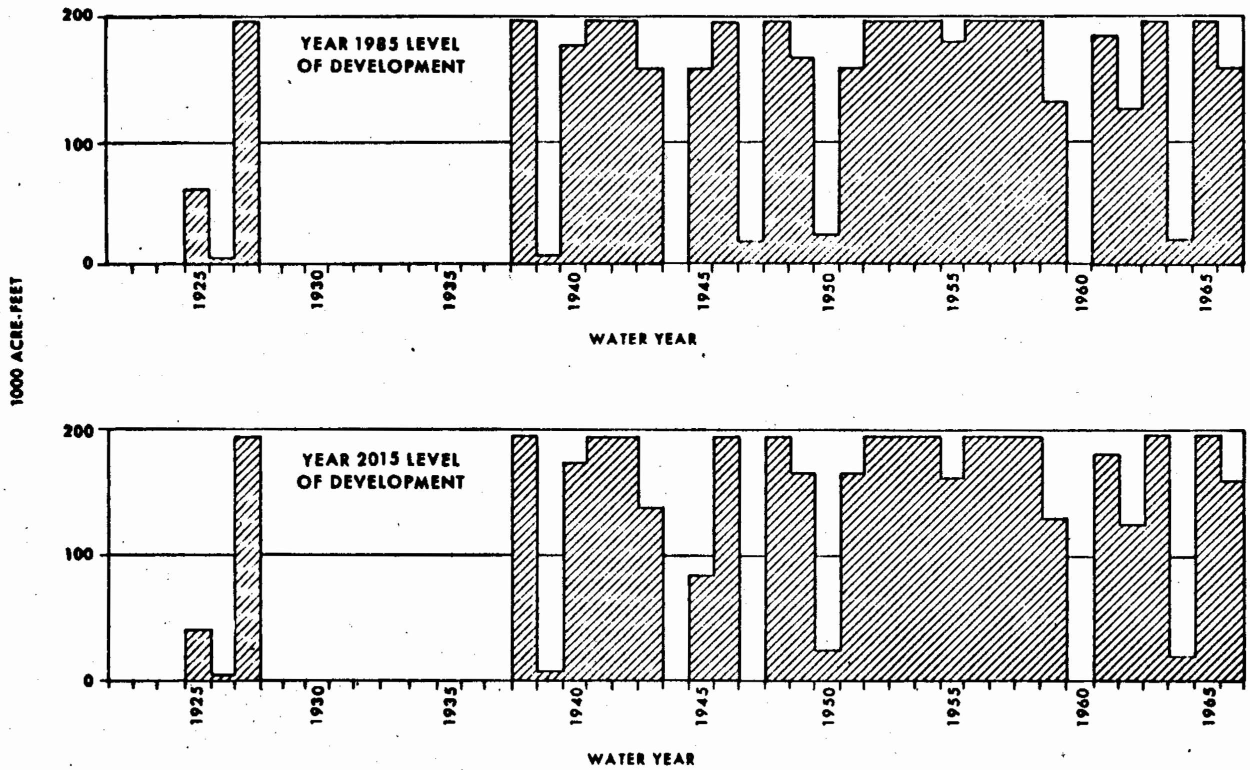
RELEASES FROM LEWISTON DAM TO TRINITY RIVER

Table 9. Trinity River fish flows below Lewiston Dam

Month	Average flow: Cubic feet per second[a]	Average flow: Acre-feet per month
January	200	12,000
February	250	15,000
March	300	18,000
April	300	18,000
May	1,750	105,000
June	1,000	60,000
July	300	18,000
August	200	12,000
September	225	13,500
October	250	15,000
November	275	16,500
December	200	12,000
Total (annual)		315,000

[a] Recommended within any given month; flow will vary with fishery management needs.

PLATE 10



INTERMITTENT WATER SUPPLY FOR THE
TRINITY RIVER BELOW LEWISTON
(LIMITED BY 195,000 ACRE-FEET/YEAR)
CENTRAL VALLEY PROJECT

Other Potential Uses

The California Department of Fish and Game has recommended the release of about 315,000 acre-feet annually, or 195,000 acre-feet more than the present annual downstream release of 120,000 acre-feet. This 195,000 acre-feet would be available on a usable pattern 14 out of the 45 years. In an additional 10 years, more than half of the 195,000 acre-feet would be available with some water available in another 6 years. The frequency of occurrence of the intermittent water supply is shown on plate 10 for year 1985 and 2015 levels of development.

No intermittent supply would be available for the 10 years from 1928 to 1937. Should a period as severe as the critical period of 1928 to 1934 occur, Clair Engle would be unable to provide any flows downstream from Lewiston in excess of the present 120,000 acre-feet per year. However, except for this 10-year period, either a full intermittent supply or at least a 50 percent supply would be available in 24 out of 35 years, and some intermittent supply would be available in 30 of those years.

Effect on Energy Generation

To provide the intermittent supply, some CVP energy generation would be sacrificed. Although some of the intermittent supply comes from usable spills, a portion of it would be derived from water which otherwise would have been released to the Clear Creek Tunnel to generate energy at the Judge Francis Carr, Spring Creek, and Keswick powerplants. In the 24 years with at least half of the 195,000 acre-foot supply provided, the average loss in generation would be about 120 million kWh per year.

WATER QUALITY

Another potential use of an intermittent surface water supply could be water quality enhancement. The water quality situation in the Sacramento-San Joaquin Delta has been one of the major areas of concern in the Central Valley Project.

Sacramento-San Joaquin Delta

The Sacramento-San Joaquin Delta encompasses about 738,000 acres. It is situated near the center of California's Central Valley at the confluence of the Sacramento and San Joaquin Rivers. These river systems contribute about 42 percent of the estimated natural runoff of the state.

Other Potential Uses

Because the Delta is opened to the San Francisco Bay complex and the Pacific Ocean, it never has a shortage of water. If the inflow from the Central Valley is insufficient to meet the consumptive needs of the Delta, saline water from the Bay enters the Delta from the west. The local water supply problem in the Delta thus becomes one of water quality, not a shortage in water quantity. Degradation by agricultural return flows and by municipal and industrial waste discharges compound this water supply problem.

Delta Water Quality Criteria

In the western Delta, criteria for the control of salinity intrusion have been established under California law by the State Water Resources Control Board and its predecessors in the administration of water rights for the State Water Project and Central Valley Project. Unlike most water quality standards that are enforced through waste discharge controls, implementing these salinity criteria will require the release of freshwater from the project reservoirs, during the drier months of most years, to push back the saltwater of San Francisco Bay. In the interior Delta, criteria have also been established for dilution of the natural concentration of mineral salts that occurs through the use and reuse of water in and upstream from the Delta. Release of stored water from project reservoirs may also be required to meet these criteria. Other water quality criteria include dissolved oxygen, turbidity, temperature, and biostimulants.

Federal and State water quality standards in the Delta include criteria adopted by the SWRCB in 1967, as supplemented by Resolutions 68-17 and 73-16. The water quality standards established by the SWRCB with their Decision 1379 (D-1379) require considerably more outflow than the presently adopted standards. This is, in the Bureau's opinion, a controversial use of project water, which the Bureau does not at this time prescribe to. Resolution of court action pertaining to D-1379 is still pending.

Study Assumptions

The studies examined to establish the intermittent surface water supply for use in the Delta, shown on plate 1, were based on these assumptions:

1. The present Federal and State water quality standards for the Delta would be met but not those set forth in D-1379.

2. No overland facilities would be constructed to provide substitute supplies for M&I users in the Delta.

3. There would be no Peripheral Canal.

The three conditions determined the Delta outflow used in the studies.

Intermittent Supply Available

The intermittent surface water supply could be used to enhance the quality of the water in the Delta to a level greater than that required by the presently adopted standards.

More supply is available in 1985 than in 2015, as shown on plate 1. In the 1985 level study, 5 years out of 45, about 1-1/2 million acre-feet would be available; in 19 years about 1 million acre-feet would be available; and in 35 years some intermittent water would be available.

In the 2015 level study, 1 year out of 45, about 1-1/2 million acre-feet would be available; in 8 years about 1 million acre-feet would be available; and in 20 years some intermittent water would be available.

At either level, however, no intermittent water is available in the Delta during the critical dry period. To enhance the water quality conditions in the Delta during this period would require the use of project water from CVP reservoirs.

The Delta water quality situation is very complex resulting from the proliferation of standards, differing outflow estimates for each standard, and the unresolved problems surrounding D-1379. There are some intermittent surface supplies that could be used for Delta water quality enhancement in most normal years. Perhaps the availability of an intermittent supply could be used as an indicator to establish criteria enabling the Bureau to satisfy its project needs and meet higher water quality standards in the Delta.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The studies made for this document show an intermittent surface water supply is available, which could be used to enhance the normal multipurpose functions of the Central Valley Project.

The most promising use seems to be as an intermittent or class 2 water supply for agriculture, marketed to irrigators in areas of need within the Central Valley. If such a plan were implemented, it would be possible to reduce the requirement for a firm CVP water supply in an area and still fully develop that area by using some class 2 water. By pumping no ground water in wet years and maximizing pumping in dry years, the firm water supply required for full development of the Tehama-Colusa service area could be reduced by 78,000 acre-feet. This water could then be used to meet the needs of other potential Bureau customers.

Irrigators would have to be willing to accept widely varying annual pumping schedules. Economic and financial analyses of use of intermittent water in any particular service area would be necessary before water users could evaluate such a use.

Using intermittent surface water supplies for downstream enhancement of fishery and recreation appears to have potential. On the Trinity River, excluding the period (1928-34) during which there would be no intermittent supply, at least a 50 percent intermittent supply would be available in 24 of 35 years. The impact of 10 years with no intermittent supply would be similar to that experienced in 1973, after a 10-year period during which the minimum release has been 120,000 acre-feet annually. If water is released from a reservoir to enhance downstream fish and recreation conditions, some flat-water recreation benefits on the reservoir itself would be lost. With releases to the Trinity River from Clair Engle Lake, some power revenue would also be lost.

The use of intermittent surface water supplies for water quality enhancement in the Sacramento-San Joaquin Delta may or may not have potential. No definite conclusions are possible without further study.

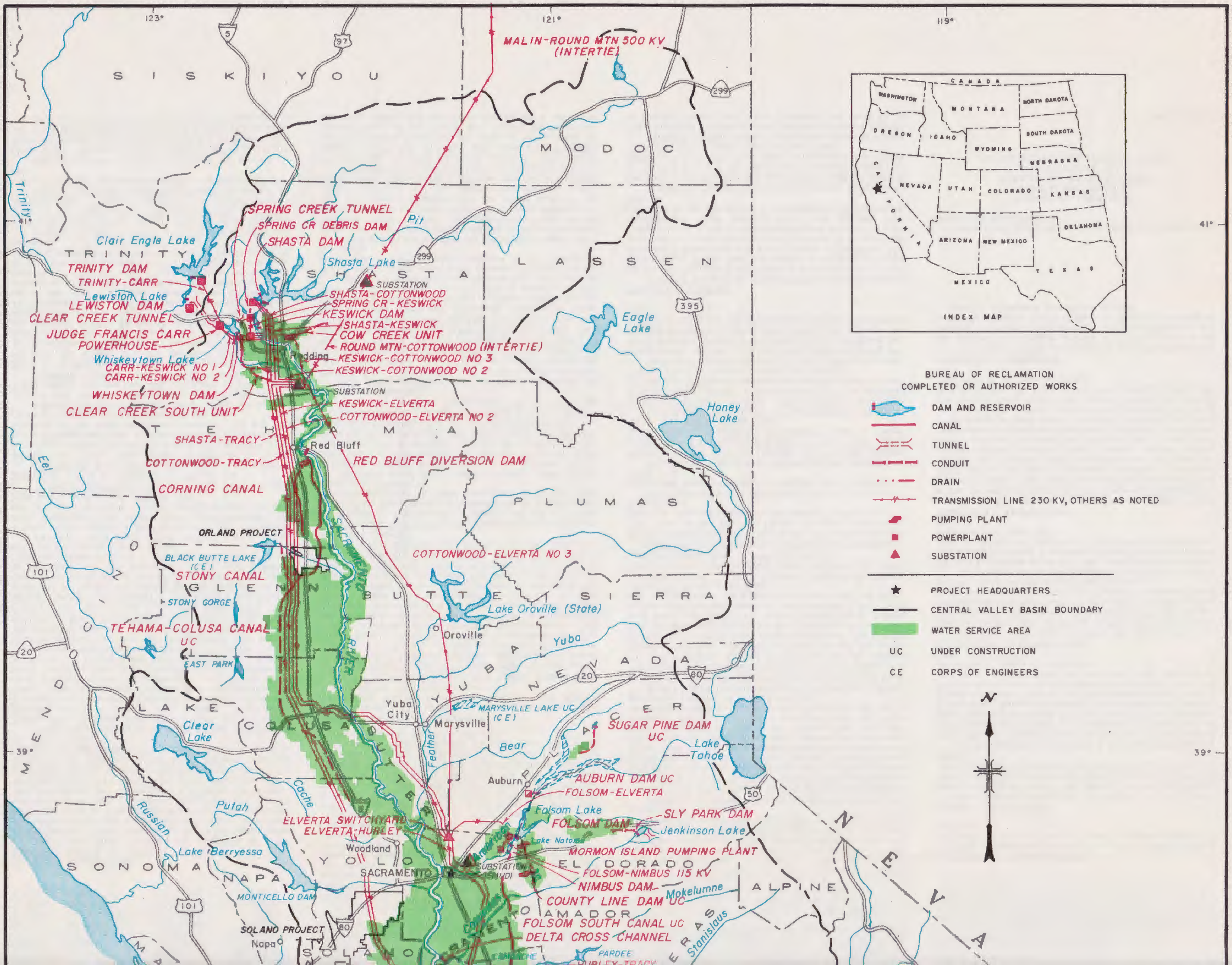
RECOMMENDATIONS

It is recommended that:

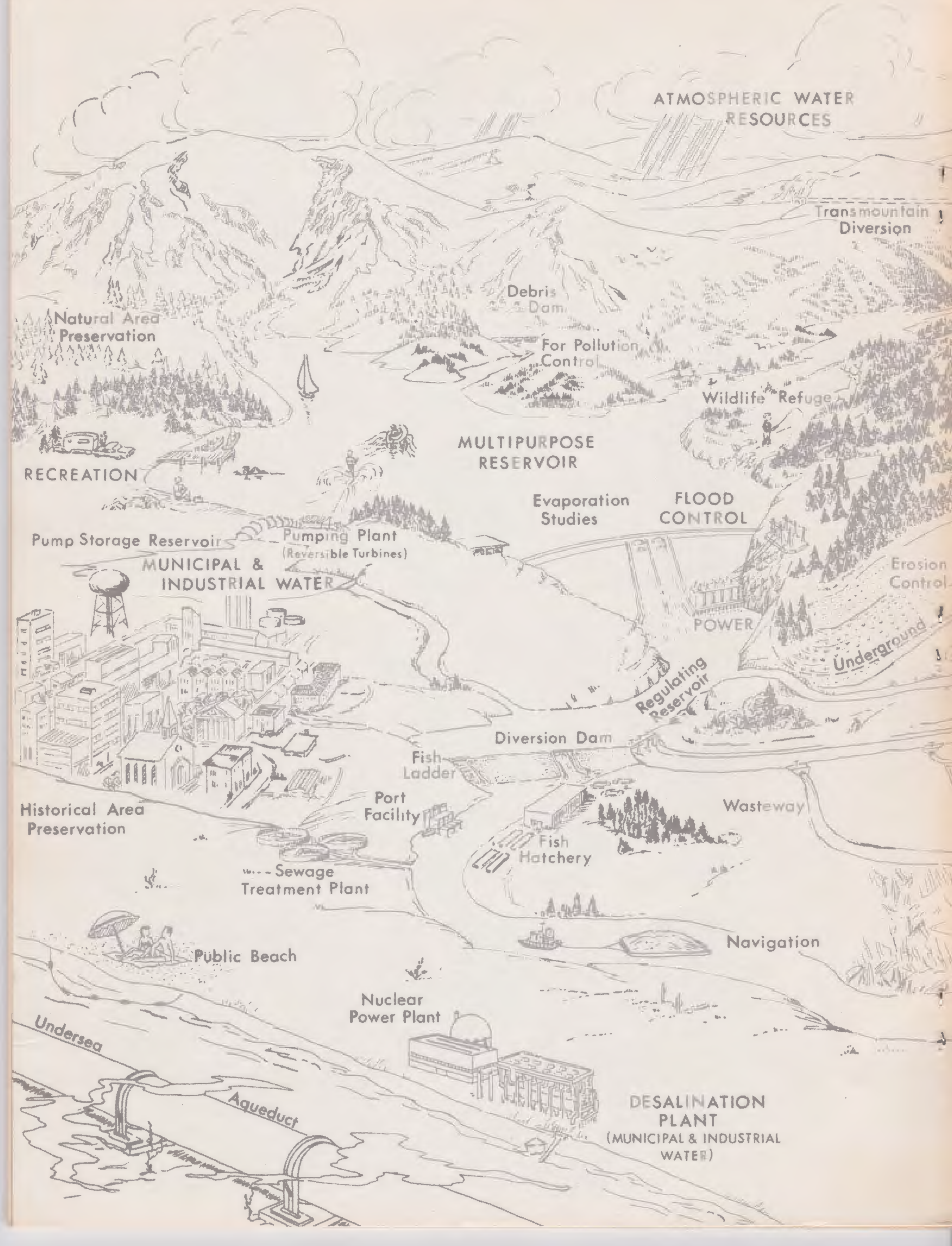
1. Intermittent surface water be used as an alternative or additional means of supplying water to potential irrigation customers. Future activities or studies to pursue this possibility be made in connection with negotiations with potential water contractors. These studies and activities should include detailed studies of conveyance limitations, ground-water integration potential, and economic and financial evaluation of this type of water supply.

2. Use of intermittent surface water be considered in studies of alternative means of supplying additional fishery flows for the Trinity River below Lewiston Dam.

3. Further studies be made relating to the use of intermittent water to enhance the water quality conditions in the Delta. The possibility of an intermittent supply as an indicator to establish criteria that would enable the Bureau to satisfy its project needs and meet higher water quality standards in the Delta should be considered.


MALIN-ROUND MTN 500 KV (INTERTIE)
SISKIYOU
MODOC
LASSEN
SHASTA
TRINITY
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
YUBA
NEVADA
PLACER
LAKE
COLUSA
SUTTER
YOLO
NAPA
SONOMA
MENDOCINO
EL DORADO
AMADOR
ALPINE
SACRAMENTO
SPRING CREEK TUNNEL
SPRING CR DEBRIS DAM
SHASTA DAM
Clair Engle Lake
TRINITY DAM
TRINITY-CARR
Lewiston Lake
LEWISTON DAM
CLEAR CREEK TUNNEL
JUDGE FRANCIS CARR POWERHOUSE
Whiskeytown Lake
CARR-KESWICK NO 1
CARR-KESWICK NO 2
WHISKEYTOWN DAM
CLEAR CREEK SOUTH UNIT
Shasta Lake
SUBSTATION
SHASTA-COTTONWOOD
SPRING CR-KESWICK
KESWICK DAM
SHASTA-KESWICK
COW CREEK UNIT
ROUND MTN-COTTONWOOD (INTERTIE)
KESWICK-COTTONWOOD NO 3
KESWICK-COTTONWOOD NO 2
Redding
KESWICK-ELVERTA
COTTONWOOD-ELVERTA NO 2
SHASTA-TRACY
COTTONWOOD-TRACY
Red Bluff
RED BLUFF DIVERSION DAM
CORNING CANAL
ORLAND PROJECT
BLACK BUTTE LAKE (CE)
STONY CANAL
STONY GORGE
TEHAMA-COLUSA CANAL UC
EAST PARK
COTTONWOOD-ELVERTA NO 3
Lake Oroville (State)
Oroville
Yuba
Yuba City
Marysville
MARYSVILLE LAKE UC (CE)
SUGAR PINE DAM UC
Lake Tahoe
Bear
Feather
Auburn
AUBURN DAM UC
FOLSOM-ELVERTA
Folsom Lake
FOLSOM DAM
SLY PARK DAM
Jenkinson Lake
Lake Natoma
MORMON ISLAND PUMPING PLANT
FOLSOM-NIMBUS 115 KV
NIMBUS DAM
COUNTY LINE DAM UC
FOLSOM SOUTH CANAL UC
DELTA CROSS CHANNEL
Mokelumne
Stanislaus
PARDEE
Clear Lake
Putah
Cache
Russian
Eel
Trinity
Pit
Sacramento River
Lake Berryessa
MONTICELLO DAM
SOLANO PROJECT
Napa
Woodland
ELVERTA SWITCHYARD
ELVERTA-HURLEY
SUBSTATION (SMUD)
Eagle Lake
Honey Lake
123°
121°
119°
41°
39°
CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
OREGON
IDAHO
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
MEXICO
INDEX MAP
BUREAU OF RECLAMATION COMPLETED OR AUTHORIZED WORKS
DAM AND RESERVOIR
CANAL
TUNNEL
CONDUIT
DRAIN
TRANSMISSION LINE 230 KV, OTHERS AS NOTED
PUMPING PLANT
POWERPLANT
SUBSTATION
PROJECT HEADQUARTERS
CENTRAL VALLEY BASIN BOUNDARY
WATER SERVICE AREA
UC UNDER CONSTRUCTION
CE CORPS OF ENGINEERS
N


UNITED STATES
DEPARTMENT OF THE INTERIOR
ROGERS C B MORTON SECRETARY
BUREAU OF RECLAMATION
GILBERT G STAMM COMMISSIONER
CENTRAL VALLEY PROJECT
CALIFORNIA
MID-PACIFIC REGION
MAP NO. 214-208-5133
MILES
0 10 20 30 40 50
0 10 20 30 40 50 60 70 80
KILOMETERS
JANUARY 1975
PACIFIC OCEAN
SOLANO PROJECT
Napa
DELTA CROSS CHANNEL
CAMANCHE
PARDEE
HURLEY-TRACY
ELVERTA-TRACY
Calaveras
NEW HOGAN LAKE (CE)
NEW MELONES DAM (CE & USBR) UC
CONTRA COSTA CANAL
TRACY-CONTRA COSTA-YGNACIO 69KV
TRACY SWITCHYARD
TRACY PUMPING PLANT
San Francisco
Oakland
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
Mono Lake
NEW DON PEDRO
Merced
Tuolumne
Lake McClure
ALAMEDA
SOUTH BAY AQUEDUCT (STATE)
DELTA-MENDOTA CANAL
CALIFORNIA AQUEDUCT (STATE)
SAN MATEO
SANTA CLARA
San Jose
SAN LUIS DAM & PUMPING-GENERATING PLANT & O'NEILL DAM (FEDERAL - STATE)
O'NEILL PUMPING PLANT
SAN FELIPE DIVISION
SANTA CRUZ
Santa Cruz
KESTERSON
MERCED
MARIPOSA
Chowchilla
HV EASTMAN LAKE (CE)
MADERA CANAL
HIDDEN LAKE (CE)
Los Banos
Millerton Lake
FRIANT DAM
SAN JOAQUIN RIVER
LOS BANOS DETENTION DAM (FEDERAL-STATE)
DOS AMIGOS PUMPING PLANT (FEDERAL-STATE)
LITTLE PANOCHE DETENTION DAM (FEDERAL-STATE)
Kings
PINE FLAT LAKE (CE)
Fresno
SAN LUIS DRAIN UC
SAN BENITO
SAN LUIS CANAL (FEDERAL - STATE)
Kaweah
Lake Kaweah (CE)
Salinas
COALINGA CANAL
TULARE
Tule
Success Lake (CE)
MONTEREY
Tulare Lake
KINGS
FRIANT-KERN CANAL
INYO
CALIFORNIA AQUEDUCT (STATE)
ISABELLA LAKE (CE)
Kern
Bakersfield
KERN
Buena Vista Lake
SAN LUIS OBISPO
Cuyama
Santa Maria
TWITCHELL DAM
Sisquoc
SANTA BARBARA
VENTURA
LOS ANGELES
123°
121°
119°
37°
35°


ATMOSPHERIC WATER RESOURCES
Transmountain Diversion
Debris Dam
For Pollution Control
Natural Area Preservation
Wildlife Refuge
MULTIPURPOSE RESERVOIR
RECREATION
Evaporation Studies
FLOOD CONTROL
Pump Storage Reservoir
Pumping Plant
(Reversible Turbines)
MUNICIPAL & INDUSTRIAL WATER
Erosion Control
POWER
Underground
Regulating Reservoir
Diversion Dam
Fish Ladder
Port Facility
Wasteway
Historical Area Preservation
Fish Hatchery
Sewage Treatment Plant
Navigation
Public Beach
Nuclear Power Plant
Undersea
Aqueduct
DESALINATION PLANT
(MUNICIPAL & INDUSTRIAL WATER)