STATE OF CALIFORNIA
EARL WARREN
Governor

PUBLICATION OF STATE WATER RESOURCES BOARD

REPORT ON FEASIBILITY OF FEATHER RIVER PROJECT AND SACRAMENTO-SAN JOAQUIN DELTA DIVERSION PROJECTS PROPOSED AS FEATURES OF THE CALIFORNIA WATER PLAN

MAY, 1951

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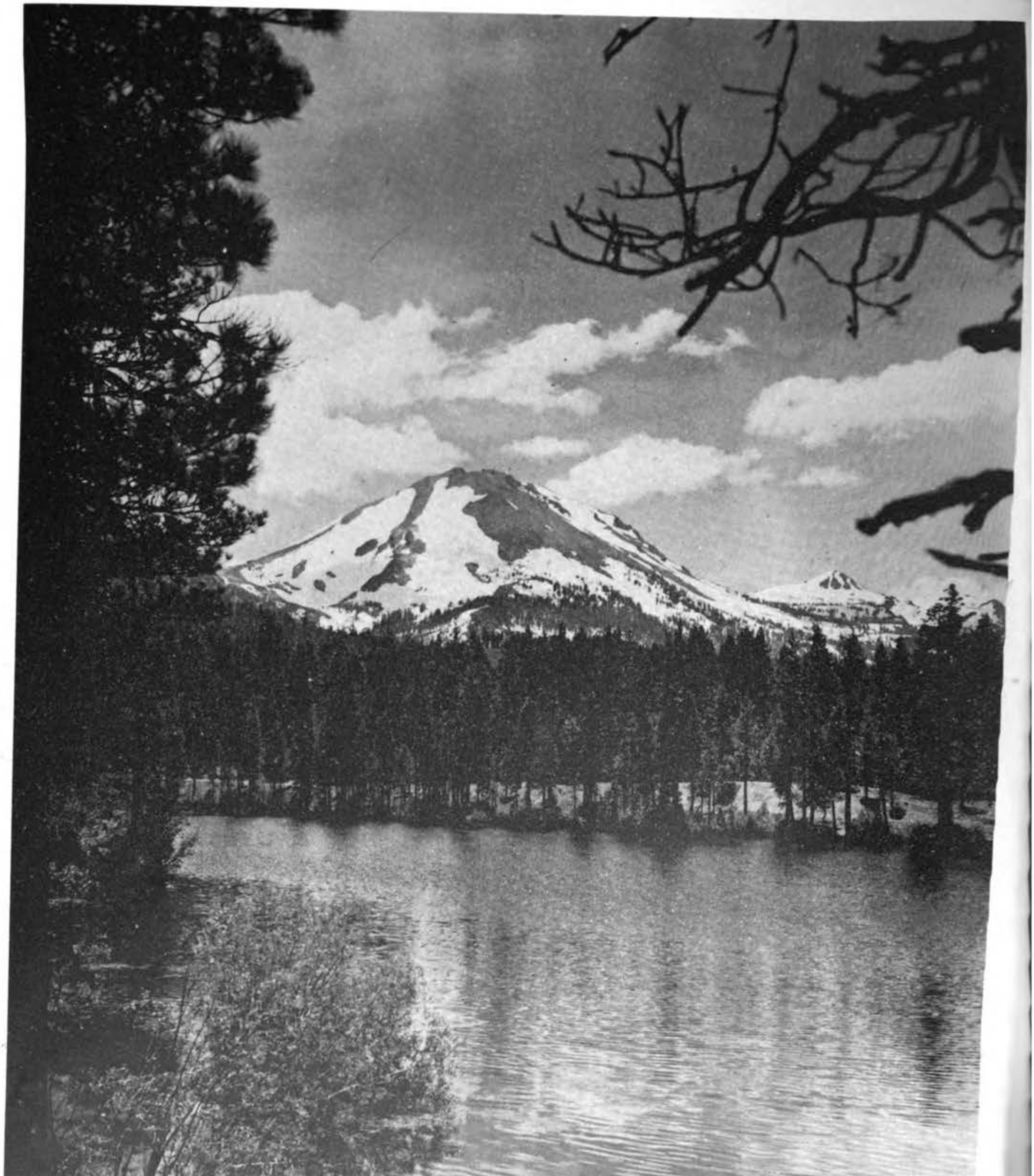

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STATE OF CALIFORNIA
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ISION OF WATER RESOURCES
101 PUBLIC WORKS BUILDING

May 17, 1951

Mr. C. A. Griffith, Chairman
State Water Resources Board
Public Works Building
Sacramento, California

Dear Mr. Griffith:

There is transmitted herewith a report entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan."

This report has been made in accordance with the terms of an agreement dated February 1, 1951, between the State Water Resources Board, the California Central Valleys Flood Control Association and the Department of Public Works of the State of California, acting through the agency of the State Engineer.

Sincerely yours,

/s/ A. D. EDMONSTON

A. D. Edmonston
State Engineer

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CHAPTER I. INTRODUCTION

The State Water Resources Board, the Department of Public Works, acting through the agency of the State Engineer, and the California Central Valleys Flood Control Association, entered into an agreement as of February 1, 1951, whereby the Association agreed to pay $7,500 for the preparation by the State Water Resources Board and the State Engineer of an interim report on the Oroville Project on the Feather River in the County of Butte. The information to be set forth in the report is as follows:

(a) The nature and extent of the project works required for the Oroville project on the Feather River in the County of Butte, for the storage, conservation, conveyance and utilization of water for beneficial purposes, including flood control, irrigation and other purposes, and the production and transmission of electric power;

(b) The cost of such project works and all canals, conduits, transmission lines and other works required for the widest practicable coordinated utilization of project water and electric power available therefrom;

(c) The engineering feasibility of said project and the possibilities of financing thereof through a contribution of Federal funds for the portion of the cost of the project properly allocated to flood control, and state or local financing of the balance of the cost.

Work on the preparation of the report, under the terms of the agreement, was to be diligently prosecuted with the objective of completion of the report on or before June 1, 1951, or as nearly thereafter as possible. A copy of the agreement is included as Appendix A of this report.

The Feather River

The Feather River is the most important tributary of the Sacramento River. It has a drainage area above Oroville of about 3,600 square miles. The seasonal runoff of the stream at that point varies from a mean of about 4½ million acre-feet to a minimum of 1,200,000 acre-feet and a maximum of twice that mean. Flood flows have occurred up to a recorded maximum of 230,000 second-feet. The smallest recorded flow is 300 second-feet on November 9, 1931. This mean seasonal runoff represents about one-fifth of that of the entire Sacramento River drainage basin above the valley floor. It is apparent, therefore, that large reservoir capacity is required to regulate the magnitude of such erratic flows, to prevent flood damage and to conserve the waters for beneficial purposes; namely, domestic, irrigation and industrial supplies, navigation, salinity control, production of electric power, and other uses. A substantial part of the surplus waters of the Sacramento River Basin lies in the Feather River area. Studies indicate that only about one-fifth of the mean seasonal runoff of the Feather River will be required to supply the ultimate water needs of its immediate service area when properly controlled and utilized. The remainder would be conserved to the extent practicable for exportation to areas of deficient water supply.

State and Federal Investigations

The State Engineer, following several years of investigation, recommended in his report to the Legislature of 1931 (Bulletin No. 25, Division of Water Resources), as a unit of the State Water Plan, the construction of a dam at the Oroville site which would impound 1,705,000 acre-feet of water. This plan was adopted by the Legislature of 1941. The Oroville dam site is on the main river about 1.7 miles below the junction of its North and Middle forks, and about 5.5 miles upstream from the City of Oroville.

Reports of the Secretary of Interior and of the Chief of Engineers, U. S. Army, issued in 1945, set forth a plan for the control and development of the waters of the Sacramento and San Joaquin River Basins. Both of these reports include as units in their respective plans, Bidwell Bar Reservoir, capacity 1,200,000 acre-feet, on the Middle Fork of the Feather River, and Big Bend Reservoir, capacity 1,000,000 acre-feet, on the North Fork, in lieu of the Oroville Reservoir recommended by the State Engineer. These Federal reports found that the estimated required reservoir capacity could be obtained more economically at the Bidwell Bar and Big Bend sites than at the Oroville site.

The State, in expressing its views and recommendations on the Federal reports, stated that, "These projects (Bidwell Bar, Big Bend, and Greenville reservoirs and three power afterbays) should be deferred until a thorough study has been made of their economic justification and until a further investigation has been made of all available reservoir sites including the Oroville site of the State Water Plan. Reservoir capacity, in addition to

existing capacity on the Feather River, should aggregate not less than 2,500,000 acre-feet for the full practicable development of the river."

Following the submission of the comments of the State, extensive work was done by the Bureau of Reclamation in exploring the foundation conditions at the Oroville site. These conditions were thoroughly examined and reported upon by competent geologists of the Federal and State departments involved. The foundations are considered to be satisfactory for the construction of a dam to the heights studied. In addition to that work, the Bureau of Reclamation has prepared new topographic maps of the dam and reservoir sites (Oroville, Bidwell Bar, and Big Bend) which are much more accurate than those used in the earlier studies. The new surveys covering the Big Bend site revealed that the capacity of the reservoir at that site for the height of dam proposed would be only about six-tenths the capacity used in the 1945 Federal reports, or about 600,000 acre-feet. This adversely affected the economics of that project materially. It resulted in an aggregate storage capacity of about 1,800,000 acre-feet for the Big Bend and Bidwell Bar sites instead of the 2,200,000 acre-feet used in the 1945 reports. This reduction of capacity was on the North Fork of the river, which has a substantially larger runoff than the combined runoffs of the Middle and South forks.

Joint Statement of Representatives of Federal and State Departments

Further intensive and comprehensive studies were made by the three interested Federal and State agencies, utilizing the new and additional data available on the foregoing Feather River

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dam and reservoir sites. These studies resulted in certain definite conclusions which are set forth in a joint statement issued at Sacramento on October 10, 1949, by the District Engineer, Sacramento District, Department of the Army; Acting Regional Director, Region 2, U. S. Bureau of Reclamation, Department of Interior; and the State Engineer of California, as follows:

(a) The Feather River above Oroville with a mean annual runoff of 4½ million acre-feet, represents one-fifth of the runoff of the entire Sacramento River Basin; and a substantial part of the surplus waters that may be developed over and above local needs could be made available for exportation to areas of deficient water supplies. Therefore, these waters should be conserved and utilized to the fullest practicable extent in planning for the development of the waters of the State.

(b) Large surface reservoir capacity at or near Oroville is required to control and conserve the erratic stream flows which range from a minimum annual runoff of 1,200,000 acre-feet to a maximum of 9,000,000 acre-feet, with flood flows ranging up to 230,000 second-feet.

(c) The reservoir capacity on the lower Feather River should be between 2,500,000 and about 3,000,000 acre-feet, for the purpose of properly controlling its flood waters and conserving such waters for beneficial purposes.

(d) The most advantageous and feasible location for constructing storage capacity of 2,500,000 to about 3,000,000 acre-feet is at the Oroville site, about 5.5

miles upstream from the City of Oroville. The dam site is suitable topographically and the foundation conditions at the dam site are considered satisfactory for construction of a reservoir to such capacity.

(e) Further studies should be directed immediately to (a) formulating a plan for the construction of reservoir capacity in the amount of 2½ to 3 million acre-feet at the Oroville site on the Feather River for flood control, irrigation, electric power and other purposes; (b) making estimates of irrigation yield, electric power output, flood control, and other benefits which would result from the operation of the project; (c) preparing cost and financial analyses of the project; and (d) submitting reports thereon.

State-Wide Water Resources Investigation

The State Legislature with the passage of the State Water Resources Act of 1945 (Chapter 1514, Statutes of 1945) announced a detailed and comprehensive declaration of State water policy. This act declares that the State should study and coordinate all water development projects, participate in the construction of flood control works and projects when benefits exceed costs, and make recommendations concerning feasibility of projects after consideration of all beneficial uses of water, with a view to the greatest and highest use thereof.

In order to carry out its purposes and objectives, the State Water Resources Act of 1945 created the State Water Resources Board, composed of seven members appointed by Governor Earl Warren, to conduct investigations, and advise the Legislature

on matters pertaining to the development and control of the water resources of the State. The Department of Public Works is directed to cooperate with and assist the Board.

The State Water Resources Board is given power to establish general policies and prescribe rules and regulations for administration of the law. A 1947 amendment removed much of the emphasis of the original act on flood control, and, to a large extent, placed conservation on an equal basis with flood control.

Implementing a general authorization contained in the State Water Resources Act of 1945, the Legislature, by Chapter 1541, Statutes of 1947, provided for a State-wide investigation of water resources, which is presently being conducted by the Division of Water Resources, Department of Public Works, under the direction of the State Water Resources Board. Continuing appropriations have been made for this work beginning in the fiscal year 1947-1948. The investigation has for its objective the formulation of a plan for the full practicable conservation, control and utilization of the State's water resources, both surface and underground, to meet present and future water needs for all beneficial purposes and uses in all areas of the State. It has been designated "The California Water Plan."

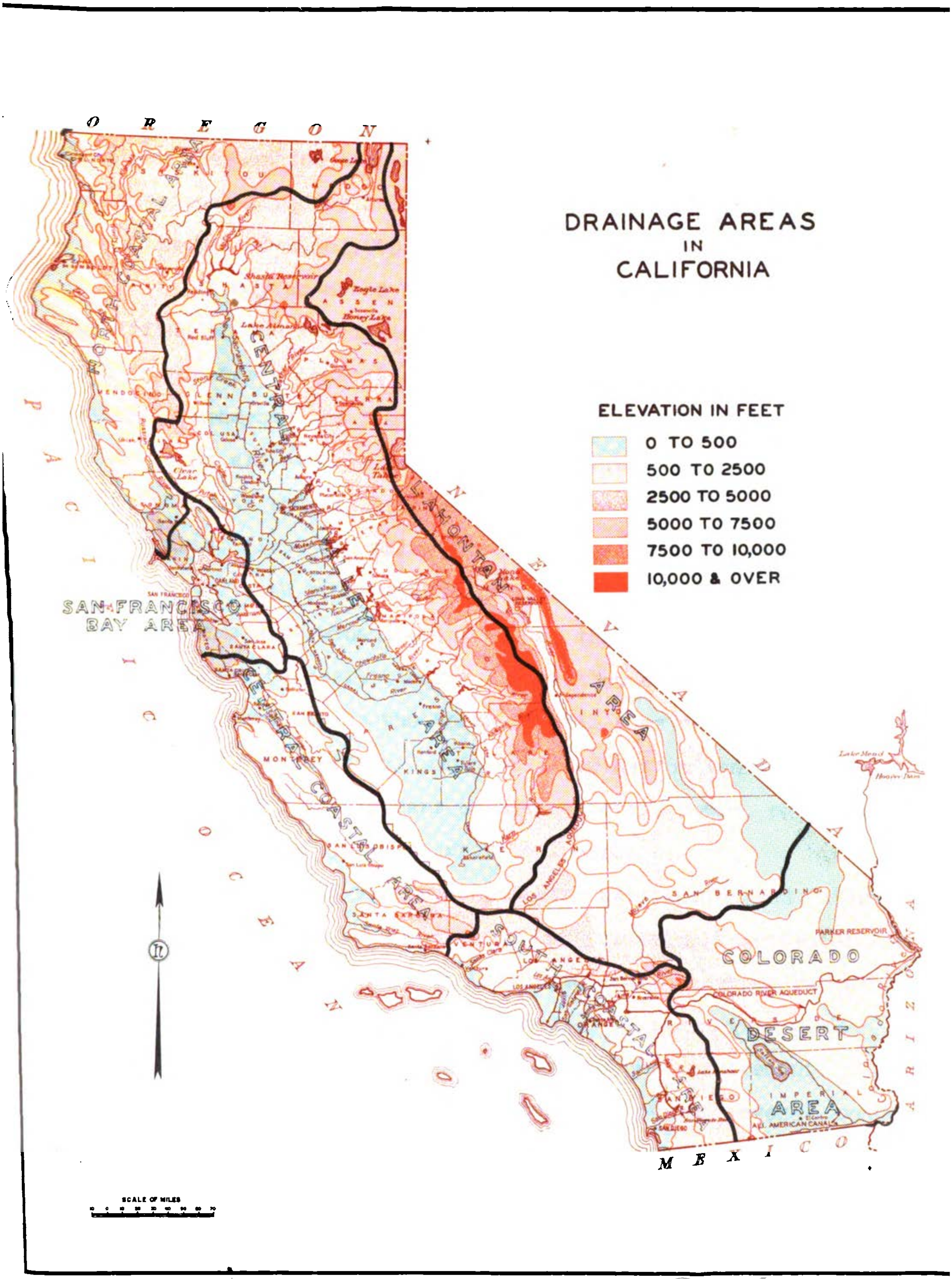
It is planned to submit the results of this investigation in four printed bulletins. Bulletin No. 1 is now in the process of being printed. It contains a state-wide inventory of water resources, including tabulations of precipitation, runoff, flood frequencies, and quality of surface and ground waters. In printed form, it will comprise some 780 pages--186 pages of text, 486 pages of tables, 90 plates, and 18 illustrations.

Bulletin No. 2 will set forth information on present water utilization and water requirements, including data on land use, consumptive use of water, and water available under existing rights and development for present and potential water service areas throughout the State. Bulletin No. 3 will present "The California Water Plan" for the conservation, control, protection and utilization of the waters of the State. Bulletin No. 4 will summarize in concise form the data and information contained in the first three bulletins.

Field and office work have been carried on concurrently on all phases of the investigation in preparation for the foregoing bulletins. Excellent cooperation has been received from Federal and State agencies and others in making the studies and formulation of the prospective plan.

The data in Bulletin No. 1 relating to runoff of the stream systems in California may be summarized by seven major geographical areas (see accompanying plate), as follows:

	Drainage Area		Seasonal Runoff	
	Square miles	Per cent of total	Average in acre-feet	Per cent of total
North Coastal	19,586	12.4	28,886,000	40.8
San Francisco Bay	4,409	2.8	1,240,000	1.8
Central Coastal	11,284	7.1	2,448,000	3.4
South Coastal	10,955	6.9	1,227,000	1.7
Central Valley	59,424	37.5	33,637,000	47.5
Lahontan	32,907	20.8	3,177,000	4.5
Colorado Desert	19,730	12.5	179,000	0.3
Total	158,295	100.0	70,794,000	100.0


DRAINAGE AREAS
IN
CALIFORNIA
ELEVATION IN FEET
0 TO 500
500 TO 2500
2500 TO 5000
5000 TO 7500
7500 TO 10,000
10,000 & OVER
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
NORTH COASTAL AREA
CENTRAL VALLEY AREA
LAHONTAN AREA
SAN FRANCISCO BAY AREA
CENTRAL COASTAL AREA
SOUTH COASTAL AREA
COLORADO DESERT
IMPERIAL AREA
Shasta Reservoir
Eagle Lake
Honey Lake
Lake Almanor
Clear Lake
Lake Mead
Hoover Dam
PARKER RESERVOIR
COLORADO RIVER AQUEDUCT
ALL AMERICAN CANAL
LOS ANGELES AQUEDUCT
SAN BERNARDINO
MONTEREY
SANTA BARBARA
SAN DIEGO
KINGS
KERN
INYO
SCALE OF MILES

The foregoing tabulation does not include the seasonal runoff of the Colorado River, estimated at about 18,000,000 acre-feet per year on the average under natural conditions at the International Boundary and in which California has rights in the annual amount of 5,362,000 acre-feet.

It may be noted from the foregoing tabulation that about two-fifths of the average seasonal runoff of the entire State occurs in the North Coastal area and nearly one-half in the Central Valley (Sacramento and San Joaquin River drainage basins).

In all studies leading to the formulation of plans for the development and utilization of the water resources in any particular area, first and prime consideration is being given to the requirements, both present and ultimate, for all uses in the local area, before a determination is made of the amounts of surplus waters that may be available for exportation to areas of deficient supply. For example, in the North Coastal area provision is being made not only for domestic, municipal, irrigation and industrial uses, but also for development of hydroelectric power, propagation of fish and wild life, and recreational needs.

Studies with reference to water utilization and water requirements have not been completed but preliminary estimates are available which are believed to be sufficiently accurate to make a preliminary comparison of the water supply in each major geographical area with its probable ultimate water requirement. Comparing these ultimate water requirements of the several areas with the available water supplies therein, it is found that the North Coastal and Central Coastal areas and the Sacramento River Basin have available water supplies in excess of their ultimate

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needs. On the other hand, the San Francisco Bay area, the San Joaquin River Basin (including Tulare Lake Basin), and the South Coastal, Lahontan and Colorado Desert areas, have ultimate water requirements far in excess of their available local water supplies.

It is apparent, therefore, that in any plan for the ultimate development and utilization of the water resources of the State, water must be transferred from the areas of surplus water supply to the areas of deficiency. The areas from which these surpluses must come are the Sacramento River Basin and the North Coastal. The Central Coastal surplus exists only in the narrow coast line southerly from the Monterey Peninsula and is relatively small in total quantity and the area is lacking in suitable reservoir sites for the regulation and control of such surplus waters. On the other hand, many reservoir sites feasible of development from engineering and geologic standpoints exist in the North Coastal area and the Sacramento River Basin. In the North Coastal area, more than 50 dam and reservoir sites have been found physically feasible of development to an aggregate reservoir capacity of 16,000,000 acre-feet and capable of being utilized to produce more than 2,000,000 kilowatts of electric power, three-fourths of the present total of 2,600,000 kilowatts of hydroelectric power installations in California. In the Sacramento River Basin, reservoir sites in excess of 40 in number and capable of storing more than 15,000,000 acre-feet of water are also physically feasible of development. With these installations, the ultimate requirements of those two areas can be met and, in addition, surplus waters provided to areas of deficient water supply.

On the basis of the inventory of the water resources

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and estimates of the ultimate water requirements so far made, adequate water supplies can be developed and regulated from California's water resources, including California's rights in and to the waters of the Colorado River, in available surface reservoir sites and ground water basins to meet the probable ultimate water requirements in the State without importing water from a source outside of the State of California, such as the Columbia River in the Pacific Northwest.

Central Valley Project

The Central Valley Project Act of 1933 (Chapter 1042, California Statutes 1933) authorized the construction of the Central Valley Project, a portion of the State Water Plan, comprising a system of works for the development and utilization of the water resources of the Sacramento and San Joaquin River drainage basins. A special State agency, the Water Project Authority of the State of California, was created to carry out construction, and then to operate and maintain the project. The members of the Authority are the Director of Public Works, Chairman, Director of Finance, Attorney General, State Controller, and State Treasurer. The Authority was authorized by the act to issue and sell revenue bonds under certain conditions in the amount of $170,000,000 for the purpose of constructing the project. The bonds were to be secured entirely by revenues from the sale of commodities resulting from the operation of the project. However, no construction work has been performed by the Authority.

Major General E. M. Markham, Chief of Engineers, U. S. Army, by letter dated April 6, 1934, transmitted a report of the Board of Engineers for Rivers and Harbors on review reports

theretofore submitted on Sacramento, San Joaquin and Kern Rivers, California, to the Chairman of the Committee on Rivers and Harbors, House of Representatives. The letter of transmittal and the report were printed as Document No. 35, Committee on Rivers and Harbors, House of Representatives, U. S., 73rd Congress, 2nd Session. The Chief of Engineers in submitting the report makes the following finding:

> "10. The Federal interest in the conservation of water by the construction of the Kennett (now Shasta) Dam largely exceeds in my opinion that evaluated by the division engineer and the Board, since by remedying the intrusion of salt water into the delta of the Sacramento and San Joaquin Rivers, it eliminates from consideration Federal participation in the construction and operation at great cost of locks and structures to prevent such intrusion, and assures a free and open passage for the highly important navigation through the channels of the delta. Based on this aspect of the case, as well as the direct benefits to navigation and flood control on the Sacramento River, I find that the general and Federal benefits from the construction of the Kennett Dam on the plans now proposed by the State warrants a special direct participation of the Federal Government of $12,000,000 in the cost of this structure."

The Rivers and Harbors Act, approved August 30, 1935 (Public Law 409, 74th Congress), adopted the foregoing House Committee Document No. 35 and authorized the expenditure of $12,000,000 for the purposes as recommended by the Chief of Engineers in that document.

In 1934 an application was made by the Water Project Authority to the Public Works Administration for a grant and loan for the construction of the entire Central Valley Project. The project was examined by several Federal agencies, practically all of which submitted favorable reports. However, the Public Works Administration never issued a final report and no grant and loan were made to the State.

On September 10, 1935, the President allotted $20,000,000 from the Emergency Relief Appropriation of 1935 for the construction of Friant Reservoir and certain other facilities to be chosen. This amount was subsequently reduced to $4,200,000 but restrictions as to the units to be constructed, and the execution of repayment contracts prior to beginning of construction, were waived.

The first Congressional appropriation for continuation of construction of the Central Valley Project was $6,900,000 contained in the First Deficiency Bill, approved June 22, 1936. Six million dollars of this amount were allocated for construction of Friant Dam and irrigation facilities therefrom.

Legislation effecting a complete reauthorization of the Central Valley Project as a Federal undertaking was enacted in the Rivers and Harbors Act (Public No. 392, 75th Congress, 1st Session) approved by the President on August 26, 1937. This act provided:

> "Sec. 2. That the $12,000,000 recommended for expenditure for a part of the Central Valley Project, California, in accordance with the plans set forth in Rivers and Harbors Committee Document Numbered 35, Seventy-third Congress, and adopted and authorized by the provisions of section 1 of the Act of August 30, 1935 (49 Stat. 1028, at 1038), entitled 'An Act authorizing the construction, repair, and preservation of certain public works on rivers and harbors and for other purposes', shall, when appropriated, be available for expenditure in accordance with the said plans by the Secretary of the Interior instead of the Secretary of War: Provided, That the transfer of authority from the Secretary of War to the Secretary of the Interior shall not render the expenditure of this fund reimbursable under the reclamation law: Provided further, That the entire Central Valley project, California, heretofore authorized and established under the provisions of the Emergency Relief Appropriation Act of 1935 (49 Stat. 115) and the First Deficiency Appropriation Act, fiscal year 1936 (49 Stat. 1622), is hereby reauthorized and declared to be for the purposes of improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses,

> and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed to accomplish the aforesaid purposes: . . ."

It was provided that the provisions of the Reclamation Law, as amended, should govern the repayment of expenditures and that the dams and reservoirs should be used ". . ., first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power."

A further reauthorization of the Central Valley Project is contained in the Rivers and Harbors Act (Public No. 868, 76th Congress, 3d Session), approved October 17, 1940. This amendment authorized the "construction under the provisions of the Federal reclamation laws of such distribution system as the Secretary of the Interior deems necessary in connection with lands for which stored waters are to be delivered, . . ."

A further reauthorization of the Central Valley Project was made in Public Law 356, 81st Congress, approved October 14, 1949, to include the American River development. The enactment reads as follows:

> "That the Central Valley project, California, authorized by section 2 of the Act of Congress of August 26, 1937 (50 Stat. 850), is hereby reauthorized to include the <u>American River development as hereinafter described, which development is declared to be for the same purposes as described and set forth in the Act of Congress of August 26, 1937 (50 Stat. 850)</u>. (Emphasis Supplied.)
>
> "Sec. 2. The American River development shall consist of: Folsom Dam and Reservoir having a storage capacity of approximately one million acre-feet, to be constructed by the Corps of Engineers at such point below the confluence of the North Fork and the South Fork of the American River near the city of Folsom, California, as the Secretary of the Army and the Chief of Engineers after consultation with the Bureau of Reclamation and other appropriate State, Federal, and

local agencies may find most advisable; and the following features for the development and use of water, to be constructed, operated, and maintained by the Secretary of the Interior through the Commissioner of Reclamation: A hydroelectric power plant with a generating capacity of approximately one hundred and twenty thousand kilowatts, and necessary hydroelectric afterbay power plants and necessary electric transmission lines to the nearest practical interconnection with the Central Valley project transmission system; a storage dam with a capacity of approximately forty thousand acre-feet to be located on Sly Park Creek, a tributary of the North Fork of Consumnas River, with necessary appurtenant works, including a diversion dam on Camp Creek, tunnel, conduit, and canals for the delivery of water to lands in El Dorado County, and incidental works appurtenant thereto. . ."

Public Law 839, 81st Congress, reauthorized the entire Central Valley Project heretofore authorized, to include an irrigation canal generally known as the Tehama-Colusa Conduit,

> " . . . to be located on the west side of the Sacramento River and equipped with all necessary pumping plants and appurtenant works, beginning at the Sacramento River near Red Bluff, California, and extending southerly through Tehama, Glenn, and Colusa Counties so as to permit the most effective irrigation of the irrigable lands lying in the vicinity of said canal and supply water for industrial, domestic, and other beneficial uses for these lands in Tehama, Glenn, and Colusa Counties or such alternate canals and pumping plants as the Commissioner of Reclamation and the Secretary of the Interior may deem necessary to accomplish the aforesaid purposes,"

and also,

> " . . an irrigation canal generally known as the Chico Canal, to be located on the east side of the Sacramento River and equipped with all necessary pumping plants and other appurtenant works, beginning at the Sacramento River near Vina, California, and extending through Tehama and Butte Counties to a point near Durham, California, so as to permit the most effective irrigation of the lands lying in the vicinity of said canal and supply water for industrial, domestic, and other beneficial uses for these lands lying within Tehama and Butte Counties or such alternate canals and pumping plants as the Commissioner of Reclamation and the Secretary of the Interior may deem necessary to accomplish the aforesaid purposes."

The act provides for the repayment of the expenditures made for the works authorized thereunder to be governed by the

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Reclamation Law. The operation of the works is to be coordinated and integrated with the operation of the existing features of the Central Valley Project. It is thereafter provided in Section 5 of the act that "no expenditure of funds shall be made for construction of the canals until the Secretary of the Interior, with approval of the President, has submitted to the Congress, with respect to such works, a completed report and finding of feasibility under the provisions of the Federal reclamation laws."

The Central Valley Project is designed to accomplish the following objectives: (1) provide additional water supplies for irrigation; (2) provide water for industrial and domestic use; (3) improve navigation on the Sacramento River; (4) increase flood protection along the Sacramento and San Joaquin rivers; (5) control salinity in the Sacramento-San Joaquin Delta region; (6) produce hydroelectric power for project requirements and commercial sale; and (7) preserve fish and wild life.

The Federal Government, through the agency of the Bureau of Reclamation, initiated construction of the Central Valley Project in October 1937, when work was started on the Contra Costa Canal, with the funds made available from the Emergency Relief Appropriation Act of 1935, and, with subsequent Congressional appropriations, has practically completed the original features thereof. These features comprise Shasta Reservoir and Power Plant, Keswick Dam and Power Plant, electric power transmission lines from the hydroelectric power plants at the Shasta and Keswick dams in Shasta County to Tracy in San Joaquin County, Delta Cross Channel, Contra Costa Canal, Delta-Mendota Canal, Friant Reservoir, Madera Canal, and the Friant-Kern Canal.

The total estimated cost of the completed project, comprising the foregoing major features and also water distribution systems, electric power connecting transmission lines, substations and switchyards, a steam-electric plant in the Sacramento-San Joaquin Delta area, American River Development, Sacramento Valley Irrigation Canals, and miscellaneous features, was estimated on January 1, 1951, by the Bureau of Reclamation and Corps of Engineers at $676,080,000.

Water was first stored in Shasta and Friant reservoirs in the season of 1943-44. Power was first generated at Shasta Power Plant in June 1944, and at Keswick Power Plant in October 1949. The first diversion of water was made into the Contra Costa Canal in August 1940, into the Madera Canal in June 1944, and into the Friant-Kern Canal in July 1949. The Delta Cross Channel, Delta-Mendota Canal, and Tracy Pumping Plant of the latter canal, are expected to be in operation in July of this year.

Federal appropriations for the American River Development have been $8,500,000 for the work being performed by the Corps of Engineers, and $2,851,000 for the work assigned to the Bureau of Reclamation. Considerable foundation excavation work for the main dam, and construction of a number of auxiliary dams, has been performed by the Corps of Engineers, and orders for power plant equipment have been placed by the Bureau of Reclamation. Completion date of the Folsom Project will be largely determined by the appropriations made for its construction by the Congress. A tentative time now set for completion of this project is the early part of 1955.

The Division of Water Resources has made extensive studies

of the operation of Shasta Reservoir to meet its several requirements according to law and existing agreements, and also in coordination with Folsom Reservoir, since the latter reservoir is an integral part of the Central Valley Project and therefore the objectives and requirements thereof are the same as for Shasta Reservoir. Certain phases of these studies which have an important bearing upon the operation of the Feather River Project are presented and discussed later in this report.

Scope and Outline of Report

As previously stated herein, the objective of this investigation is to report upon the Feather River Project with reference to its (a) engineering feasibility, and (b) financial feasibility under State and local financing, with financial assistance from the Federal Government in the interest of flood control, both when operated as an independent unit and when operated in coordination with projects which could utilize water and electric power produced by the Feather River Project. These latter projects include those which would divert water from the channels of the Sacramento-San Joaquin Delta westerly to Santa Clara and Alameda counties and southerly to the lands on the west side of the San Joaquin Valley and to areas south of the Tehachapi Mountains. In connection with the studies and analyses relating to the aforementioned diversion projects, the Oroville Reservoir of the Feather River Project is operated to supplement the water supply available from other sources in the Sacramento-San Joaquin Delta so as to furnish a continuous supply to such diversion projects. The Feather River Project and the projects diverting from the Sacramento-San Joaquin Delta are delineated on Plate 1.

The subject matter of this report is presented in five chapters, as follows: Chapter I, Introduction; Chapter II, Feather River Project; Chapter III, Sacramento-San Joaquin Delta Diversion Projects; Chapter IV, Financial Analyses; and Chapter V, Conclusions and Recommendations.

Additional supporting data are presented in appendices to the report, as follows: A, Agreement between State Water Resources Board, the California Central Valleys Flood Control Association, and the Department of Public Works; B, Feather River Project - Operation Studies Oroville Reservoir, 1921-1947 by months; C, Feather River Project - Water Uses and Diversions from Sacramento-San Joaquin Delta, 1921-1947 by months; D, Estimated Cost, Santa Clara-Alameda Diversion; E, Estimated Cost, San Joaquin Valley-Southern California Diversion; and F, Plates for Feather River Project Report, Numbers 1 to 15.

CHAPTER II. FEATHER RIVER PROJECT

The Feather River Project as presented and discussed in this report comprises the following major features: (a) dam on the Feather River 1.7 miles below the junction of the North and Middle forks of the stream and 5.5 miles above the City of Oroville in Butte County, (b) power plant at the dam, (c) afterbay dam and power plant 4.5 miles below the main dam and one mile above the City of Oroville, (d) the Delta Cross-Channel, and (e) an electric power transmission line from the power plants to a substation near Bethany in San Joaquin County.

The Division of Water Resources has previously prepared a "Report on Comparison of Oroville, Big Bend and Bidwell Bar Reservoir Sites for Development of Feather River," dated August 1949. That report was made with the objective of selecting the best site or sites for major reservoir storage on the Feather River. It was concluded in that report that major storage capacity can be most feasibly and economically provided at the Oroville Reservoir site. The report indicated that the lowest net annual cost per acre-foot of irrigation yield with the reservoir operation for irrigation with incidental power, would be for a capacity of about 1,750,000 acre-feet. However, in order to secure a more nearly complete control of the Feather River, a greater reservoir capacity in the amount of 3,500,000 acre-feet is required. It is believed that such capacity should be adopted to secure a more complete control of the runoff of the stream for the purposes of flood control and irrigation in the Sacramento Valley and electric power production, and as a firming supply to waters now available in the

Sacramento-San Joaquin Delta in the winter months of most years, for possible exportation to the Santa Clara Valley, San Joaquin Valley, and to southern California. Therefore, this report will make inquiry as to the feasibility of constructing a reservoir of 3,500,000 acre-feet capacity at the Oroville site and operating the reservoir to furnish flood protection to lands and improvements along the Feather River and to supply supplemental water to the local water service areas and for exportation to the above mentioned areas, and for production of electric power.

The Feather River Project is discussed and data thereon are presented in this chapter as to (a) water supply, (b) reservoir operation, (c) cost estimate, and (d) flood control benefits.

Water Supply

The water supply available at the Oroville Reservoir site is based upon records obtained by the United States Geological Survey at the stream gaging station on the Feather River near Oroville since October 1901. The drainage area above the present gage which is about 5.5 miles upstream from Oroville, is 3,610 square miles. Prior to October 1934, the gage was located at Oroville and the drainage area was 3,640 square miles.

Water and Power Developments above Oroville Reservoir

Power and irrigation storage and diversion on the Feather River above the Oroville Reservoir site have considerable influence upon the runoff which reaches the dam site. The storage reservoirs are shown on Plate 2 and are listed hereafter.

Reservoir	Branch of river on which located	Storage capacity	
Lake Almanor	North Fork	649,800	acre-feet
Butt Valley	"	50,000	"
Buck's Storage	"	103,000	"
Buck's Diversion	"	5,843	"
Mountain Meadows	"	24,000	"
Three Lakes	"	513	"
Grizzly Forebay	"	1,112	
Rock Creek	"	4,660	
Cresta	"	4,440	
Round Valley	West Branch	1,285	"
Philbrook	"	4,875	"
Lake Wilenor	"	8,600	"
Lost Creek	South Fork	5,200	"

The power and irrigation diversions which do not return to the stream above Oroville are:

Name	Annual Diversion	
Palermo Canal	14,500	acre-feet
Forbestown Ditch	15,500	"
Hendricks Canal	41,000	"
Miocene and Wilenor Canals	38,100	"
Total	109,100	acre-feet

In addition to the foregoing developments and diversions, the Oroville-Wyandotte Irrigation District is giving consideration to the development of a power and irrigation project on the South Fork of the Feather River above Oroville. The proposed plan is to store 42,000 acre-feet at the Little Grass Valley reservoir site on the main South Fork and 55,000 acre-feet at the Lost-Sly reser-

voir site on Lost Creek, a tributary of the South Fork. Storage of 4,800 acre-feet on Slate Creek, a tributary of the Yuba River, and diversion of the stored water to the Lost-Sly Reservoir is also planned as part of the project. Use of the stored water from these reservoirs for irrigation as well as for power is contemplated but it was assumed that for the present the water would be returned to the stream above Oroville Reservoir after use for power at the proposed Woodleaf and Forbestown power plants.

Present Impaired Flows at Oroville Reservoir

In making the reservoir operation studies, the period 1921 through 1947 was used to determine power output and irrigation supply, while a longer period, 1902 through 1947, was used to determine the effect of the reservoir on flood flows. For the period 1921 through 1947, the stream was assumed to have reached present development, and the present impaired inflow to Oroville Reservoir was computed from the U.S.G.S. recorded flows corrected for storage and release in the reservoirs of the Oroville-Wyandotte proposed plan described above, without the inclusion of any Yuba River water from Slate Creek.

For the period 1902 through 1920 the historical natural flow of the Feather River at Oroville was computed and the present impaired flow calculated by correcting for storage and release at the power and irrigation reservoirs of the upper Feather River described previously. The storage and release corrections for Butt Valley, Bucks storage and diversion, Mountain Meadows, Three Lakes, Grizzly Forebay, Round Valley, Philbrook, and Lake Wilenor reservoirs were taken as the average of the last 10 years of opera-

tion. Lake Almanor storage and release was found by making an operation study of that reservoir using the natural flow of the North Fork at Prattville, corrected for Mountain Meadows storage and release, as the inflow. The storage and release for the proposed Little Grass Valley and Lost-Sly reservoirs was found by making operation studies of these reservoirs using estimated inflow and a release equal to the maximum continuous flow obtainable for the period 1928 through 1934. The diversions of the Palermo, Forbestown, Hendricks, Miocene, and Wilenor canals were deducted from the natural flow. The amounts of these diversions were taken as the average of 8 years of operation, 1942 through 1949.

The natural and present impaired flows were estimated on a monthly basis and are summarized by years for the period 1902-1947 in Table 1.

Stream Flow Into Suisun Bay

In the operation studies of the Oroville Reservoir one of the objectives was to firm (create a supply without deficiency) the excess waters available in the Sacramento-San Joaquin Delta for export to areas to the west and south. In this connection the flow into Suisun Bay including that for salinity control was computed. The amount of this flow was computed in a study made of the combined operation of Shasta and Folsom reservoirs. In this study mandatory releases were made from the Shasta and Folsom reservoirs to meet the requirements of the Central Valley Project. These releases were sufficient to supplement flows from other sources to make water available for the following:

1. Riparian and appropriative rights along the Sacramento River from Shasta Reservoir to Sacramento.
2. Maintenance of flow of 5,000 second-feet at Knights Landing for navigation.
3. Consumptive uses and evaporation in the Sacramento-San Joaquin Delta.
4. A supply to the Contra Costa Canal of 55,000 acre-feet per year.
5. A supply to the West Delta Uplands of 80,000 acre-feet per year.
6. Requirements under the Exchange Agreement.
7. Salinity control to Antioch (4,500 second-feet into Suisun Bay).

Use was made of estimated return flows for meeting requirements downstream from Knights Landing.

After meeting all of the foregoing requirements, the study showed that there would have been an additional firm yield from Shasta Reservoir under an irrigation schedule of 550,000 acre-feet per year and a firm irrigation yield from Folsom Reservoir of 975,000 acre-feet per year.

Table I

ANNUAL FLOWS OF THE FEATHER RIVER AT OROVILLE DAM SITE
Drainage Area 3,610 square miles

All quantities in 1,000 acre-feet

Year	Natural flow	Present impaired flow	Year	Natural flow	Present impaired flow
1902	4,695.5	4,329.0	1926	3,609.8	3,215.8
03	5,419.7	5,016.7	27	5,416.8	4,644.4
04	8,714.1	8,427.6	28	3,867.8	3,436.9
1905	4,025.5	3,745.1	29	2,618.4	2,660.8
			1930	3,237.5	2,934.7
06	7,316.4	6,913.2			
07	9,389.4	9,024.5	31	1,619.8	1,445.5
08	3,369.3	3,137.6	32	3,077.3	2,504.9
09	8,157.2	7,722.9	33	2,042.5	1,771.5
1910	4,066.3	3,830.4	34	2,032.6	1,787.6
			1935	4,179.5	3,759.8
11	6,990.2	6,603.5			
12	2,318.3	2,087.9	1936	4,217.8	3,942.2
13	3,073.7	2,761.2	37	4,489.4	3,984.4
14	7,868.5	7,440.9	38	7,325.6	7,065.0
1915	6,195.8	5,861.7	39	1,747.2	1,550.8
			1940	6,301.3	5,815.2
16	7,080.2	6,708.8			
17	4,820.2	4,493.9	41	6,614.2	6,156.0
18	2,790.2	2,575.5	42	6,282.6	5,943.1
19	3,583.6	3,235.9	43	5,189.6	4,886.8
1920	3,123.4	2,874.8	44	3,063.5	2,762.8
			1945	4,031.7	4,026.8
21	5,136.3	4,756.2			
22	5,245.5	4,880.4	46	3,240.3	3,235.4
23	2,790.3	2,510.4	47	2,193.3	2,208.6
24	1,419.9	1,201.2			
1925	3,106.9	2,687.6			

The mean annual natural and impaired flows for the period 1902-1947 are 4,502,100 acre-feet and 4,186,200 acre-feet, respectively, and the same flows for the period 1921-1947 are 3,855,500 acre-feet and 3,547,200 acre-feet respectively.

Reservoir Operation

Two operation studies of the Oroville Reservoir have been made for the purpose of this report. One study was made to provide for downstream prior rights, flood control, power generation, and an incidental irrigation supply. The second study was made to provide for downstream prior rights and additional requirements of the Feather River service area, flood control, firming of excess flows in the Sacramento-San Joaquin Delta to make possible a continuous diversion therefrom, and the generation of power.

In making both of these operation studies, the following assumptions and criteria were used:

(1) The water supply used was the present impaired run-off of the Feather River at Oroville dam site, estimated as described in the section of this chapter on water supply, and set forth by years in Table 1.

(2) The areas and capacities of the Oroville Reservoir used were those obtained from topographic maps made by the Fairchild Company, by photogrammetric methods, for the U. S. Bureau of Reclamation in 1946. In computing these data, maps on a scale of 1 inch equals 400 feet, with contours at ten-foot intervals were used. The areas and capacities for the reservoir are shown in Table 2.

(3) In the coordinated operation studies of the Shasta and Folsom reservoirs for the Central Valley Project, the calculation of the releases required from the reservoirs to meet requirements in the Delta was predicated on the assumption that the Feather River flow into the Sacramento River would continue as under present conditions. Therefore, in this study, certain

Table 2

Areas and Capacities of Oroville Reservoir
United States Geological Survey datum

Height of dam in feet (5-foot freeboard)	Water surface elevation in reservoir in feet	Area of water surface in acres	Capacity of reservoir in acre-feet
10	200	0	0
30	220	26	200
50	240	67	1,100
70	260	115	3,100
90	280	200	6,300
110	300	300	11,300
130	320	445	18,700
150	340	605	29,200
170	360	799	43,300
190	380	995	61,200
210	400	1,189	83,100
230	420	1,450	109,500
250	440	1,705	141,000
270	460	2,000	178,500
290	480	2,327	221,700
310	500	2,685	271,800
330	520	3,085	329,400
350	540	3,500	395,300
370	560	3,927	470,000
390	580	4,340	552,700
410	600	4,738	643,300
430	620	5,250	743,200
450	640	5,785	853,400
470	660	6,355	975,100
490	680	6,970	1,108,300
510	700	7,618	1,254,100
530	720	8,260	1,412,600
550	740	8,950	1,584,600
570	760	9,675	1,770,700
590	780	10,450	1,972,000
610	800	11,220	2,188,600
630	820	12,050	2,421,200
650	840	12,900	2,670,800
670	860	13,780	2,937,700
690	880	14,600	3,221,600
710	900	15,450	3,522,800

releases from Oroville were made to replace these uncontrolled flows in months when they were depended upon in the former study to meet the Central Valley Project requirements. These releases averaged 134,000 acre-feet per year and occurred mostly in the months of July, August, and September.

(4) Evaporation losses from the reservoir surface were taken as 3.5 feet per year net, to take place in the months of April to November, inclusive.

(5) The installed capacities of the power plants at the Oroville and Oroville Afterbay dams would be 440,000 kilowatts and 25,000 kilowatts, respectively.

(6) The overall efficiency of the Oroville power plant was assumed to be 83 per cent while operating at heads between the maximum head of 703 feet and the design head of 558 feet, and from 83 per cent to 78 per cent, on a straight line basis, from the design head down to half the maximum head of 351.5 feet. Plant efficiency for the Oroville Afterbay plant was assumed to be constant at 80 per cent.

(7) Power load characteristics of the Pacific Gas and Electric Company system as of the year 1949 were used, as follows:

Month	Monthly Peak in % of Annual Peak	Kwh. per Kw. of Annual Peak	Monthly Load Factor	Upper Limit of 100% L. F.
Jan.	90.7	442.0	65.5	35.5
Feb.	87.9	396.4	67.1	39.3
Mar.	84.3	425.2	67.8	34.1
Apr.	86.6	440.2	70.6	42.7
May	88.3	463.2	70.5	42.7
June	97.6	503.8	71.7	40.8
July	100.0	545.3	73.3	53.3
Aug.	99.4	545.0	73.7	53.1
Sept.	94.6	472.7	69.4	39.8
Oct.	91.9	449.9	65.8	40.6
Nov.	90.8	424.3	64.9	37.3
Dec.	96.8	445.8	61.9	33.3
Total		5,553.8	63.4	

(8) A system load of sufficient size to utilize all the installed hydro-capacity in kilowatts was assumed, energy outputs were limited to amounts that could be used within that system load, and minimum power releases were made to produce sufficient energy in conjunction with an assumed auxiliary steam-electric plant output to meet the system energy requirements.

(9) Reservoir operating criteria were used to permit the maximum use of water through the power plants and at the same time give assurance that no operational failure would occur in any year, or period of years, as dry as those experienced in the period studied.

(10) It was assumed that the design of the power turbines would be such that the discharging capacity at the maximum head would be equal to that at half the maximum head. This assumption results in a design head of about eight-tenths of the maximum head, above which full output capacity of the installed generating equipment may be obtained. At one-half of the maximum head only one-half the output capacity is available. Between the design head and the minimum head the output capacity is assumed to vary with the three halves power of the head. In this study the auxiliary power supply is assumed to be steam-electric capacity.

(11) The dependable capacity of the Oroville and afterbay power plants was taken as the difference between the annual system peak demand and the auxiliary steam-electric capacity required, both expressed in kilowatts.

(12) Flood control operation was considered to be a primary function of Oroville Reservoir. Flood flow storage space was reserved beginning with a zero reservation on the first day of November and increasing on a straight line basis to the maximum reservation of 500,000 acre-feet on the 15th day of November. This maximum reserve was held until the first day of April and then allowed to reduce uniformly to a zero reservation on the first day of May. Further discussion of the flood control operation appears later in this chapter.

Operation of Oroville Reservoir Primarily for Power Generation

Using the foregoing criteria, a study was made of the 3,500,000 acre-foot Oroville Reservoir and its afterbay, operated

primarily for the generation of power, for the period 1921-1947. This study shows that an average annual output of 1,742,600,000 kilowatt-hours of electric energy could have been generated in that period at the hydroelectric power plants, with a dependable plant capacity of 348,100 kilowatts. Also, with this operation, a firm irrigation supply of 500,000 acre-feet per year, in addition to present downstream prior rights, based on 1947 diversions, would have been available. The inflows to the reservoir, reservoir storage, releases, and electric energy outputs with this operation for the period 1921-1947, by years in Table 3, by months in the tabulation included as Appendix B of this report and graphically on Plate 4.

Operation of Oroville Reservoir to Provide Water for Continuous Diversion from the Sacramento-San Joaquin Delta

In this study, the 3,500,000 acre-foot Oroville Reservoir was operated to firm excess waters, available in the Sacramento-San Joaquin Delta in winter months of most years, to provide a continuous draft for export from the Delta by pumping to Santa Clara Valley, San Joaquin Valley, and southern California. The study covered the period 1921-1947.

In making the study, the reservoir was operated first to meet the requirements of the Feather River Service Area, which is located on the Sacramento Valley floor with Nelson on the north, Butte Creek and the Sutter By-pass on the west, the Feather River channel on the east, and the junction of the river with Sutter By-pass as the southerly limit. There are 322,200 acres of gross irrigable area within the service area. This area is shown on Plate 3. The other criteria used in making the study are those previously stated.

Table 3

FEATHER RIVER PROJECT

Oroville Reservoir Operating for Flood
Control, Irrigation, and Power Generation

Annual Summary

Year	Inflow to reservoir	Operation in Coordination with Sacramento-San Joaquin Delta Diversion Projects							Operation primarily for power			
		Reservoir storage on first of year	Evaporation	Releases from reservoir-1,000 Ac.Ft.				Electric energy output	Reservoir storage on first of year	Evaporation	Release from reservoir	Electric energy output
				Net requirement for Feather River Service Area	Requirement to yield a supply of 3,930 sec.ft. in Delta	Power generation and waste through flood control outlets and over spillway	Total					
	1000 Ac.Ft.	1000 Ac.Ft.	1000 Ac.Ft.					1,000,000 kilowatt hours	1000 Ac.Ft.	1000 Ac.Ft.	1000 Ac.Ft.	1,000,000 kilowatt hours
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921	4,756.2	2,539.1	50.2	631.0	353.7	3,705.8	4,706.0	2,366.8	2,898.5	51.0	4,789.8	2,307.8
22	4,880.4	2,539.1	50.1	631.0	216.0	3,967.8	4,830.3	2,207.5	2,813.9	51.4	4,744.4	2,199.1
23	2,510.4	2,539.1	49.1	631.0	917.5	953.2	2,517.2	1,527.9	2,898.5	50.5	2,653.1	1,625.7
24	1,201.2	2,483.2	33.3	631.0	1,819.4	271.4	2,737.3	1,399.6	2,705.3	40.1	2,326.4	1,291.3
25	2,687.6	913.8	38.0	631.0	779.5	363.5	1,789.5	954.6	1,540.0	40.6	2,353.2	1,291.3
26	3,215.8	1,773.9	46.6	631.0	1,320.8	436.7	2,404.0	1,415.5	1,833.8	46.1	2,214.9	1,291.3
27	4,644.4	2,539.1	49.3	631.0	653.6	3,295.0	4,595.1	2,277.3	2,788.6	51.1	4,483.4	2,086.5
28	3,436.9	2,539.1	48.6	631.0	1,210.6	1,700.1	3,557.2	1,767.2	2,898.5	50.3	3,590.4	1,699.8
29	2,660.8	2,370.2	42.2	631.0	1,776.0	168.1	2,590.6	1,463.6	2,694.7	47.6	2,399.3	1,433.4
1930	2,934.7	2,398.2	49.2	631.0	1,548.9	549.2	2,744.6	1,661.5	2,908.6	50.6	2,894.2	1,726.6
31	1,445.5	2,539.1	37.6	631.0	1,892.5	229.4	2,768.4	1,471.1	2,898.5	45.1	2,208.3	1,291.3
32	2,504.9	1,178.6	39.7	631.0	1,093.3	249.7	1,989.5	1,086.9	2,090.6	47.5	2,194.6	1,291.3
33	1,771.5	1,654.3	35.3	631.0	1,184.0	242.0	2,072.5	1,069.2	2,353.4	40.8	2,317.4	1,291.3
34	1,787.6	1,318.0	26.0	412.4	1,800.3	410.5	2,633.3	1,164.2	1,766.7	33.4	2,582.5	1,291.3
35	3,759.8	446.3	40.7	631.0	1,044.9	361.4	2,052.8	1,116.2	938.4	41.9	2,420.2	1,291.3
36	3,942.2	2,112.6	49.2	631.0	1,049.6	1,887.4	3,583.5	1,995.2	2,236.1	50.5	3,403.2	1,884.1
37	3,984.4	2,422.1	49.2	631.0	903.2	1,807.6	3,357.3	1,833.5	2,724.6	51.0	3,658.0	1,891.1
38	7,065.0	3,000.0	50.4	631.0	47.3	6,781.7	7,475.5	2,587.1	3,000.0	51.6	7,114.9	2,381.6
39	1,550.8	2,539.1	39.5	631.0	1,709.5	198.3	2,554.3	1,424.8	2,898.5	47.1	2,172.4	1,293.1
1940	5,815.2	1,496.1	49.3	631.0	815.4	3,100.4	4,562.3	2,233.7	2,229.8	51.1	4,993.9	2,135.9

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1941	6,156.0	2,699.7	49.8	631.0	189.9	5,123.0	5,959.4	2,606.9	3,000.0	51.4	6,104.6	2,384.5
42	5,943.1	2,846.5	50.6	631.0	59.5	5,493.9	6,199.9	2,730.0	3,000.0	51.6	5,993.0	2,542.4
43	4,886.8	2,539.1	49.2	631.0	670.5	3,520.6	4,837.6	2,324.4	2,898.5	51.2	4,950.0	2,180.7
44	2,762.8	2,539.1	48.8	631.0	1,075.3	992.1	2,713.9	1,643.0	2,784.1	50.5	2,597.9	1,594.2
45	4,026.8	2,539.2	49.1	631.0	766.0	2,136.3	3,548.8	2,135.8	2,898.5	50.6	3,874.7	1,983.6
46	3,235.4	2,968.1	49.2	631.0	843.6	2,125.1	3,615.2	2,109.5	3,000.0	50.5	3,299.7	1,917.2
47	2,208.6	2,539.1	44.9	631.0	1,461.1	529.5	2,637.1	1,535.8	2,885.2	49.3	2,390.2	1,452.5
27 year mean	3,547.2	2,222.7	45.0	622.9	1,007.5	1,874.1	3,519.7	1,781.8	2,577.2	47.9	3,508.3	1,742.6

The ultimate consumptive irrigation use requirement of the Feather River Service Area, including the areas now having prior rights to Feather River water, is estimated to be 631,000 acre-feet per year over and above effective rainfall. Assuming an irrigation efficiency of 65 per cent, the gross requirement of the area would be 970,000 acre-feet per year. The difference between the former and latter figures was considered to be available return flow with a month lag between diversion and eventual arrival in the Delta. The monthly distribution of the foregoing amounts and the return flow is shown in the following tabulation:

Month	% of Total	Gross Requirement	Consumptive Use	Return Flow
		Quantities in 1,000 acre-feet		
Jan.	0	0	0	0
Feb.	0	0	0	0
Mar.	1	9.7	6.3	
Apr.	5	48.5	31.6	3.4
May	16	155.2	101.0	16.9
June	20	194.0	126.2	54.2
July	22	213.4	138.8	67.8
Aug.	20	194.0	126.2	74.6
Sept.	12	116.4	75.7	67.8
Oct.	4	38.8	25.2	40.7
Nov.	0	0	0	13.6
Dec.	0	0	0	0
Total	100	970.0	631.0	339.0

The study shows that with the available excess water in the Delta supplemented by releases from Oroville Reservoir it was possible to obtain a continuous flow for diversion of 3,930 second-feet without deficiency, or about 2,845,000 acre-feet annually, over the 27-year period of operation. The incidental hydroelectric energy obtainable at generation from the power plants at Oroville and Oroville Afterbay dams would have been 1,777,000,000 kilowatt hours annually with a dependable capacity of 232,000 kilowatts. The inflows to the reservoir, reservoir storage, releases for the several purposes for which the reservoir was operated and the electric energy output for the period 1921-1947, are shown by years in Table 3, by months in the tabulation included as Appendix B of this report, and graphically on Plate 5.

Inflows to the Sacramento-San Joaquin Delta, and the uses of those inflows for the period 1921-1947 are shown by years in Table 4, by months in the tabulation included as Appendix C of this report, and graphically on Plate 6. The inflows to the Sacramento-San Joaquin Delta comprise uncontrolled flows; spills from existing reservoirs, except Shasta Reservoir; return flows; Central Valley Project requirements in and from the Delta, and spills, with coordinated operation of Shasta and Folsom reservoirs; and Oroville reservoir water required to make possible a continuous diversion of 3,930 second-feet from the Delta. The diversions comprise the Central Valley Project requirements for salinity control, consumptive use in the Delta, use on the west side Delta Uplands, export through the Contra Costa Canal, and the Exchange Contract. They also comprise a water supply for lands adjacent to the Delta-Mendota Canal when available from excess flows and the continuous flow of 3,930 second-feet for export to the Santa Clara Valley,

Table 4

FEATHER RIVER PROJECT

Water Uses and Diversions from Sacramento-San Joaquin Delta
Annual Summary
Quantities in 1,000 acre-feet

Year	Water Supply: Uncontrolled inflow to Delta from Sacramento-San Joaquin River basin modified by present developments and operation of Folsom and Oroville reservoirs	Water Supply: Water released from Oroville Reservoir to supplement surplus water in Delta so as to provide a continuous diversion of 3930 Sec.Ft. therefrom	Water Supply: Water released from Oroville Reservoir specifically for power generation, and water wasted over spillway and through flood control outlets	Water Supply: Total	Requirements of the Central Valley Project: Required flow into Suisun Bay to prevent encroachment of saline waters into the Delta (4500 Sec.Ft.)	Requirements of the Central Valley Project: Estimated water requirements of the Contra Costa Conduit in 1960 and the present requirements of the Delta Uplands	Requirements of the Central Valley Project: Consumptive irrigation requirements and evaporation losses in Delta	Requirements of the Central Valley Project: Water diverted to meet requirements of Exchange Agreement, dated July 27, 1939, between United States and San Joaquin and Kings River Canal Company, San Luis Canal Company, and Firebaugh Canal Company	Requirements of the Central Valley Project: Total	Irrigation supply reserved for the area adjacent to Delta-Mendota Canal when a surplus above Central Valley Project requirements exists in the Delta	Inflow to Delta in excess of Central Valley Project requirements 5-(10+11)	Continuous water supply without deficiency of 3930 Sec.Ft. for diversion to Santa Clara Valley, San Joaquin Valley and Southern California
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921	21,486.8	353.7	3,721.3	25,561.8	3,258.0	135.8	1,296.9	870.9	5,561.6	113.0	19,887.2	2,844.7
22	21,637.4	216.0	3,983.3	25,786.7	3,258.0	135.8	1,296.9	884.4	5,575.1	113.0	20,098.6	2,844.7
23	11,913.7	917.5	968.7	13,799.7	3,258.0	135.8	1,296.9	872.8	5,563.5	61.0	8,175.4	2,844.7
24	6,921.7	1,819.4	286.9	9,028.0	3,266.9	135.8	1,296.9	737.1	5,436.7	10.1	3,581.2	2,852.5
25	14,311.9	779.5	379.0	15,470.4	3,258.0	135.8	1,296.9	867.5	5,558.2	108.1	9,804.1	2,844.7
26	13,830.8	1,320.8	452.2	15,603.8	3,258.0	135.8	1,296.9	814.6	5,505.3	39.5	10,059.0	2,844.7
27	24,141.0	653.6	3,310.5	28,105.1	3,258.0	135.8	1,296.9	887.3	5,578.0	103.6	22,423.5	2,844.7
28	15,927.8	1,210.6	1,715.6	18,854.0	3,266.9	135.8	1,296.9	814.4	5,514.0	39.5	13,300.5	2,852.5
29	7,694.6	1,776.0	183.6	9,654.2	3,258.0	135.8	1,296.9	803.5	5,494.2	61.0	4,099.0	2,844.7
1930	9,719.8	1,548.9	564.7	11,833.4	3,258.0	135.8	1,296.9	803.1	5,493.8	61.0	6,278.6	2,844.7
31	7,414.4	1,892.5	244.9	9,551.8	3,258.0	135.8	1,296.9	735.4	5,426.1	10.1	4,115.6	2,844.7
32	11,464.0	1,093.3	265.2	12,822.5	3,266.9	135.8	1,296.9	881.8	5,581.4	61.0	7,180.1	2,852.5
33	8,295.5	1,184.0	257.5	9,737.0	3,258.0	135.8	1,296.9	843.1	5,533.8	61.0	4,142.2	2,844.7
34	8,253.3	1,800.3	421.2	10,474.2	3,258.0	135.8	1,296.9	775.6	5,466.3	10.1	4,997.8	2,844.7
35	14,622.4	1,044.9	376.9	16,044.2	3,258.0	135.8	1,296.9	883.0	5,573.7	61.0	10,409.5	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
36	18,371.0	1,049.6	1,902.9	21,323.5	3,266.9	135.8	1,296.9	884.4	5,584.0	61.0	15,678.5	2,852.5
37	20,408.5	903.2	1,823.1	23,134.8	3,258.0	135.8	1,296.9	877.5	5,568.2	61.0	17,505.6	2,844.7
38	34,348.2	47.3	6,797.2	41,192.7	3,258.0	135.8	1,296.9	565.7	5,256.4	113.0	35,823.3	2,844.7
39	7,472.0	1,709.5	213.8	9,395.3	3,258.0	135.8	1,296.9	803.0	5,493.7	18.0	3,883.6	2,844.7
1940	26,672.0	815.4	3,115.9	30,603.3	3,266.9	135.8	1,296.9	859.1	5,558.7	61.0	24,989.6	2,852.5
41	33,403.0	189.9	5,138.5	38,731.4	3,258.0	135.8	1,296.9	905.8	5,596.5	113.0	33,021.9	2,844.7
42	27,483.0	59.5	5,509.4	33,051.9	3,258.0	135.8	1,296.9	904.2	5,594.9	113.0	27,344.0	2,844.7
43	21,950.9	670.5	3,536.1	26,157.5	3,258.0	135.8	1,296.9	880.7	5,571.4	113.0	20,473.1	2,844.7
44	10,739.0	1,075.3	1,007.6	12,821.9	3,266.9	135.8	1,296.9	879.0	5,578.6	61.0	7,182.3	2,852.5
45	19,600.0	766.0	2,151.8	22,517.8	3,258.0	135.8	1,296.9	913.1	5,603.8	61.0	16,853.0	2,844.7
46	13,871.5	843.6	2,140.6	16,855.7	3,258.0	135.8	1,296.9	872.6	5,563.3	64.0	11,228.4	2,844.7
47	8,613.6	1,461.1	545.0	10,619.7	3,258.0	135.8	1,296.9	826.5	5,517.2	39.5	5,063.0	2,844.7
27 year mean	16,317.3	1,007.5	1,889.4	19,212.3	3,260.0	135.8	1,296.9	838.7	5,531.4	66.4	13,614.5	2,846.4

San Joaquin Valley and southern California. It is shown that this flow would have been available without deficiency in all years of the period studied.

Estimated Cost of Feather River Project

The costs of the several features of the Feather River Project have been estimated, based upon current prices of construction. The estimates are presented herein for (a) Oroville Reservoir and power plants, (b) transmission lines and substations, and (c) Delta Cross Channel. The estimated cost of the reservoir includes acquisition of necessary lands and rights of way, relocation of railroads, highways and roads, and construction of dams and power plants.

Oroville Reservoir

The Oroville dam site is located in Sections 1 and 2, T. 19 N., R. 4 E., and Section 35, T. 20 N., R. 4 E., M.D.B.& M., and is immediately upstream from State Highway No. 24 crossing of the Feather River about 5.5 miles from Oroville. The site has been mapped by the Division of Water Resources on a scale of 200 feet to the inch with a contour interval of 10 feet. This topographic map was used in laying out the dam and appurtenant works and estimating construction quantities.

Geology of dam site. - Elmer C. Marliave, Supervising Engineering Geologist, Division of Water Resources, examined the Oroville dam site and sources of aggregate for dam construction on February 8, 9 and 10, 1949, and has reported as follows:

The foundation rocks at the site are entirely metamorphics and while appearing to be largely meta igneous may contain meta volcanics and meta-sediments. The terms amphibolite, amphibolite schist and greenstones are applicable generally to this type of rock. They strike across the channel and dip steeply upstream in a favorable attitude, and are strongly jointed. Where exposed

along the channel section and for some sixty feet upwards the rock is hard and fresh with tight joints through a few narrow mud seams and shear zones are somewhat softer. Upwards on the abutments rock exposures are very few and practically all data must be deduced from core drilling. The rock exposed in the channel area should prove suitable for overpour spillway if moderately protected.

Just upstream from the proposed axis the high rock line along the channel drops sharply. There are also indications of more pronounced jointing and deeper weathering. This is undoubtedly due to some structural control not as yet evident. Also, there appears to be some structural feature striking diagonally downstream from right to left abutment from point upstream from axis on right abutment to a point on axis on left abutment at about elevation 300. It may represent a shear or closely spaced joints or a difference in rock type but it should be thoroughly explored as it cuts through left abutment under the proposed structure.

Moderate grout requirements are anticipated to consolidate portions of the foundation area. If this can be done, considerable excavation can be eliminated. It is assumed that fresh rock with clean or stained joints that is not badly sheared can be grouted to provide a suitable foundation. Such areas could also be drained whether grouted or not if deemed desirable. A suitable grout curtain could be placed near the upstream face and this might well replace a cut-off. The developed surface should be uneven enough after shaping to preclude the possibility of sliding.

The right abutment appears to have the most even slope and has a light brush and tree growth. Soil is estimated to average about eight feet in depth. Below this is a zone of weathered

rock grading into fresher rock at depths of about twenty feet on the average, though still strongly jointed. From twenty to about fifty feet the rock appears to be reasonably tight and contains only minor defects. An average of about 55 feet of stripping is estimated, of which about 30 per cent can be removed by power shovel. Grouting on this abutment is anticipated to be about 50 per cent greater than on the left abutment.

The channel proper averages about 80 feet in width and is entirely in fresh rock with minor defects. The channel is estimated to contain 50 feet of gravel and about ten feet of stripping will be necessary to shape the gorge and remove soft seams. Adjacent to channel section the hard fresh rock rises to about 60 feet above the channel and most of the stripping here will be taken care of in shaping the section.

The slope of the left abutment is a little steeper in the lower third than right abutment and has a poorly defined bench or possibly remnant of a terrace about halfway up where the slope becomes much gentler. Soil cover is estimated to be about six feet deep and supports a light to moderately dense growth of brush and light trees. Suitable foundation appears to exist at slightly shallower depth over this abutment and stripping will average an estimated 45 feet. Grouting in moderate amounts should be anticipated.

An overpour spillway can be utilized at this site by affording moderate protection to the rock near downstream toe. A natural saddle at about elevation 865 and a ravine below it offers a suitable spillway location. Rock of good quality should be found about 30 feet below surface in this saddle. Lining

would probably be needed for a short distance from the spillway lip.

Ample quantities of coarse aggregates may be obtained from the old dredge tailings southwest of Oroville. There may be some recoverable quantities of sand and fine aggregate in this material. The pebbles and cobbles are largely metamorphics and will require little washing.

Several million yards of clean quartzose sand, with small gravel to 1 inch, is located near Pentz and is derived from hydraulic operations in the Cherokee mine. More sand is obtainable from unproven nearby sources and large quantities could be shipped by rail from Marysville.

Proven quantities of earth materials are scant though there should be unlimited quantities west of Oroville in the valley. The tuffaceous beds near the foothills may not prove acceptable for fill for a high dam.

Several suitable sites for low afterbay dams may be found between the site and the town of Oroville.

This area is considered to be one of low seismic activity.

Of particular interest is the condition of right abutment between elevations 500 and 750. The U.S.E.D. core drill hole 1F2 did not look promising. U.S.B.R. holes on either side appeared better as they were drilled so as to cross-cut the foliation. There is an area between the elevations mentioned that may require deep excavation. This seems to be critical and other exploration should be pointed towards proving the suitability of this area. A test pit would be the most suitable means of exploring. If possible, the adjacent area should be grouted prior to sinking the shaft. Similar work should be done on left abutment. Core drill

holes are a second choice for exploration but might be used first to determine the areas to be explored by shaft. The apparent structural feature on left abutment near axis at elevation 300 should be explored by drift or drill holes.

The following conclusions are submitted in the report:

1. A safe concrete gravity or earthen dam can be built at this site to a height of about 700 feet.

2. The best geologic location appears to be at site now proposed. The rock appears to be fresher and sounder than along the upstream area. There are small and possibly large slides upstream, and weathering appears to have proceeded to greater depths in this area.

3. Ample quantities of coarse aggregates are available in the vicinity of Oroville and considerable sand is available near the town of Pentz, about 5 and 8 miles respectively from the site by air line.

4. The most unfavorable situation is the fracturing and jointing of the foundation rock which has allowed weathering to considerable depths and will therefore require a great deal of rock excavation.

5. An overpour spillway is feasible and a topographic saddle and draw beyond right end offers another spillway possibility.

Improvements flooded. - The Oroville Reservoir, capacity 3,500,000 acre-feet, would flood 15,450 acres of land up to elevation 900 feet, U. S. Geological Survey datum. The height of dam above stream bed would be 711 feet. The lands submerged were evaluated by field inspection and checked against recent property sales by the revenue stamps attached to deeds in the county recorder's office. The following table sets forth the estimated value of the lands that would be acquired.

Land Type	Acres	Unit Cost	Total Cost
River channel	1,350	$ 2	$2,700
River bank and highway	954	5	4,770
Right of way	452	5	2,260
Pasture land	19,311	10	193,110
Timber land	3,478	20	69,560
Industrial land	61	200	12,200
Irrigated land	234	300	70,200
State park	77	260	20,000
Cultivated (Non-irrigated) land	17	250	4,250
Total lands to be acquired	25,934		$379,050

A preliminary relocation of the main line of the Western Pacific Railroad between San Francisco and Salt Lake has been made by the U. S. Bureau of Reclamation for the 3,500,000 acre-foot capacity of Oroville Reservoir. Engineers of the Western Pacific Railroad and the Division of Water Resources have examined the location and it has been accepted by the three agencies as a feasible location. The construction quantities involved in the

relocation have been furnished to this office by the Bureau of Reclamation and unit prices as of the present have been applied to those quantities in estimating the cost of the relocation.

The proposed railroad relocation would be about 23.4 miles long as shown on Plate 7 and would replace 27.1 miles of existing line which presently is located along the main river and the North Fork above Oroville.

Features of the proposed relocation include 23.4 miles of main track; four complete passing tracks; five railroad tunnels with a total length of 3.4 miles, the longest tunnel with a length of 8,550 feet; 5,000,000 cubic yards of roadway excavation, and three bridges. The first bridge across the Feather River across Oroville Afterbay Reservoir would be about 1,100 feet long. The second bridge would be a combination railroad and highway bridge over West Branch of Feather River with main structure 1,870 feet long and length along highway deck 2,210 feet. The distance of top of highway deck above streambed is 470 feet. The third bridge would be 1,000 feet long across the North Fork of the Feather River. The present railroad follows closely above the bed of the river on a maximum ascending gradient of one per cent compensated from Oroville to the divide of the Sierra Nevada at elevation 5,000 feet near Portola. The maximum ascending gradient on the existing main track for the first 13.6 miles above Oroville does not exceed 0.4 per cent, the remaining 13.5 miles to Intake does not exceed 1 per cent (compensated). The maximum degree of curvature on the existing line that would be flooded is 10 degrees. The total curvature on the same portion of line is 572 degrees and 16 minutes. The grade on the relocated line has been held to a

maximum of one per cent (compensated) and includes adverse grade of about 9.4 feet. The maximum degree of curvature on the relocated line would be 5 degrees. The total curvature on the relocated line would be 133 degrees and 6 minutes.

The proposed State Highway relocation as shown on Plate 7 would be about 17.5 miles in length and would replace 20.5 miles of existing highway and the cost thereof is included as part of the project.

The costs of relocating the Feather Falls railroad and County roads were estimated and are included in the cost of the Oroville Reservoir. The Palermo Canal which would be flooded would be supplied by an outlet through the dam on the left abutment. For infrequent years of low reservoir stage, the cost of a pumping plant to serve the canal has been added to the project cost.

The Las Plumas Power Plant of the Pacific Gas and Electric Company has been evaluated on the following basis: The average annual power generation 1939-1949, inclusive, of 430,600,000 kilowatt hours was valued at 6 mills per kilowatt hour at the plant. Operation and maintenance annual charge was deducted and a net revenue at the plant of $2,463,400 obtained. The last installation in the plant, which was built in 1908, was in 1916. Assuming 1916 to 1951 as 35 years of elapsed life and with a total life of 70 years, the present value of annual net revenues for the next 35 years at a rate of .0855 resulted in a figure of $27,181,000. This is considered the amount that the company would have to invest to return the net revenue it will receive for the remaining life of the power plant and also meet depreciation, insurance,

local and state taxes and a cost of money of 5 per cent on their investment.

The cost of power and telephone lines that would be flooded have been evaluated. A summary of the cost of flooded lands and improvements and relocations and acquisitions is as follows:

Lands	$379,000
Improvements	1,800,000
State Highway	3,600,000
County roads	532,000
County road bridges	532,300
Telephone lines	269,600
Power lines	537,800
Feather Falls Railroad	756,000
Western Pacific Railroad	28,181,400
Las Plumas Power Plant	27,181,000
Palermo Canal outlet and pump	30,000
Total	$63,799,100

The figure of $28,181,400 for the cost of relocating Western Pacific Railroad includes the cost of a combination railroad and highway bridge across the West Branch of the Feather River.

Dams and power plants. - In estimating the cost of the main dam a gravity concrete dam section, curved in plan, was used. The upstream face of the section used was vertical for heights up to 400 feet. For heights in excess of 400 feet the face was vertical to a point 400 feet below the crest and from that point sloped upstream on a slope of .4 to 1. The downstream slope was .8 to 1 for all heights of the dam. The crest width was assumed at 30 feet. The crest length of the concrete dam would be 5,700 feet. A layout and cross-section for the dam are shown on Plate 8.

Excavation depths to sound rock foundation varied from 40 feet at the upper extremity of the right abutment to a maximum of 80 feet at about 1,150 feet from that point toward streambed. This depth was continued for a thousand foot length in the same direction, then gradually decreased to 10 feet at the river channel. Excavation depths through the channel are

were 10 feet of rock and 50 feet of gravel. On the left abutment the excavation depths were increased from the 10-foot depth at channel edge to a maximum of 90 feet at a point about 700 feet distant toward the upper extremity of the left abutment. This depth was continued, in the same direction, for 300 feet and then decreased to 40 feet in a distance of 600 feet and from that point on increased to 50 feet at left abutment extremity.

A double row of holes at 10-foot centers to a depth of 50 feet was estimated for the upstream grout curtain. An allowance was included for consolidation grouting of about 25 per cent of the foundation area.

Two auxiliary earthfill dams are required at low points in the periphery of the reservoir. The type of the earth dams is a center impervious section blanketed on each side with pervious materials. The impervious section has a top width of 10 feet and 1 to 1 side slopes were carried to 20 feet below natural ground. Excavation under the impervious section included 1 to 1 side slopes from the bottom of excavation to ground surface. The pervious blanket sections on each side of the impervious section have a ten foot top width and slope on 2½ to 1 to intersection with natural ground with a shallow surface stripping under the sections. The dike on the southerly rim of the reservoir has a crest length of 1,340 feet and a maximum height of 35 feet above natural ground. It is located in Sections 7 and 18, T. 19 N., R. 5 E. The other auxiliary dam is 1,060 feet long with a maximum height of 45 feet above natural ground. It is located near the right abutment extremity of the concrete dam.

Using the flood control reservation of 500,000 acre-feet of reservoir space the upper 35 feet of the reservoir was so

utilized. Twenty-seven 10-foot diameter steel lined outlets in 3 banks through the spillway section of the dam were estimated to discharge the controlled flow capacity of 100,000 second-feet.

The spillway design flood was taken as the estimated 1 in 100 year frequency of occurrence flood with its crest followed three days later by the crest of the estimated 1 in 1,000 year flood. The estimated crests were 294,000 second feet and 470,000 second feet, respectively. Spillway capacity was based on passing the spillway design flood through the flood control openings in the dam and over the spillway, utilizing reservoir retention, and limiting the encroachment on the dam freeboard. The spillway capacity at normal pool elevation is 292,000 second feet and would be controlled by four 33-feet by 110-feet long hydraulically operated, segmented, steel drum gates set in the crest of the spillway.

The power plant would be located on the left abutment below the dam at the end of the spillway apron. Steel penstocks were carried through the dam and laid on concrete saddles on benches cut in the rock below the dam to the power plant.

Estimates of cost have been prepared of the Oroville Afterbay Dam and Power Plant located about one-half mile above the highway bridge across the Feather River in Oroville.

Interest during construction has been included at a 3 per cent rate over half the estimated construction period applied to the construction cost plus fifteen per cent for contingencies and 10 per cent for engineering and administration.

The estimated costs of the Oroville Dam, power plant and Oroville Afterbay and power plant are set forth in the following tables.

COST OF OROVILLE RESERVOIR WITH FLOOD CONTROL FEATURES

Height of dam above streambed	711 feet
Capacity of reservoir	3,500,000 acre-feet
Capacity of spillway	292,000 second-feet
Capacity of flood control outlets	100,000 second-feet

April 1951 prices

Exploration and core drilling	$ 100,000
Diversion of river during construction	500,000
Clearing reservoir site	2,325,000
By-pass tunnel at dam for railroad	2,324,900
Excavation for dam, 4,562,400 cu.yds. @ $1.00 to $4.00	18,111,000
Mass concrete, 13,791,600 cu.yds. at $10	137,916,000
Reinforced concrete, 72,500 cu.yds. @ $40 to $100	3,623,500
Auxiliary dams, 596,400 cu.yds. at $0.50 to $1.50	499,600
Trash rack steel and miscellaneous metal work	1,868,000
Cooling concrete including pipe	6,959,000
Foundation treatment	2,003,600
River outlet conduits, 4,324,000 lbs. at $0.25	1,081,000
Ring seal gates, 12,722,000 lbs. at $0.45	5,724,900
Spillway gates, 6,316,000 lbs. at $0.30	1,894,800
Reinforcing steel, 13,000,000 lbs. at $0.15	1,950,000
Spillway bridge	288,200
Permanent camp	500,000
Lands and improvements flooded	3,999,400
Relocation of Western Pacific R.R.	28,181,400
Relocation of State Highway	3,600,000
Relocation of Electric Utilities	807,400
Las Plumas Power Plant	27,181,000
Palermo Canal outlet and pumping plant	30,000
Subtotal	251,468,700
Administration and engineering, 10 per cent	25,146,900
Contingencies, 15 per cent	37,720,300
Interest during construction	28,290,200
Total cost of dam and reservoir	$342,626,100

COST OF POWER PLANT FOR OROVILLE RESERVOIR

Installed capacity	440,000 kilowatts

April 1951 prices

Excavation, 1,135,800 cu.yds. @ $4.00 to $5.00	$ 4,708,600
Penstock anchors, 4,400 cu.yds. at $15	66,000
Reinforced concrete, 11,640 cu.yds. at $30 to $90	877,800
Trash racks, coaster gates and gantry cranes	2,211,300
Penstocks	5,550,900
Reinforcing steel, 2,200,000 lbs. at $0.15	330,000
Building and equipment, 440,000 kilowatts at $81	35,640,000
Subtotal	49,384,600
Administration and engineering, 10 per cent	4,938,500
Contingencies, 15 per cent	7,407,700
Interest during construction	2,777,900
Total cost of power plant	$64,508,700

COST OF OROVILLE AFTERBAY AND POWER PLANT

Height of dam,	70 feet
Capacity of spillway,	390,000 second-feet
Installed capacity of power plant	25,000 kilowatts

April 1951 prices

DAM AND RESERVOIR

Exploration and core drilling	$ 35,000
Diversion of river during construction	100,000
Clearing reservoir	52,500
Excavation for dam, 109,000 cu. yds. at $4	436,000
Mass concrete, 51,600 cu.yds. at $14	722,400
Reinforced concrete, 7,120 cu. yds. at $40	284,800
Spillway gates	2,466,400
Foundation treatment	35,000
Lands and improvements flooded	173,300
Permanent camp	50,000
Subtotal	4,355,400
Administration and engineering, 10 per cent	435,500
Contingencies, 15 per cent	653,300
Interest during construction	163,300
Total cost of dam and reservoir	$5,607,500

POWER PLANT

Intake structure	422,600
Tunnel	1,214,000
Penstocks	145,000
Permanent camp	100,000
Building and equipment 25,000 kilowatts at $190	4,750,000
Subtotal	6,631,600
Administration and engineering, 10 per cent	663,200
Contingencies, 15 per cent	994,700
Interest during construction	248,700
Total cost of power plant	8,538,200
Total cost of dam, reservoir, and power plant	$14,145,700

Transmission Line and Switchyard. - The Oroville to Bethany transmission line consists of one single circuit and one double circuit steel tower line. The line traverses moderately cultivated land for a distance of 150 miles from Oroville Dam to the terminal switchyard near Bethany. Enroute the line passes west of Wheatland and skirts the east side of Folsom, from which point it runs southerly to a point near Bellota and then veers west to the terminal substation and switchyard near Bethany. The line is all within a light loading area with respect to ice and wind loads and passes over area that will permit from easy to average construction conditions. The line is shown on Plate 1 and on Plate 14 and the capital cost is as follows:

COST OF OROVILLE-BETHANY TRANSMISSION LINE
AND TERMINAL SUBSTATION AND SWITCHYARD

April 1951 prices

Transmission Line

Item					
Towers & Fixtures					
Single-Circuit	150	Mi.	@	$15,400	$2,310,000
Double-Circuit	"	"	@	23,100	3,465,000
Conductors & Devices					
Single-Circuit	"	"	@	6,360	954,000
Double-Circuit	"	"	@	12,750	1,913,000
Insulators & Hardware					
Single-Circuit	"	"	@	1,130	170,000
Double-Circuit	"	"	@	2,250	338,000
Groundwire, Grounds & Hardware					
Single-Circuit	"	"	@	1,880	282,000
Double-Circuit	"	"	@	1,880	282,000

San Joaquin River Crossing		$ 500,000
Land and Land Rights	5400 acs. @ $500	2,700,000
Clearing Land and Rights of Way	- -	583,000
Subtotal		$ 13,497,000
Administration and engineering, 10 per cent		1,349,700
Contingencies, 15 per cent		2,024,600
Interest during construction		253,100
Total cost of transmission line		17,124,400

Terminal Switchyard

Oil Circuit Breaker Positions	5 at $156,000	$ 780,000
Air Break Switch Positions	4 at 36,700	147,000
Transformer Positions	1 at 112,000	112,000
Transformer Bank for Synchronous Condenser	1 at 485,000	485,000
Synchronous Condenser	1 at 528,000	528,000
Land	5 acres at $1,000	5,000
Subtotal		$ 2,057,000
Administration and engineering, 10 per cent		205,700
Contingencies, 15 per cent		308,600
Interest during construction		38,600
Total cost of terminal switchyard		2,609,900
Total cost of transmission line and terminal switchyard		$19,734,300

Delta Cross Channel. - The Delta Cross Channel would be required to carry water from the Sacramento River to the San Joaquin River delta. A channel similar to the Delta Cross Channel of the Central Valley Project would be required. An allowance also has been made for dredging in the delta channels. The estimated cost of the cross channel is as follows:

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[illegible]

COST OF DELTA CROSS CHANNEL

Inlet works and cross channel		$1,000,000
Dredging-enlargement of channels below cross channel	1,500,000 cu.yds. @ $0.30	450,000
Dredging-inlet channels to pumping out of delta	5,000,000 cu.yds. @ $0.30	1,500,000
Subtotal		2,950,000
Administration and engineering, 10 per cent		295,000
Contingencies at 15 per cent		442,500
Interest during construction		110,600
Total cost		$3,798,100

The estimated total capital cost of the Oroville Reservoir Power Plant, Afterbay and Power Plant, Oroville-Bethany Transmission Line and Terminal Substation and Switchyard, and Delta Cross Channel is summarized as follows:

SUMMARY OF COST OF FEATHER RIVER PROJECT

Oroville Dam and Reservoir	$342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line	17,124,000
Terminal Switchyard	2,610,000
Delta Cross Channel	3,798,000
Total estimated cost	$444,813,000

Flood Control Benefits

The Feather River and its tributaries are among the principal contributors to flood flows in Sacramento Valley. There have been a number of notable floods recorded within relatively recent years, which, if uncontrolled under present conditions would have caused heavy damages, loss of property, and hazard to life and health. The Feather River and its tributaries on the Sacramento Valley floor are included in the Sacramento River Flood Control Project. However, the degree of protection provided by existing leveed channels is not comparable with protection afforded by existing facilities or by those under construction on other major and minor streams and floodways within the Project.

Sacramento River Flood Control Project

The Sacramento River Flood Control Project is a system of works comprising levees, by-passes and weirs and river channel enlargment designed and constructed for the control and disposal of flood waters flowing through Sacramento Valley. An area of about 1,000,000 acres is protected from inundation by these works, including the metropolitan areas in and around the cities of Sacramento, Marysville, Yuba City, Oroville; many other small communities and settlements; and intensively developed irrigated agricultural land.

Authorization for construction of Sacramento River Flood Control Project is set forth in Acts of Congress of the United States of 1917, 1928, 1936, 1941 and 1944 and in Acts of the Legislature of the State of California in 1911, 1925, 1927, 1935, 1939 and 1945. The Project is a joint Federal-State-local development.

Total expenditures to date on the Project amount to about $120,000,000 divided approximately equally among the United States, the State of California, and local interests.

The companion Federal and State legislation has been held to constitute a contract between the two governments, under the provisions of which the United States has, since 1941, assumed the cost of constructing the Project works, provided the State or local interests furnish, without cost to the United States, all lands, easements and rights-of-way necessary for the completion of the Project; bear the expense of necessary highway, railroad and utility alterations; hold and save the United States free from damages resulting from construction of the works; and maintain and operate all works, after completion, in accordance with regulations prescribed by the Secretary of the Army.

The physical works include levees along Sacramento River from its mouth at Collinsville to Ord Ferry on the west side of the river and to the Butte-Glenn County line on the east side; levees along both banks of the Feather River from its mouth to Honcut Creek and on the right bank from Honcut Creek to Hamilton Bend, six miles below Oroville; levees along lower reaches of the American, Bear and Yuba rivers and the south bank of Honcut Creek; leveed by-passes through the Yolo and Sutter basins operated with the Moulton, Colusa, Tisdale, Fremont and Sacramento weirs located on Sacramento River for the purpose of discharging excess river channel flood flows into Sutter and Yolo by-passes; and the enlarged Sacramento River channel extending from the mouth of Cache Slough to Collinsville for ultimate disposal of flood waters into Suisun Bay. The major features of the Project are shown on Plate 3.

Designed capacities of the various features and sections of this system of works are based upon flood flow quantities of March 1907 and January 1909, and are set forth in the so-called "Grant Report" (Senate Document 23, 69th Congress, 1st Session), dated December 8, 1925. However, in some instances, the designed capacities are not the actual capacities determined by stream flow measurements.

Since the adoption of the plan for the flood control project by the State of California in 1911, and by the Congress of the United States on May 15, 1928, the Central Valley Project has been constructed by the U. S. Bureau of Reclamation. A key feature of the Central Valley Project is Shasta Reservoir, constructed to a capacity of 4,500,000 acre-feet, on upper Sacramento River above Redding. The reservoir is operated for flood control, utilizing a maximum space of 1,300,000 acre-feet for that purpose during the flood season. It was first operated for flood control during the 1945-46 season. The operation of Shasta Reservoir has a marked effect on the control of floods in the upper reaches of Sacramento River and in Butte Basin and Sutter By-pass to the confluence with Feather River, but lesser effect below that point.

Sacramento River Flood Control Project levees on Feather River and its tributaries have been generally completed to Project standards except for a section aggregating about eight and one-half miles in length along the right bank in Butte County, and a short section of Reclamation District No. 10 levee north of Marysville. At the former location only inadequate flood protection is provided by the bank of the Sutter-Butte Canal which temporarily serves as a levee.

Historical Conditions

Feather River, under natural conditions, overflowed large areas beyond its low water channel from Hamilton Bend six miles below Oroville to its confluence with Sacramento River. The area subject to inundation from Feather River through failure of existing levees is delineated on Plate 3.

Along the left bank from Oroville to Honcut Creek the inundation was confined to a relatively narrow strip limited by bluffs paralleling the river channel. A wider area between Honcut Creek and the Yuba River at Marysville was subject to inundation. Below Marysville and the confluence with Yuba River the combined flow of both streams flooded extensive low lying areas adjacent to the left bank of Feather River and joined flood waters of Bear River in the southern portion of the pocket. Overbank flow on the left bank below Bear River found its way into American Basin and flooded vast areas extending southward to the American River.

Feather River found greatest opportunity to discharge its surplus waters along the right bank. At Hamilton Bend overbank flow through Hamilton Slough coursed westward to enter Butte Basin where it joined Sacramento River overflows near Colusa. The magnitude of this flow from Feather River is evidenced from reports concerning the 1907 and 1909 floods which state that the rush of water from Feather River flowed over Butte Basin, breached Sacramento River levees and entered Colusa Basin.

Below Hamilton Bend flood flows overpoured the right bank of the river through a number of slough channels leading to Sutter Basin, among which was Gilsizer Slough passing through the area now

occupied by Yuba City. The entire area between Feather River and Sutter Basin south of Gridley with the exception of the Marysville Buttes was subject to inundation.

Prevention of overflow and reclamation of lands bordering Feather River were undertaken by unorganized individual effort soon after the first rush of settlers following the discovery of gold in 1848. The first organized efforts toward reclamation were the formation of Levee District No. 1 in 1873 and Levee District No. 9 in 1879 along the right bank of Feather River from a point about six miles upstream from Yuba City downstream to a point opposite the mouth of Bear River and the formation of the Marysville Levee Commission in 1876. There was no further effort toward organization until the period between 1907 and 1913 when nearly the entire remaining area subject to overflow from Feather River waters, including the American Basin, formed into nine separate reclamation districts numbered, in order of formation, 777, 784, 803, 817, 823, 833, 1000, 1001 and 10. The lack of coordination among the activities of the various districts resulted in the construction of levees of competitive height and channels and flowage areas of inadequate width. The interest of the State of California and Federal Government in flood control and maintenance of navigable channels led to authorization of the Sacramento River Flood Control Project and formation of the Sacramento-San Joaquin Drainage District, part of which included within its boundaries all of the areas subject to inundation from Feather River and its tributaries. The then existing levees were adopted as Project works and most of them were or are being improved or reconstructed to Project

standards by the Federal and State governments with varying degrees of financial contribution from those sources and from local interests.

There were a number of floods of considerable magnitude during the first two decades following 1850 among which was the great flood of January 1862. Other notable floods occurred at various times. However, it was not until the U. S. Geological Survey, in cooperation with the State of California, established stream gaging stations on Feather River at Oroville in 1902, on Yuba River at Smartsville in 1903 and on Bear River near Van Trent in 1905 that quantitative comparison could be made of flood flows in the Feather River system. The greatest flood since the installation of those stations occurred in March 1907 with a peak flow of 230,000 second-feet at Oroville and it appears safe to assume, on the basis of fragmentary records, that only the flood of January 1862 may have been of greater magnitude. Three large floods with peak magnitudes at Oroville in the order of 185,000 second-feet occurred in January 1909, March 1928 and December 1937.

Between Oroville at the mouth of the Feather River canyon and Hamilton Bend, the river is flanked by rolling hills and such areas as may be inundated are of no economic importance. During the flood of March 1907 the lower portions of Oroville were flooded to a considerable depth. However, the probability of repetition of such flooding has been removed by improvement of levees and dredging the river channel so that the city is now considered to be safe against floods in excess of any of record.

From Robinson Bend, immediately upstream from the bridge on the Oroville-Gridley Road, to Honcut Creek on the left bank of

the river there is a relatively narrow strip of high quality agricultural land which is subject to inundation when flows at Oroville exceed 50,000 second-feet or about two times in three years on the average under present conditions. Particularly severe in this reach is the condition on a small area at Robinson Bend where overbank flow at moderate stages causes heavy scour to orchards and the county road and threatens to change the course of the river. Attempts to stabilize the channel and limit overflows to specific areas without undue increase in flood plane elevations have not been successful. No other efforts toward reclamation have been made on the left bank upstream from Honcut Creek.

In all floods prior to 1937 water escaped freely into Butte Basin over the right bank of Feather River at Hamilton Bend. In December 1937 a levee at that location was overtopped and breached allowing a considerable quantity of water to escape from the main channel. Conditions at Hamilton Bend had also been changed by gold dredging operations parallel to the river bank and in the channel. The levee at Hamilton Bend has been strengthened, raised and extended and no water has escaped to Butte Basin since 1937. However, peak flood flows at Oroville have not exceeded 152,000 second-feet between 1937 and the date of this report.

Below Hamilton Bend on the right bank for a distance of about 12 miles to the Sutter County line no district organization has been formed to construct reclamation works. Constructed levees aggregate only 3.5 miles in length. For the remaining distance of about 8.5 miles protection is afforded by the Sutter-Butte Canal, completed in 1905, the bank of which restrains flood flows to a

limited degree. With the escape to Butte Basin now restricted that canal bank probably would not afford protection during a repetition of the larger floods of record.

Downstream from Honcut Creek and continuing along the remainder of Feather River, overflows inundated extensive areas. The waters commingled to the west with Sacramento River flood waters. In 1907 and 1909, at the latitude of Marysville the flooded area extended westward in a continuous expanse for some 25 miles with only occasional high knolls and alluvial ridges standing above the flood level. This was before the reclamation of Sutter Basin and construction of Sutter By-pass. American Basin, later reclaimed by Reclamation Districts No. 1000 and 1001, was protected only by low individual river levees incapable of restraining the flood. The levees surrounding the City of Marysville withstood those floods as they have all others since 1875. There were, however, many breaks on both banks upstream and downstream from Marysville.

After the floods of 1907 and 1909, organized reclamation was resumed with new vigor and the floods of 1928, 1937 and 1940 were successfully controlled along the right bank. Reclamation District No. 784 along the left bank of Feather River between the Yuba and Bear rivers was inundated during those floods, as was Reclamation District No. 10 in December 1937. Critical conditions developed at many localities, particularly near Nicolaus in 1928, below Yuba City in 1940 and in lower Sutter By-pass during all major floods.

In 1942, a relatively small flood on Feather River together with Sutter By-pass flows breached the levee of Reclamation District No. 803 and inundated some 32,000 acres between those two

channels. In 1950 large areas in Reclamation District No. 784 and adjacent lands and in Reclamation District No. 1001 were flooded. However, the flood waters came from Yuba and Bear rivers, respectively, at points well upstream from their confluence with Feather River. In this flood, those tributaries established new maximum peak discharge records, whereas the Feather River had only 92,000 second-feet at crest at Oroville.

Flow Criteria Governing Flood Control

In a report of the State Water Resources Board entitled "Alternative Plans for Control of Floods in Upper Sacramento Valley", September 1948, detailed studies were presented showing the effect of Shasta Reservoir on flood flows in Sacramento Valley above Feather River. It was shown that the average frequency of occurence of floods subsequent to the construction of Shasta Reservoir would equal or exceed Project flood plane elevations on Sacramento River only once in more than 100 years and as infrequently as once in 170 years in Upper Sutter By-pass, whereas on other portions of the Project the existing degree of protection is not nearly so great. On Feather River above Marysville the Project flood plane elevation would have been exceeded four times during the past 50 years and below Marysville it would have been exceeded at least during three years and possibly during a fourth in the same period. The estimated long-time probable frequency of such exceedance on Feather River above its confluence with Sutter By-pass is about once in 15 years or less, on the average.

On American River at Sacramento the Project flood plane would have been exceeded four times during three of the past 50

years and the estimated long-time probable frequency of such exceedance is about one year in 25 years on the average. Thus it may be noted that the degree of protection now provided with Shasta Reservoir in operation to areas along upper Sacramento River is at least seven times that now afforded lands and communities along Feather River and four times that now afforded the City of Sacramento and environs. The latter condition is being corrected by the construction of Folsom Reservoir on American River which will provide protection for the highly developed Sacramento area against a flood with an estimated frequency in excess of once in 500 years.

The provision of adequate flood control storage on Feather River at Oroville would give a degree of protection to landowners and communities along Feather River about equal to that provided by Shasta Reservoir on upper Sacramento River and would provide additional reduction in flood flows and attendant flood hazard below the junction of Feather River and Sutter By-pass and in Yolo By-pass.

The Project flood plane at the Gridley Bridge gaging station is 102.0 feet, U.S.E.D. datum, corresponding to a flow of about 160,000 second-feet. That quantity and stage has not been recorded by reason of the relief afforded by flow into Butte Basin through Hamilton Slough during the larger floods of record. In 1940, when all flows were confined, the stage at Gridley Bridge reached 101.55 with a flow of about 145,000 second-feet. In this flood it was necessary to sack road crossings and low points on the Sutter-Butte Canal bank to prevent inundation of protected lands.

A controlled release of 100,000 second-feet would create a stage of 99.5 feet, U.S.E.D. datum, at the Gridley Bridge and with

which only minor additional levee construction along or in lieu of the Sutter-Butte Canal bank would be required; backwater flooding on lands north of Robinson Bend in the area between the canal and the dredger tailings would be reduced; and a lesser area of recently developed land north of Honcut Creek would be subject to overflow. A controlled release of 50,000 second-feet, corresponding to a stage of 95 feet at the Gridley Bridge, would eliminate practically all damaging flows on overflow lands on the left bank between Gridley Bridge and Honcut Creek. Such flows now occur about two times in three years on the average.

Controlled releases of 100,000 second-feet or less from Oroville and local inflow below that point can readily be carried through present leveed channels in the reach from Honcut Creek to Marysville. The levees would then provide a high degree of protection to the intensively developed agricultural and urban area on both sides of the river.

The adopted Sacramento River Flood Control Project flood plane on Feather River at Marysville is 76.6 feet, U.S.E.D. datum, and about equal to that attained during the flood of December 1937. During that flood a considerable flow left the Feather River channel at Hamilton Bend which, if confined, to the river channel would have created stages in excess of flood plane elevations downstream at least to the Bear River. The two floods of 1940 reached a stage approximately one foot below Project flood plane. The flood stages at Marysville on both Feather and Yuba rivers are influenced by the combined flows of the two streams. Project flood plane stage is reached with a combined flow of about 200,000 second-feet. Peak

flows in Yuba River at Smartsville, about nineteen miles upstream from Marysville, exceeded 100,000 second-feet during the floods of 1907, 1909, 1928, 1937 and 1950 and were, or would have been, approximately 100,000 second-feet at the mouth if confined to the leveed channel. Therefore, it is apparent that in order to control flood discharges in Feather River below Marysville to safe channel capacities it is necessary to limit flood control releases from Oroville Dam to 100,000 second-feet.

In all of the foregoing floods, Reclamation District No. 784, situate along the left bank of Feather River between the Yuba and Bear rivers, was inundated from Feather River or tributary streams. Its levees were for many years substandard in height and located so close to the river bank that the channel capacity was seriously restricted. However, recent reconstruction, including necessary set-backs, has corrected the limitations on channel capacity and the levees are now capable of withstanding a flood of 200,000 second-feet.

At Nicolaus near the confluence of Feather River and Sutter By-pass, the Project flood plane elevation is 52.7 feet, U.S.E.D. datum. Stages at this station are influenced by the combined discharges of the two water courses. The maximum recorded stage at Nicolaus was 51.0 feet in 1940. However, the District 70 levee failure on upper Sutter By-pass prevented higher stages at downstream stations, including Nicolaus which is affected by backwater from Sutter By-pass. By comparison, the flood of February 1942, which breached the right bank levee of Feather River downstream from Nicolaus shortly after the passage of the crest at that station, reached a stage only one foot below the record stage of

1940 with flows well below the Project quantities at the confluence of Sutter By-pass and Feather River. The estimated peak combined discharge is 290,000 second-feet.

Peak flows on Feather River usually reach the confluence with Sutter By-pass at least 16 hours prior to the time of arrival of peak flows on Sutter By-pass. This condition is significant in that flood heights in lower Sutter By-pass would not be materially reduced by the operation of Shasta Reservoir on Sacramento River when the controlling discharge is from the Feather River system. Releases from Shasta Reservoir during operation for flood control are designed to limit flows in Sacramento River at Red Bluff and Chico Landing to 100,000 second-feet and 130,000 second-feet, respectively. Thus, in the earlier stages of a flood, releases equal to inflow are made until storage is required to limit flows to the adopted criteria. In most floods of record in which the combined flow of Sacramento and Feather rivers would have created critical stages in lower Sutter By-pass, if confined to leveed channels, the instantaneous flow from Sacramento River which would have combined with the peak discharge from Feather River would have been essentially the same either with or without the operation of Shasta Reservoir for flood control. Assuming Shasta Reservoir in operation and all flows confined to leveed Project channels, critical stages equal to or greater than those attained in February 1942 would have resulted in lower Sutter By-pass during the floods of March 1907, January 1909, March 1928, December 1937, February 1940, March 1940 and February 1942. Studies indicate levee failures would have occurred in 1907 and 1909.

A controlled release of 100,000 second-feet from Oroville Dam combined with maximum recorded floods from Yuba and Bear rivers would produce a peak flow into Sutter By-pass from Feather River of about 215,000 second-feet which is about the magnitude of actual peak flows during the two floods of 1940. With Shasta and Oroville reservoirs in operation during the major floods of record, the total peak flows in Sutter By-pass below the confluence with Feather River would have varied from 315,000 to 340,000 second-feet which magnitudes are within the limits of safe channel capacity.

Flood Control Operation of Oroville Reservoir

On the basis of detailed analyses set forth in "Alternative Plans for the Control of Floods in Upper Sacramento Valley" and additional studies made for this report it was determined that the maximum flood control release from Oroville Dam to limit downstream flows to present safe leveed channel capacities was 100,000 second-feet. It was further determined that controlled releases must be limited to 50,000 second-feet in order to relieve unreclaimed overflow lands along Feather River from damaging inundation.

Operation studies on Oroville Reservoir were made to determine the flood control storage reservation required to limit releases, insofar as practicable, to 50,000 second-feet and in no case to exceed 100,000 second-feet. After several trial studies it was found that a reservation of 500,000 acre-feet would accomplish the desired control with releases limited to 50,000 second-feet whenever available storage space was more than 400,000 acre-feet, and to 100,000 second-feet whenever the available storage was less than 400,000 acre-feet. The flood control reservation of 500,000

acre-feet was maintained and used for the control of floods from November 15 to April 1, after which it was progressively reduced to obtain a full reservoir on May 1. The foregoing method of flood control operation would provide regulation for a flood with an estimated frequency of occurrence of about once in 150 years and give a degree of protection about equal to that on Sacramento River and Sutter By-pass with Shasta Reservoir in operation.

Flood control operation of Oroville Reservoir was coordinated with irrigation and power studies for the historical period 1903 to 1950. Therefore, the reservoir stage at the beginning of the flood was that which would have occurred under operation of Oroville Reservoir throughout that period. The following tabulation sets forth for each flood of record, the date of occurrence of the peak discharge, the peak magnitude, the controlled release, the storage in Oroville Reservoir at the beginning of the flood, the maximum storage during the flood, and the storage utilized in controlling the flood.

It is desired to point out that the tabulation indicates a storage requirement of 555,000 acre-feet for the flood of January 1909, whereas the maximum space allocated to flood control is 500,000 acre-feet. This is due to the availability of 750,000 acre-feet of storage at the beginning of the flood and limitation of releases to 50,000 second-feet until available storage space was reduced to 400,000 acre-feet after which releases were increased to 100,000 second-feet. If available storage had been only the 500,000 acre-feet reserved for flood control, only 432,000 acre-feet would have been utilized to regulate the flood to the prescribed

PEAK FLOOD FLOWS AND STORAGE REQUIREMENTS
ON FEATHER RIVER AT OROVILLE

Date of Peak Flow	Historical Peak Flow 1000 sec.ft.	Controlled Release 1000 sec.ft.	Res.Storage Beg. of Flood 1000 ac.ft.	Max. Storage During Flood 1000 ac.ft.	Max.Storage Utilized 1000 ac.ft.
Mar. 30, 1903	99.3	50.0	2986.0	3098.4	112.4
Nov. 14, 1903	87.0	50.0	2757.2	2883.3	126.1
Nov. 21, 1903	90.0	50.0	2922.7	3002.3	79.6
Feb. 16, 1904	101.7	50.0	2894.3	3011.7	117.4
Feb. 24, 1904	112.8	100.0	2945.6	3106.1	160.5
Mar. 18, 1904	99.8	100.0	3000.0	3106.4	106.4
Jan. 18, 1906	109.8	50.0	2730.5	2844.2	113.7
Mar. 26, 1906	56.0	50.0	3000.0	3006.7	6.7
Feb. 3, 1907	81.8	50.0	2709.8	2800.3	90.5
Mar. 19, 1907	230.0	100.0	3000.0	3373.5	373.5
Jan. 16, 1909	180.0	100.0	2748.9	3303.9	555.0
Jan. 31, 1911	84.8	50.0	2702.3	2749.7	47.4
Apr. 6, 1911	69.7	50.0	3083.3	3117.9	34.6
Dec. 31, 1913	122.0	50.0	2565.4	2729.7	164.3
Jan. 25, 1914	64.3	50.0	2910.9	2928.5	17.6
Feb. 21, 1914	71.8	50.0	3000.0	3023.1	23.1
Feb. 2, 1915	52.5	6.3	2746.0	2768.7	22.7
May 11, 1915	81.4	81.4	3500.0	3500.0	0
Feb. 25, 1917	80.4	50.0	2908.7	2960.1	51.4
Feb. 11, 1919	66.7	50.0	2720.0	2730.6	10.6
Nov. 19, 1920	64.0	1.0	2164.9	2240.9	76.0
Feb. 6, 1925	66.0	1.1	1049.6	1228.0	178.4
Feb. 4, 1926	57.4	1.1	1929.6	1973.7	44.1
Feb. 21, 1927	94.0	50.0	2913.0	2996.3	83.3
Mar. 26, 1928	185.0	100.0	2958.4	3191.8	233.4
Dec. 13, 1929	68.8	1.3	1834.3	1960.8	126.5
Apr. 8, 1935	58.6	1.3	1162.9	1235.8	72.9
Jan. 15, 1936	66.5	1.0	2374.1	2430.7	56.6
Feb. 21, 1936	85.4	50.0	2862.4	2895.4	33.0
Dec. 11, 1937	185.4	50.0	2694.4	3007.5	313.1
Mar. 23, 1938	55.0	50.0	3000.0	3002.6	2.6
Feb. 27, 1940	132.8	50.0	2701.8	3022.2	320.4
Mar. 26, 1940	59.2	50.0	2963.9	2967.6	3.7
Mar. 29, 1940	152.0	100.0	2986.0	3140.9	154.9
Feb. 10, 1941	84.2	50.0	3000.0	3062.8	62.8
Dec. 16, 1941	63.1	50.0	2707.9	2715.6	7.7
Jan. 27, 1942	76.6	50.0	2979.3	3006.7	27.4
Feb. 6, 1942	110.0	50.0	3000.0	3089.8	89.8
Jan. 21, 1943	108.0	50.0	2853.5	2946.0	92.5
Feb. 2, 1945	59.8	50.0	3000.0	3003.3	3.3
Dec. 29, 1945	60.1	50.0	2954.6	2955.5	0.9
Nov. 21, 1950	90.9	50.0	3000.0	3058.7	58.7

flows by reason of the longer period over which releases of 100,000 second-feet would have been made.

In many of the historical floods the entire flood flow would have been absorbed in Oroville Reservoir with releases limited to power requirements, by reason of the low reservoir level prevailing at the time. Operation of Oroville Reservoir would have made it possible to regulate releases to 50,000 second-feet in all but six years of the 50-year period of record.

Evaluation of Flood Control

The area protected by flood control works on Feather River embraces about 300,000 acres and constitutes one of the more highly developed agricultural areas of the State including not only crop lands but also large storage, processing and other marketing facilities. The famous "Peach Bowl", which in 1947 produced peaches valued at $10,000,000 representing about 20 percent of the State's total, is located on the Feather River flood plain, principally in Sutter County north and south of Yuba City. In addition there are large areas devoted to walnuts, almonds and prunes interspersed with other deciduous fruits extending in a continuous belt along the right bank of the river from Hamilton Bend to a point opposite Bear River and, to a lesser degree, along the left bank of the river. Complete cultural surveys of the Sutter-Yuba ground water basin were made in 1948 and 1949 in connection with the special cooperative investigation by the Division of Water Resources for the State Water Resources Board. Culture on a small area in Butte County was approximated. It is estimated that more than one-half the entire area is devoted to the production of irrigated crops, about one-third

of which is planted to deciduous fruits and nuts. Urban and suburban developments, farmsteads, roads and utilities occupy about 20,000 acres and the remainder of the area is dry-farmed or fallow land interspersed with a small amount of waste land.

Yuba City and Marysville, with populations of 7856 and 7777 in 1950, respectively, are the principal business and industrial centers in the area. Gridley, the next most important community, had a population in 1950 of 3021. The population of the Feather River flood plain is estimated at about 50,000.

A survey of the Feather River flood plain was made to ascertain the value of lands and improvements and to provide bases for estimating future values and the possible flood damage that could be prevented by the construction of Oroville Reservoir. Records of property sales for the year 1950 were compared with assessed valuations from which it was determined that the present value of the area subject to inundation from Feather River is $340,000,000, including all lands, improvements, utilities and personal property. This area is delineated on Plate 3 to which previous reference has been made. It is to be noted that lands along the westerly side of Sutter Bypass and below the confluence of Sacramento and Feather rivers are not included in the valuation although their flood hazard is in part attributable to flood flows from the latter stream and its tributaries. The valuations of the entire area and of its various geographical subdivisions are listed in the following tabulation.

There are no estimates available of damages caused by floods prior to 1937. During that year and also following the floods of 1940 and 1942, the Division of Water Resources and the Corps of

Present Market Value of Lands, Improvements and Utilities in Feather River Flood Plain

Zone	Market Values in Dollars			
	Land	Improvements	Utilities	Total
LEFT BANK				
North of Honcut Creek	5,560,000	2,450,000	1,760,000	9,770,000
R.D. No. 10 and lands adjacent to Simmerly Slough	5,810,000	3,160,000	1,760,000	10,730,000
City of Marysville and environs	19,660,000	67,930,000	17,530,000	105,120,000
R.D. No. 784	6,170,000	10,820,000	1,580,000	18,570,000
R.D. No. 1001	5,120,000	5,620,000	740,000	11,480,000
RIGHT BANK				
North of Gridley and east of Butte Basin	11,610,000	8,340,000	8,300,000	28,250,000
South of Gridley and north of State Highway No. 20	24,240,000	23,480,000	6,320,000	54,040,000
Yuba City and environs	6,100,000	37,940,000	13,390,000	57,430,000
South of State Highway No. 20 and east of Sutter By-pass	18,930,000	22,260,000	3,820,000	45,010,000
Total	103,200,000	182,000,000	55,200,000	340,400,000

Engineers made damage surveys of all inundated areas. The estimated damage directly attributable to Feather River, based on costs and prices prevailing at those times were $931,000 in December 1937, $300,000 in February and March 1940, and $2,086,000 in February 1942. It was estimated that an additional loss of $874,000 would have obtained in 1942 if the land had been unwatered too late to permit planting of summer field crops.

During the decade 1940-50 the population of the affected area increased about 50 per cent; farm costs and prices have increased two to three times; replacement cost of farm and home buildings and personal property increased similarly; and development of the area has been greatly intensified. Assuming present cost indices and stages of development, damages during past floods would have been several times their historical amounts. It is believed that growth of the area will keep pace with future expansion of the State as a whole. Continued urbanization in and around Yuba City and Marysville and more intensive agricultural practices throughout the area are to be anticipated.

Damage which would occur on the area with a recurrence of floods such as 1907, 1909 or larger, is dependent upon the location of levee failures. With the elimination of the escapeway at Hamilton Bend, the most critical section now appears to be along the right bank at about the latitude of Gridley where inadequate protection is afforded by the Sutter-Butte Canal bank. For purposes of estimating flood control benefits creditable to the proposed Oroville Reservoir it is assumed that levee failure would occur in the Gridley vicinity and submerge an area of 130,000 acres including Reclamation Districts Nos. 777, 803, 823; Levee Districts Nos.

1 and 9, Sutter County; a portion of Drainage District No. 1, Butte County; and considerable unorganized territory. Included in the area are Yuba City and Live Oak; the Southern Pacific and Sacramento-Northern railroads; U. S. Highway 99E, State Highways 20 and 24 and many miles of county roads; the Sutter-Butte Canal system and many individual irrigation systems; and 32,000 acres of orchards among a completely developed agricultural area. The present value of lands and improvements is estimated to be $157,000,000. About one-third of the flooded area would be subject to a relatively short period of inundation during the passage of the flood with depths probably not averaging more than a few feet. However, about two-thirds of the area would be inundated for a long period by the pocketing of flood waters between Feather River and Sutter By-pass and the inability of such water to drain back into floodways by reason of continuing high stages therein. In February 1942, when the flood receded rapidly and there were no succeeding storms to maintain high stages in Project channels, the backwater on the upper half of the flooded area in Levee District No. 1 Sutter County was not completely drained off until two weeks after the levee failure. Complete unwatering was not accomplished until one month after the break. The assumed location of levee failure with recurrence of historic floods would result in estimated overbank discharges of 175,000 acre-feet in 1907, 140,000 acre-feet in 1909, 60,000 acre-feet in 1937 and 55,000 acre-feet in 1928. A flood with an estimated frequency of occurrence of once in 150 years, which could be controlled in Oroville Reservoir would, if uncontrolled, discharge even greater quantities overbank and levee failures would probably occur at locations other than in the Gridley vicinity.

If it is assumed that the cost of Oroville Dam and Reservoir would be amortized over a 50-year period the non-reimbursable features of the project should be written off during the same period. Investigation of past trends showed that an average annual increase in market value of more than four per cent had occurred within the area between 1930 and 1950. In arriving at the rate of increase in market value for the 1930-1950 period, no consideration was given to the extremely low values prevailing during the depression years. The market values in 1930 were computed by applying the market-assessed value ratio for the latter part of the 1920 decade to the 1930 assessed values. The latter had not yet been affected by the economic collapse although market values had begun to fall. Therefore the computed trend spans, but is not influenced by, the extremely low value years.

The area is now in a relatively mature state of development so that anticipated rates of increase, attributable to technological advances, inflationary influences, increased population and physical plant expansion, may be somewnat less than rates indicated by past trends. Therefore, in estimating future valuations to be protected by flood control works and from which a reasonable value of the flood control allocation to Oroville Dam and Reservoir might be determined, it was assumed that the increment of development between 1950 and 1975 would be one-half the 1930-1950 increment, or two per cent per year, and between 1975 and 2000 one-half that of the preceding 25-year period, or one per cent per year. On these bases the valuation of the gross protected area would be $558,000,000 in 1975 and $715,000,000 in 2000 with corresponding populations of 82,000 and 105,000. The area along the right bank

from the latitude of Gridley southerly to Sutter By-pass, most vulnerable to flooding, has estimated future values of $257,000,000 in 1975 and $329,000,000 in 2000.

In order to arrive at possible values of flood damage with a repetition of historic floods, it is necessary to determine a percentage of the gross value of property that may be damaged. The estimated market value at the time of inundation of the area flooded in February 1942, including improvements, personal property and utilities is $21,000,000 and damage was estimated at $2,086,000, or about 10 per cent of the market value. In March 1940 there were about 30,000 acres flooded in Reclamation Districts Nos. 70 and 1660 in Sutter County with damages estimated at $1,744,000. This area is similar to that flooded from Feather River except that a smaller proportion of the land is devoted to orchards. Market values were comparable and damage amounted to about nine per cent of those values. With the flooding of highly developed urban, suburban, and suburban-agricultural areas the ratio of damage to market value would be substantially more than 10 per cent. It has, therefore, been assumed that inundation would result in damages amounting to 10 per cent of market values on agricultural lands and to 15 per cent in Yuba City and environs.

In all four of the previously mentioned floods which would have exceeded present safe channel capacities, the flow would pass over the highly developed area north of Yuba City, flood a considerable portion of that community and finally pocket between Sutter By-pass and Feather River. The area has a present market value of $157,000,000 of which $57,000,000 is in Yuba City and its immediate environs. By 1975, the mid-point of the amortization period if con-

struction were to be started immediately, the estimated values would be $257,000,000 and $93,000,000, respectively. These values have, therefore, been used in estimating flood control benefits creditable to Oroville Reservoir.

Under the foregoing assumptions, a flood similar to 1907 would cause damage in the amount of $25,100,000. The relationship between total overflow and damage is not direct in that the more valuable areas containing highly developed agricultural lands and urban and suburban developments would be flooded at all times, whereas the area escaping inundation in the smaller floods would comprise principally marginal lands near the Sutter Buttes. The flood of January 1909 would probably cause about 90 per cent as much damage as that of 1907. The floods of December 1937 and March 1928 would each cause damage equal to about one-half that of 1907.

The total damage for a repetition of the historical record of the last 50 years through the amortization period would be $79,700,000 or an average annual damage of $1,590,000 which, if capitalized at three per cent, would indicate an allowable flood control allocation to Oroville Dam and Reservoir of $53,000,000. The foregoing estimates do not include possible loss of trees due to prolonged flooding late in the season. Such would be the situation with a repetition of the 1907 and 1928 floods under which conditions the average annual losses would be appreciably increased.

In addition to potential damages by levee failure there is also damage to the unprotected land immediately north of Honcut Creek. Reduced frequency of inundation by construction of Oroville Dam would create opportunity for improved land use. The flood plane corresponding to 95.0 feet on the Gridley gage, which is now exceeded about two

times in three years, would be exceeded only about once in seven years on the average. Similarly a flood plane corresponding to 99.5 feet on the Gridley gage would be exceeded only once in 150 years, compared to about once in four years under present conditions

The reduction in flow from the Feather River and its tributaries would materially reduce flood hazard and maintenance of, and repair to, levees and other flood control works along Feather River and lower Sutter By-pass. The remainder of the Sacramento River Flood Control Project below the confluence of Sacramento and Feather rivers would receive less tangible but appreciable benefit from Oroville Dam and Reservoir, particularly when operated coordinately with Shasta and Folsom reservoirs.

The levees protecting the City of Marysville are among the strongest and best maintained in the Sacramento River Flood Control Project. However, it is conceivable that failure could occur in which case the damage to the city, which has a present market value of $105,000,000 and an estimated value for 1975 of $172,000,000, would be tremendous. Furthermore, the small amount of storage for flood waters resulting from the inundation of that community would not provide sufficient relief to the levees protecting other areas to assure their adequacy during floods such as 1907 and 1909. In the event of a disaster of that nature damages might be considerably larger than herein contemplated.

CHAPTER III. SACRAMENTO - SAN JOAQUIN DELTA DIVERSION PROJECTS

The agreement between the State Water Resources Board and California Central Valleys Flood Control Association provides that the cost of works for the widest practicable utilization of the water produced by the Feather River Project be investigated and submitted in this report. The projects studied in this connection and reported upon herein are the Santa Clara-Alameda Diversion Project and the San Joaquin Valley-Southern California Diversion Project. These projects would divert water from the channels of the San Joaquin Delta and would serve areas in need of supplemental water to meet deficiencies, both immediate and ultimate.

It has been previously stated in Chapter I of this report that the ultimate water requirements of San Francisco Bay Area, San Joaquin River Basin, and South Coastal, Lahontan, and Colorado River Desert areas are far in excess of their available local water supplies. Preliminary studies indicate that Santa Clara and Alameda counties, located in the San Francisco Bay Area, will require ultimately substantial water supplies in addition to the local supplies and supplies received from importations of the City of San Francisco from the Tuolumne River, and East Bay Municipal Utility District from the Mokelumne River. For the South Coastal area, it is presently estimated that a supply of 2,500,000 acre-feet annually will be required ultimately to supplement local supplies, importations by the Metropolitan Water District of Southern California of 1,212,000 acre-feet annually from the Colorado River, and importations by the City of Los Angeles of

300,000 acre-feet annually from Owens Valley and Mono Basin. It is further estimated that 2,500,000 acre-feet annually will be needed ultimately to supplement the water demands in the Lahontan and Colorado Desert areas in addition to California's rights to Colorado River water which, in the aggregate, total 5,362,000 acre-feet annually. The west side of the San Joaquin Valley comprising about 1,000,000 acres of irrigable land will require ultimately about 2,000,000 acre-feet of imported water. Therefore, the total amount of additional imported water needed for southern California and west side of San Joaquin Valley would be about 7,000,000 acre-feet annually.

It was also pointed out in Chapter I that supplemental water supplies for the areas of deficient water supply in the San Joaquin River Basin, San Francisco Bay Basin, and southern California to meet their ultimate requirements, must come from the areas of surplus in the Sacramento River Basin and the North Coastal area which have water supplies in excess of their ultimate needs.

In studying various plans for importing water from the areas of surplus to the foregoing areas of deficient supply, the Division of Water Resources has determined that the logical and most practicable plan would be to utilize the Sacramento-San Joaquin Delta as a point of diversion.

The plan of utilizing the Sacramento-San Joaquin Delta as the source of supply and point of diversion has many practical advantages. The point of diversion is below all riparian owners and users of water in the basins above the delta, and, therefore, is not dependent on the vagaries of a single stream. Water developed in any part of the Sacramento or San Joaquin River basins could find

its way by gravity to the delta, and the same is true of surplus water that would be transferred from the North Coastal area to the Sacramento River Basin.

The area known as the Sacramento-San Joaquin Delta is situated in the lowest part of the Central Valley Basin. In its original state of nature, it consisted of swamp and overflow lands gradually built up through the ages by accumulations of decayed vegetation and deposits of silt brought down by the Sacramento and San Joaquin rivers. These rivers, upon reaching the delta, spread out into a network of channels separated by islands in a delta formation, and finally discharge their waters into Suisun Bay, which forms the northerly arm of San Francisco Bay. The delta has a gross area of about 500,000 acres, and is roughly 20 miles wide and 50 miles long. It extends from Collinsville and Antioch at the lower end, to Sacramento on the Sacramento River and Stockton on the San Joaquin River on the upper ends. The network of channels, for the most part navigable, have an aggregate length of 550 miles and an open water surface area of 38,000 acres. These channels are the source of water supply for the 350,000 acres of land under irrigation in the delta area. A typical view of the delta is shown on the accompanying photograph.

In planning the investigation and report as provided for in the agreement, it was decided, for the purposes of the report, to estimate the cost of delivering initially about one-third of the 5,000,000 acre-feet estimated as the supplemental water requirements for southern California under ultimate conditions, and all of the ultimate supplemental water requirements of the west side of the San Joaquin Valley. This required a 6,000-second-foot conduit and

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cost estimates are presented herein on that basis.

Concurrently with the preparation of those estimates, studies were being made of the water yield of the Oroville Reservoir. As previously set forth, it was found that the reservoir could be operated so as to make available in the Sacramento-San Joaquin Delta channels for exportation, 3,930 second-feet of continuous flow of water, amounting to 2,845,000 acre-feet annually, as compared with the conduit capacity of 6,000 second-feet selected for the San Joaquin Valley-Southern California Diversion conduit. Since time did not permit a detailed revision of the estimates already in preparation, the estimates for the 6,000-second-foot conduit are presented herein, with discussion thereon in Chapter IV, "Financial Analyses."

Estimates are presented herein for the cost of works to deliver from the delta channels 127,000 acre-feet of water annually to Santa Clara and Alameda counties. This amount of water is much less than will be ultimately needed in those counties for a supplemental supply and is not to be considered as the amount made available by an initial development. Further investigation would be required to determine the magnitude of an initial project which would be coordinated with an ultimate plan. The project presented herein is submitted for the purpose of indicating the engineering feasibility of conveying water from the delta to those areas and the cost thereof.

A large number of samples of water have been taken from the Sacramento-San Joaquin delta channels over a period of years and analyzed for mineral constituents. Some of the analyses have been complete, and some only partial, furnishing data on chlorine,

sodium, and total solids. A sample was taken from Italian Slough on Old River in the San Joaquin Delta on September 7, 1950, and analyzed. Expressed in parts per million, the total solids were 250; calcium, 44; sodium, 55; bicarbonate, 106; chloride, 107; and sulphate, 52. The water was of good mineral quality and well suited for domestic and agricultural uses. Analyses of many other samples taken in the delta above the point of incursion of sea water show comparable results.

Santa Clara-Alameda Diversion

The conduit to transport water from the Sacramento-San Joaquin Delta to Santa Clara and Alameda counties would divert from Old River in the San Joaquin Delta at Italian Slough about a mile east of Byron Hot Springs. An aerial view of the Delta area in this vicinity is shown on the accompanying photograph. From this diversion the water would be lifted by pumping from sea level to an elevation of 722 feet at a tunnel through the Coast Range near Brushy Peak, approximately two miles north of Altamont Pass. From this tunnel it would be carried in a pressure conduit into Livermore Valley.

At a point about four miles northwest of Livermore, the conduit would divide into two branches. One branch would continue northwesterly to a point about two miles westerly of San Ramon, where the conveyed waters would discharge through a short tunnel into a proposed storage reservoir in Crow Canyon. The stored waters would serve the central bay shore area of Alameda County. The other branch would extend southerly, serving the south bay shore of Alameda County and the east side of Santa Clara Valley.

SACRAMENTO-SAN JOAQUIN DELTA

Regulatory storage would be provided at a site on Arroyo de Los Coches near Milpitas and terminal storage at Silver Creek near Evergreen.

The location of the aqueduct and a profile showing the general ground elevations and the hydraulic grade line are shown on Plate 9.

Physical Features of the Project

Brief descriptions of the units of the Santa Clara-Alameda Diversion project follow. Typical sections of the several types of conduits and dams to which reference is made are shown on Plate 12.

Italian Slough Channel. - The actual source of water supply is the Old River channel of the San Joaquin River, but the diversion point is located on Italian Slough, a tributary channel. Italian Slough is a leveed and maintained channel, presently used by several diverters for irrigation supply. Allowance was made in the study for dredging a length of 15,200 feet of this slough to carry the ultimate diversion quantity of 365 second-feet in addition to the flow necessary to serve existing diversions.

Intake Canal. - The intake canal was also planned to carry the ultimate requirement of 365 second-feet. It would extend from Italian Slough to Pumping Plant No. 1, a distance of one mile. Maximum depth of cut at the pumping plant would be approximately 40 feet. The canal would be unlined.

Pumping Plant No. 1. - The capacity of this plant as used for this report is 185 second-feet. The static head on the plant is 352 feet. It is proposed to install three pumping units, one of which would be for "stand-by" purposes. The discharge pen-

stock would be a 7-foot diameter reinforced concrete cylinder pipe 2.2 miles in length.

Canal Between Pumping Plants Nos. 1 and 2. - The capacity of this canal as used for this report is also 365 second-feet. It would be concrete lined and about 1.5 miles in length. The water surface with the design flow would slope from elevation 352 feet at the head of the discharge pipe line from Pumping Plant No. 1 to elevation 350 feet at Pumping Plant No. 2.

Pumping Plant No. 2. - This plant would have the same capacity and number of units as Plant No. 1. The static head would be 363 feet. The discharge pipe line would extend from the pumping plant to Brushy Peak Tunnel. It would be a 7-foot diameter reinforced concrete cylinder pipe with a length of 2.8 miles. Its capacity would be 185 second-feet.

Brushy Peak Tunnel. - This tunnel would be of horseshoe shaped section, concrete lined, and have a nominal diameter of 8.7 feet. It would be 1.4 miles in length, and have a capacity of 365 second-feet.

Brushy Peak Tunnel to Doolan Junction. - The conduit in this section would be reinforced concrete cylinder pipe. It would have a diameter of 7 feet for a distance of 1.4 miles from the tunnel outlet to Livermore Junction, and 6.5 feet for a distance of 6.4 miles from the latter point to Doolan Junction about four miles northwest of Livermore. The capacity of the first section would be 185 second-feet and the latter section 155 second-feet.

Alameda County Aqueduct. - This aqueduct would be comprised of 11.1 miles of 5-foot diameter reinforced concrete

cylinder pipe and a 0.6-mile, 6.5-foot diameter, concrete lined tunnel near San Ramon into a proposed reservoir in Crow Canyon. The capacity of the pipe line would be 78 second-feet and that of the tunnel 156 second-feet.

Santa Clara County Aqueduct. - This aqueduct would be comprised of 35.8 miles of 5-foot diameter reinforced concrete cylinder pipe. The first 22.1 miles from Doolan Junction to Air Point reservoir junction would have a capacity of 78 second-feet, the next 6.2 miles would have a capacity of 110 second-feet and the last 7.5 miles, to Evergreen Reservoir, would have a capacity of 75 second-feet.

Reservoirs. - The Crow Canyon reservoir would be formed by a rolled earth fill dam 165 feet high and would have a storage capacity of 16,000 acre-feet. The Air Point reservoir on Arroyo de los Coches would be formed by a rolled earth and rock fill dam 250 feet high and would have a capacity of 20,100 acre-feet. The Evergreen reservoir on Silver Creek would be formed by a rolled earth fill dam and would have a capacity of 6,000 acre-feet.

Cost of the Project

The estimated costs of the several features of the Santa Clara-Alameda Diversion are based on prices as of April 1951. The cost for each feature includes those of the necessary lands and rights of way. Survey information adequate for estimates was available for the Crow Canyon and Air Point dams and reservoirs. Costs of other features were based on data obtained from U. S. Geological Survey topographic maps. A summary of the principal unit prices used in the estimates are given in the following tabulation:

Unit Prices

Slough and intake canal excavation	$0.25 per cu.yd.
Canal excavation	$0.40 " " "
Canal bank compaction	$0.18 " " "
Dam foundation excavation	$0.50-0.75
Dam embankment	$0.25-0.85 " " "
Tunnel excavation and lining	
6.5 foot diameter	$168 per lin.ft.
8.7 " "	$187 " " "
Canal lining	$ 35 " cu.yd
Reinforcing steel in place	$0.15 per pound
Reinforced concrete pipe in place	
5 to 7-foot diameter	$187,000-$431,500 per mile

A summary of the estimated costs of the units of the project, grouped under the types of those units, is given in the following tabulation. A more detailed estimate of cost is included in Appendix D of this report.

Estimated Cost of Santa Clara-Alameda Diversion

Conveyance Units		
Italian Slough	$ 32,400	
Intake Canal	257,200	
Canal-P.P. No. 1 to P.P. No. 2	212,200	
Brushy Peak Tunnel	1,411,900	
San Ramon Tunnel	537,600	
Reinforced concrete pipe	13,825,100	
Subtotal - - -		$16,276,400
Pumping Plants		
Plants Nos. 1 and 2	$2,290,000	2,290,000
Reservoirs		
Crow Canyon	$1,628,600	
Air Point	3,428,400	
Evergreen	504,900	
Subtotal - - -		5,561,900
Subtotal - Construction		$24,128,300
Engineering and administration, 10 per cent		2,412,800
Contingencies, 15 per cent		3,619,200
Interest during construction		904,700
Total capital cost - - -		$31,065,000

San Joaquin Valley-Southern California Diversion

The conduit to transport the exportable water from the Sacramento-San Joaquin Delta to the San Joaquin Valley and to southern California would divert from Old River at a point near Bethany and about five miles northwest of Tracy. The water would be lifted 225 feet into a canal which would convey it to a point near the south line of Merced County, where a pumping plant would again lift it to elevation 400 feet. The canal would then follow approximately on grade contour along the west side of the San Joaquin Valley to the Buena Vista Hills where another pumping plant would lift the water to elevation 500 feet. Four additional pumping lifts and a canal would deliver the water to the mouth of Pastoria Creek, 3 miles east of Grapevine, at elevation 1,500 feet. At this point a series of pump lifts would raise the water to elevation 3,375 feet to a tunnel 3.9 miles in length, followed by one 6.6 miles long, which would convey the water through the Tehachapi Mountains to the divide between the Santa Clara River Basin and the desert.

The conduit would then extend along the westerly edge of the Antelope Valley, on the desert side of the mountains, passing above the Fairmont Reservoir on the Los Angeles Aqueduct. It would cross Amargosa Creek and follow the south side of that creek, pass above the Palmdale Reservoir, and cross Soledad Pass at Vincent and Little Rock Creek below the Little Rock-Palmdale Dam. The course of the conduit would then be easterly across the Mojave Desert to the portal of a 3-mile tunnel at elevation about 3,260 feet, between Mojave River and Devil Canyon, a tributary of the Santa Ana River and a source of water for the City of San Bernardino. The conduit would then be a series of tunnels follow-

ing the south slope of the mountains north of San Bernardino and Redlands to a siphon across the San Gorgonio Pass between Beaumont and Banning. The course of the conduit, mostly in tunnels, would then bear southerly along the mountains east of the San Jacinto Valley, passing above Lake Henshaw on the San Luis Rey River and crossing the headwaters of the San Diego and Sweetwater rivers to a terminus at an elevation of 2,850 feet on a tributary of the Tia Juana River. The total length of the conduit would be about 567 miles. The route and profile of the conduit are shown on Plate 10, which is in six sheets.

Physical Works

A brief description of the physical works of the conduit, divided into sections as determined by the carrying capacity follows. Typical sections of the conduit, to which reference is made in the description, are shown on Plate 13. As indicated on that plate, all canal sections would be concrete lined. The U. S. Geological Survey topographic maps were used in determining the location of the conduit but an inspection of the proposed location was made on the ground by the engineers, and the geology along the line was studied and reported upon by engineering-geologists of the Division of Water Resources. Data obtained by these geologists were utilized in determining the location of the conduit, the types of materials which would be encountered during construction and, in some instances, the type of conduit to be used.

Section Mile 0 to Mile 157.6, Capacity 6,000 second-Feet. - A series of four pumping plants would lift the water from sea level at a point on Old River near Bethany to elevation 225 feet. An alternative plan which would bear further investigation

is to make the lift by one pumping plant at a location to the north of the present intake of the Tracy Pumping Plant of the Central Valley Project. The alignment of the canal through this section would approximately parallel the existing Delta-Mendota Canal on the uphill side and from one-quarter to a half mile from it to the west. At the several points where it would come close to the existing canal a field inspection indicates ample room for the proposed work without interference with the constructed canal. At Mile 81.7, Pumping Plant No. 5 would lift the water from elevation 202.8 feet to elevation 400 feet. At this point the canal diverges from its course parallel to the Delta-Mendota Canal and follows southeasterly along the base of the hills to about mile 92.5 where, after crossing Little Panoche Creek, the route turns to cross the valley floor, the section terminating at the south line of Fresno County.

This 157.6-mile section was designed for a capacity of 6,000 second-feet. It would require 156.0 miles of concrete lined canal, 14 siphons, 191 drainage structures, 80 farm bridges, 65 county road bridges, 16 canal checks, 36 turnouts, and five pumping plants with an initial installed capacity of 3,755 second-feet each.

Section Mile 157.6 to 183.5, Capacity 4,200 second-feet. - The canal through this section would continue southeasterly, following the easterly slope of the Kettleman Hills, and is located in Kings County for its full length. This 25.9 mile section was designed for a capacity of 4,200 second-feet. It would require 25.3 miles of concrete lined canal, 7 siphons, 40 drainage structures, 7 farm bridges, 12 county road bridges,

3 canal checks and 4 turnouts.

Section Mile 183.5 to Mile 246.0, Capacity 4,000 second-feet. - The conduit through this section would follow along the easterly slope of the Lost Hills, and the northeasterly slope at the base of the Elk Hills, in a general southeasterly direction. The proposed route turns west at the southeast extremity of the Elk Hills, follows the south base of the Elk Hills, crosses the Taft to Bakersfield U. S. Highway No. 399 and circles to the west of Buena Vista Lake area. This 62.5 mile section was designed for a capacity of 4,000 second-feet. It would require 1 siphon, 141 drainage structures, 42 farm bridges, 25 county road bridges, 1 highway bridge, 6 canal checks, and 10 turnouts.

Section Mile 246.0 to 290.6, Capacity 3,500 second-feet. - At Mile 246.0 Pumping Plant No. 6 would lift the water from elevation 350.4 feet to elevation 500 feet. It would have an initial capacity of 2,795 second-feet. From the discharge outlet of Pumping Plant No. 6, the conduit would follow southwesterly along the base of the Buena Vista Hills to a point about 2 miles west of San Emidio where the proposed route turns abruptly to the east and then southerly to Wheeler Ridge. At the four mile points shown in the following tabulation, pumping plants would lift the water to a saddle in Wheeler Ridge:

Mile	Pumping Plant No	Elevation in Feet From	Elevation in Feet To
271.0	7	493.2	600.0
272.0	8	599.8	800.0
274.0	9	799.6	1150.0
274.3	10	1150.0	1500.0

The canal would then follow southeasterly along the southern end of the San Joaquin Valley floor, crossing U. S. Highway No. 99 between Bakersfield and Los Angeles at a point about one mile north of Grapevine, to the point where Pastoria Creek debouches onto the valley floor. The conduit on this 44.6-mile section was designed for a capacity of 3,500 second-feet. The pumping plants would have initial capacities of 2,550 second-feet. The section would include 43.2 miles of concrete lined canal, 10 siphons, 97 drainage structures, 31 farm bridges, 7 county road bridges, 4 canal checks, 20 turnouts and 5 pumping plants.

Section Mile 290.6 to Mile 302.4, Capacity 2,500 second-feet. - A short distance up the Pastoria Creek Canyon on the left side of the canyon is the site for a proposed series of six pumping plants. The pumping plants would lift the water from elevation 1,493.3 to elevation 3,375 feet as follows:

Mile	Pumping Plant No.	Elevation in Feet From	Elevation in Feet To
290.6	11	1,493.3	1,806.9
290.8	12	1,806.9	2,120.5
290.9	13	2,120.5	2,434.1
291.0	14	2,434.1	2,747.7
291.1	15	2,747.7	3,061.3
291.2	16	3,061.3	3,375.0

The last pumping plant would discharge into the portal of a 3.9-mile tunnel which would terminate in a tributary of Pastoria Creek. This tunnel would be followed immediately by another one 6.6 miles long through the Tehachapi Mountains to terminate in the vicinity of Quail Lake. The tunnel section would

be followed by a siphon at Quail Lake under the state highway from Gorman to Lancaster. At this point water could be discharged to Piru Creek, a tributary of the Santa Clara River, or to the Antelope Valley. This 11.8 mile section was designed for a capacity of 2,500 second-feet. It would include 10.5 miles of concrete lined tunnel, 1 siphon, 1 turnout, and six pumping plants.

Section Mile 302.4 to Mile 327.0, Capacity 2,000 second-feet. - The conduit beginning at Mile 302.4 follows through the hills to the west of the Antelope Valley to the vicinity of Fairmont Reservoir on the Los Angeles Aqueduct and would be mostly concrete covered conduit. In the vicinity of the Fairmont Reservoir the conduit would be about 300 feet above the normal water level of that reservoir and water could be delivered to the Antelope Valley or to the Los Angeles Aqueduct. This 24.6-mile section was designed for a capacity of 2,000 second feet. It would include 2.6 miles of concrete lined canal, 20.4 miles of concrete covered conduit, 0.6 miles of concrete lined tunnel, 12 siphons, 21 drainage structures, 2 farm bridges, 2 county road bridges, and 1 canal check and turnout.

Section Mile 327.0 to Mile 369.6, Capacity 1,500 second-feet. - The conduit in this section would continue mostly as a covered concrete section, along the hills to the west of the Antelope Valley and follow along the north side of Portal Ridge to a 6,500-foot tunnel through the ridge and then into a siphon across Amargosa Creek. The alignment would then follow along the south bank of the creek, being located south of the San Andreas Rift Zone. The crossing of the fault area is made by the Portal Ridge tunnel near its outlet, and by the Amargosa Creek siphon.

The proposed route continues southeasterly passing about one-half mile to the southwest of the Palmdale Reservoir, 475 feet above the normal water level of that reservoir, and crosses the Soledad Pass at Vincent. The section ends at the head of a siphon across Little Rock Creek. The design capacity of this 42.6-mile section is 1,500 second-feet. It would include 40.6 miles of concrete covered conduit, 1.2 miles of concrete lined tunnel, 5 siphons, 46 drainage structures, and 1 turnout.

Section Mile 369.6 to Mile 428.4, Capacity 1,200 second-feet. - From the siphon across Little Rock Creek, which is located downstream a short distance below the Little Rock Dam, the course of the conduit would be easterly across the Mojave Desert. About 15 miles west of Victorville the proposed alignment takes a southeasterly course, crossing U. S. highways 395 and 66, and runs thence to a point about one mile south of Hesperia where it turns abruptly south. There would be a three-mile tunnel between the Antelope Valley and the West Fork of the Mojave River. The conduit would continue southerly to a point near Cedar Springs where there would be a three-mile tunnel through the San Bernardino Mountains to Devil Canyon, a tributary of the Santa Ana River, and a source of water supply for the City of San Bernardino. The design capacity of this 58.8-mile section is 1,200 second-feet. The conduit would include 4.0 miles of concrete covered conduit, 46.7 miles of concrete lined canal, 6.4 miles of concrete-lined tunnel, 9 siphons, 54 drainage structures, 34 farm bridges, 9 county road bridges, 2 highway bridges, 6 canal checks, and 2 turnouts.

Section Mile 428.4 to Mile 444.3, Capacity 1,100 second-feet. - The conduit in this section would be a series of concrete

lined tunnels with a capacity of 1,100 second-feet, along the southwesterly slope of the San Bernardino Mountains. The 15.9 mile length is all 15 foot diameter concrete lined tunnel, with one turnout.

Section Mile 444.3 to Mile 461.3, Capacity 850 second-feet. - The conduit in this section would continue as a series of concrete lined tunnels running in a general southeasterly direction, with a siphon crossing at the Santa Ana River, and would end at a point about 2 miles northeast of Beaumont. This 17.0 mile length of 850 second-foot capacity conduit would include 16.9 miles of concrete lined tunnel, 1 siphon and 1 turnout.

Section Mile 461.3 to Mile 480.3, Capacity 800 second-feet. - A single barrel steel siphon would carry the water across the San Gorgonio Pass on a route about due south between Beaumont and Banning. The conduit would then continue southeasterly as a series of tunnels through the San Jacinto Mountains. This 19-mile section of 800 second-foot capacity conduit would include 12.1 miles of concrete lined tunnel, a 6.9 mile long siphon and a turnout.

Section Mile 480.3 to Mile 539.8, Capacity 500 second-feet. - The conduit would continue southeasterly to the San Jacinto River, then southwesterly and southerly through the mountains into San Diego County as a series of tunnels. After crossing the San Diego County line the conduit would be a concrete lined canal section passing to the north and east of Lake Henshaw and about 250 feet above the normal water surface of that lake. The proposed route turns southerly opposite Warner Springs, skirting the Lake Henshaw area. This 59.5-mile section of 500-second foot

capacity conduit would include 29.8 miles of concrete lined canal, 29.1 miles of concrete lined tunnel, 1 siphon, 47 drainage structures, 7 farm bridges, 5 county road bridges and a turnout.

Section Mile 539.8 to Mile 546.2, Capacity 300 second-feet. - The conduit in this section would run southeasterly with a short section of canal and then through a series of concrete lined tunnels through the mountains to the San Diego River. This 6.4-mile length of the 300-second-foot capacity conduit would include 1.9 miles of concrete lined canal, 4.5 miles of concrete lined tunnel, 4 drainage structures, one farm bridge, a county road bridge, and 1 turnout.

Section Mile 546.2 to Mile 566.6, Capacity 200 second-feet. - The conduit would continue southerly to a terminus at Horsethief Canyon, a tributary of Cottonwood Creek. The 20.4 miles of 200-second-foot capacity conduit would be all in concrete lined tunnel and include turnouts at the Sweetwater River and at the terminus.

The 566.6 miles of conduit from the Sacramento-San Joaquin Delta to the tributary of Cottonwood Creek in San Diego County would include 368.0 miles of concrete lined canal, 65.0 miles of concrete covered conduit, 117.6 miles of concrete lined tunnel, 13.4 miles of siphon, and appurtenant structures as checks, turnouts, drainage structures, wasteways, bridges and fencing along the canal right of way.

Cost of the Project

The estimated costs of the several features of San Joaquin Valley-Southern California Diversion are based on prices as of April 1951. Rights-of-way have been included in the estimate

for two parallel conduits of the same size as estimated for the single conduit. It has been considered that rights-of-way for ultimate requirements should be purchased under the initial plan. A summary of the principal unit prices used in the estimates are given in the following tabulation:

UNIT PRICES USED IN COST ESTIMATE OF SAN JOAQUIN VALLEY-SOUTHERN CALIFORNIA DIVERSION

Canal excavation - earth	$0.18 to $0.30 per c.y.
" " rock	1.50 per c.y.
" trimming - earth	.25 to .30 per s.y.
" " - rock	1.50 per s.y.
" embankment -	.20 to .25 per c.y.
" lining - concrete	20.00 to 30.00 per c.y.
Covered conduit excavation - earth	.30 per c.y.
" " " - rock	1.50 per c.y.
" " backfill	.25 per c.y.
" " concrete	30.00 per c.y.
Tunnel excavation	18.00 to 35.00 per c.y.
" timbering	300.00 per M.B.M
" lining - concrete	35.00 per c.y.
Structures	
Excavation - culverts	1.00 per c.y.
" - siphons	.75 per c.y.
" - bridges	1.50 per c.y.
Reinforced concrete - culverts	60.00 per c.y.
" " - siphons	55.00 per c.y.
" " - bridges	65.00 per c.y.
" " - turnouts	50.00 per c.y.
" " - drainage inlets	60.00 per c.y.
Timber - bridges	300.00 per M.B.M
Steel siphons and pumping plant discharge pipes	.185 per lb.
Miscellaneous steel	.35 to .50 per lb.
Reinforcing steel	.15 per lb.
Structural steel	.40 per lb.
Right-of-way fencing	1,650.00 per mile

Pumping plants - building and equipment

No. 1	24,100 kw.	(H= 50.5 feet)	$238.00 per kw.
No. 2	24,000 kw.	(H= 50.3 feet)	238.00 per kw.
No. 3	24,000 kw.	(H= 50.3 feet)	238.00 per kw.
No. 4	35,900 kw.	(H= 75.2 feet)	176.00 per kw.
No. 5	96,000 kw.	(H= 201.0 feet)	117.00 per kw.
No. 6	53,700 kw.	(H= 151.3 feet)	134.00 per kw.
No. 7	34,900 kw.	(H= 107.6 feet)	152.00 per kw.
No. 8	65,000 kw.	(H= 200.7 feet)	119.00 per kw.
No. 9	113,800 kw.	(H= 350.7 feet)	103.00 per kw.
No.10	113,500 kw.	(H= 350.3 feet)	103.00 per kw.
No.11	97,800 kw.	(H= 314.1 feet)	108.00 per kw.
No.12	97,900 kw.	(H= 314.4 feet)	108.00 per kw.
No.13	97,900 kw.	(H= 314.3 feet)	108.00 per kw.
No.14	97,900 kw.	(H= 314.2 feet)	108.00 per kw.
No.15	98,000 kw.	(H= 314.6 feet)	108.00 per kw.
No.16	98,300 kw.	(H= 315.5 feet)	108.00 per kw.

In making the final plans of the canal, the number and design of the pumping plants may be materially changed. The pumping unit sizes and lifts selected for this report were used because information is available on costs of pumping plants having units of similar size, operating under similar heads. To obtain the costs of plants having large units, operating under high heads, would require special designing, which was not feasible for this report. The estimated costs of the plants are believed to be adequate to cover any revised installation.

Detailed cost estimates of the San Joaquin Valley-Southern California Diversion by carrying capacity in second feet, in fourteen numbered sections, are included as Appendix E of this report. A summary of the estimated cost by sections is given in the following tabulation:

ESTIMATED COST - SAN JOAQUIN VALLEY-SOUTHERN CALIFORNIA DIVERSION

Section 1	Delta to Fresno-Kings County Line Mile 0.0 to mile 157.6 6,000 second-feet capacity	$128,520,000
Section II	Fresno-Kings County Line to Kings-Kern County Line Mile 157.6 to mile 183.5 4,200 second-feet capacity	13,057,000

[illegible]

Section III	Kings-Kern County Line to Buena Vista Hills Mile 183.5 to mile 246.0 4,000 second-feet capacity	$ 23,666,000
Section IV	Buena Vista Hills to Pastoria Creek Mile 246.0 to mile 290.6 3,500 second-feet capacity	80,895,000
Section V	Pastoria Creek to Quail Lake Mile 290.6 to mile 302.4 2,500 second-feet capacity	161,842,000
Section VI	Quail Lake to Fairmont Reservoir Mile 302.4 to mile 327.0 2,000 second-feet capacity	54,829,000
Section VII	Fairmont Reservoir to Little Rock Creek Mile 327.0 to mile 369.6 1,500 second-feet capacity	75,171,000
Section VIII	Little Rock Creek to Devil Canyon Mile 369.6 to mile 428.4 1,200 second-feet capacity	44,430,000
Section IX	Devil Canyon to Alder Creek Mile 428.4 to mile 444.3 1,100 second-feet capacity	46,028,000
Section X	Alder Creek to Beaumont Mile 444.3 to mile 461.3 850 second-feet capacity	39,755,000
Section XI	Beaumont to North Fork San Jacinto River Mile 461.3 to mile 480.3 800 second-feet capacity	43,968,000
Section XII	North Fork San Jacinto River to Lake Henshaw Mile 480.3 to mile 539.8 500 second-feet capacity	55,189,000
Section XIII	Lake Henshaw to San Diego River Mile 539.8 to mile 546.2 300 second-feet capacity	5,842,000
Section XIV	San Diego River to Horsethief Canyon Mile 546.2 to mile 566.6 200 second-feet capacity	21,317,000
Total		$794,509,000

Santa Barbara-Ventura Diversion

A conduit route that would serve Santa Barbara, Ventura, and part of San Luis Obispo counties has also been studied. At a point on the main San Joaquin Valley-Southern California Diversion conduit about 252.5 miles from the diversion point in the Sacramento-San Joaquin Delta, and about four miles northeast of Maricopa, a series of seventeen pumping plants would lift the water from elevation 497 feet in the conduit, across the Maricopa Flat, to elevation 3,000 feet in Cienega Canyon in a distance of about 12.3 miles. A canal would begin at the top of the pump lifts and run to the south of U. S. Highway 399 to the east side of Cuyama Valley. It would then follow the east side of the valley, just to the east of Highway 399, to Mile 33.4 near the mouth of Quatal Canyon, a tributary of the Cuyama River, near the Santa Barbara-Ventura County line. At this point a series of four pump lifts would raise the water to elevation 3,500 feet, with the conduit between the lifts being parallel and adjacent to U. S. Highway 399 up the Cuyama River. The conduit would continue along the east side of the Cuyama River to Mile 41.9 where it would cross the highway and Cuyama River in a siphon to the portal of an 8.1 mile tunnel which would terminate in Lacosca Creek, a tributary of Mono Creek, which runs into the Santa Ynez River above Gibraltar Reservoir. A tunnel starting at the terminus of the 8.1 mile tunnel at Lacosca Creek, and extending southeasterly for 7 miles, would deliver water into Matilija Creek, a tributary of the Ventura River. With additional conduits water could be delivered to parts of the Cuyama Valley not served enroute by the conduits.

The route and profile of this diversion are shown on Plate 11.

CHAPTER IV. FINANCIAL ANALYSES

In order to evaluate the financial feasibility of the Feather River Project as a single unit and also in conjunction with the Sacramento-San Joaquin Delta Diversion Projects, several financial analyses have been prepared and are presented in this chapter. The analyses are made utilizing capital costs previously set forth in Chapter III of this report. Certain costs are considered as the interest either of the Federal or State government and are shown as non-reimbursable. The annual costs include interest, repayment, replacements, operation and maintenance, insurance and general expense. Each analysis is made on the basis of 2 per cent and 3 per cent interest. The same interest rate is carried through the items of repayment and depreciation.

It is to be noted that these analyses are based upon the assumption that the entire electric power and water output would be sold at the outset of the project operation at the prices set forth in the several analyses. Therefore, these analyses must be considered of a preliminary nature and only indicative of financial feasibility.

List of Analyses

The financial analyses made in this report, each on the two interest rates, are as follows:

1A. Feather River Project - All costs reimbursable.
B. Feather River Project - with certain costs non-reimbursable.

2. Feather River Project and Santa Clara-Alameda Diversion.

3. Feather River Project, Santa Clara-Alameda Diversion and San Joaquin Valley Diversion to mile 246.0.

4. Feather River Project, Santa Clara-Alameda Diversion and San Joaquin Valley-Southern California Diversion.

5. Feather River Project, Santa Clara-Alameda Diversion, and San Joaquin Valley Diversion to mile 246.0, with cost of excess capacity of San Joaquin Valley conduit allocated to deferred use and repayment.

Capital Costs

The estimated capital costs of the several features considered in the financial analyses are summarized as follows:

Oroville Dam and Reservoir	$342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line and Substation	19,734,000
Delta Cross Channel	3,798,000
Santa Clara-Alameda Diversion	31,065,000
San Joaquin Valley-Southern California Diversion	794,509,000
Total Cost	$1,270,387,000

Non-reimbursable Costs

With the exception of Analysis No. 1, it has been assumed in the other analyses that the Federal Government would contribute to the Feather River Project without reimbursement the sum of $50,000,000 in interest of flood control since the Oroville Reservoir would be operated to control floods on the Feather River resulting in substantial benefits to lands and communities along that

river. There is a well established Federal policy for Federal financial participation in projects of this character.

Also, with the exception of Analysis No. 1, it has been assumed in the other analyses that the State of California would contribute to the Feather River Project, without reimbursement, the sum of $86,296,000, in the interest of flood control and water development by assuming the costs of lands and improvements flooded and relocation of utilities involved. It would appear that such financial participation would be justified in accord with the policies set forth in Chapter 1514, Statutes of 1945.

Electric Power Revenue From Feather River Project

The power revenue from the project is considered as being derived from the sale of the project output as commercial power. This output consisting of 1,777. million Kwh. annually will result in delivery at the Bethany terminal switchyard of about 1,670 million Kwh. annually. It is believed that the value of this power at the terminal switchyard, it being approximately at load center of Northern California, will be 7 mills per Kwh. This is somewhat less than the present cost of power delivered by the power company now serving the area from either the hydro or steam plants that it has recently construsted.

Cost of Power for Pumping

The power for pumping at the Santa Clara-Alameda diversion pumping plants and at pumping plants 1, 2, 3, 4 and 5 of the San Joaquin Valley-Southern California diversion will be transmitted from the Bethany Switchyard of the Feather River Project. Cost of power at any of the aforementioned pumping plants is considered to

be 7 mills, the commercial rate mentioned above plus the cost of transmission to the pumping plants, or 7.2 mills per Kwh. for delivered energy.

The 7.2 mill rate above is predicated on pumping water from the Sacramento-San Joaquin Delta at a constant rate. Under one of the financial analyses appearing subsequently in the report, this assumption is replaced by a varying month to month irrigation demand. Under the latter, power amounts required in summer months are much in excess of amounts in winter months. This results in less annual kilowatt hours per kilowatt of installed capacity thereby increasing the cost of power to pumping plants 1, 2, 3, 4 and 5, to 7.4 mills per kilowatt hour.

The basis of the cost of power for pumping for plants Nos. 6 through 16 as used in this report is the generation of the power by a modern steam-electric plant and a transmission system to the eleven plants to be served. In this connection three locations for the steam-electric plant and transmission system were investigated. Two of the possibilities studied were alternate locations on the shore of the Pacific Ocean, one near Oceano with a transmission line up the Cuyama River Valley and over the divide to the San Joaquin Valley to the vicinity of Maricopa and then to the pumping plants; the other a location in the Ventura-Point Hueneme area with two possible transmission routes to the pumping plants. A field inspection of the two alternate routes from the ocean and analysis of costs involved indicated that the better route was Oceano to pumping plants. The locations of Oceano steam-electric plant and transmission system are shown on Plate 15. The capital cost of this plant and the transmission system is shown in the following table.

Cost of Oceano Steam-Electric Plant and
Transmission System to San Joaquin Valley Pumping Plants

Steam-Electric Plant and Step-up Substation

Total cost	1,178,200 Kw. @ $160	$188,500,000

Transmission System

Towers and fixtures		
Single circuit	9.2 miles @ $18,140	167,000
Double circuit	335.5 miles @ $27,190	9,122,000
Conductors and devices		
Single circuit	9.2 miles @ $6,370	59,000
Double circuit	335.5 miles @ $12,740	4,274,000
Insulators and hardware		
Single circuit	9.2 miles @ $1,130	10,000
Double circuit	335.5 miles @ $2,260	758,000
Groundwire, grounds and hardware		
Single circuit	9.2 miles @ $1,880	17,000
Double circuit	335.5 miles @ $1,880	631,000
Oil circuit breaker positions	14 @ $156,200	2,187,000
Air break switch positions	13 @ $36,800	478,000
Right of way and clearing		2,217,000
Sub-total - - -		$19,920,000
Engineering and administration 10%		1,992,000
Contingencies 15%		2,988,000
Interest during construction		374,000
Total cost transmission system - - -		$25,274,000
Total cost steam-electric plant and transmission system - - -		$213,774,000

Having decided on the best location for a steam-electric plant on the ocean shore and a transmission line route to the pumping plants, there remains the comparison of that scheme with an inland steam-electric plant and transmission system. The location of the inland plant was taken at pumping plant No. 7 near Wheeler Ridge. The steam plant condenser cooling water would be taken from the canal. The annual costs of the two power sources have been set forth on a unit cost basis for 1 kilowatt of capacity and 8,760 kilowatt hours annually delivered at the pumping plant motor terminals as follows:

Oceano Steam-electric Plant Basis

Production Requirement

		Kw.	Kwh
Pump and motor availability factor	at 95%	1.05	8,760
System losses and unaccounted for energy	at 15%	1.24	10,350
Power plant availability factor	at 85%	1.46	10,350

Steam Plant Cost

Current steam plant cost is estimated at $160.00 per Kw. including stepup transformers but excluding transmission line.

Production economy is assumed at 630 Kwh. per bbl. oil.

Annual Expense

Fixed Charges	Per Cent 2 per cent	3 per cent
Cost of money	2.00	3.00
Insurance	.30	.30
Replacements	3.12	2.74
Amortization	1.18	.89
Total - - -	6.60	6.93

Operating Expenses

Steam plant O and M including general expense	$5.00
Stepup transformers O and M including general expense	.45
Sub-total - -	$5.45
Standby fuel 0.5 bbl. at $1.70 per bbl.	.85
Total - -	$6.30

Steam-electric Unit Annual Expense

	2 per cent	3 per cent
Power plant and stepup transformers fixed expense	$15.40	$16.20
O and M including general expense	7.95	7.95
Standby fuel	.85	.85
Total	$24.20	$25.00

Fuel Oil Increment (630 Kwh./bbl. $1.70 oil at plant connection)

Fuel cost to furnish one Kwh. to pump motors 1.18x$1.70÷630 = 3.2 mills

Cost of Power at Generation to Furnish Pumping Requirements

	Mills per Kwh	
	2 per cent	3 per cent
Fixed and operating expense (8760 Kwh/yr.)	2.76	2.86
Fuel increment	3.20	3.20
Total at generation	5.96	6.06

Cost of Power Delivered

	Mills per Kwh	
	2 per cent	3 per cent
Production	5.96	6.06
Transmission	.20	.21
Total	6.16	6.27

Inland Steam-electric Plant Basis

Production Requirement

		Kw	Kwh
Pump and motor availability factor	at 95%	1.05	8,760
System losses and unaccounted for energy	at 10%	1.17	9,750
Power plant availability factor	at 85%	1.38	9,750

Steam Plant Cost

Current steam plant cost is estimated at $160.00 per Kw. including stepup transformers but excluding transmission line.

Production economy is assumed at 510 Kwh. per bbl. of oil.

Annual Expense

Fixed Charges	Per Cent 2 per cent	3 per cent
Cost of money	2.00	3.00
Insurance	.30	.30
Replacements	3.12	2.74
Amortization	1.18	.89
Total	6.60	6.93

Operating Expenses

Steam plant O and M including general expense	$5.00
Stepup transformers O and M including general expense	.45
Sub-total	$5.45
Standby fuel 0.5 bbl. at $1.90 per bbl.	.95
Total	$6.40

Steam-electric Unit Annual Expense	2 per cent	3 per cent
Power plant and stepup transformers fixed expense	$14.50	$15.30
O and M including general expense	7.50	7.50
Standby fuel	.95	.95
Total	$22.95	$23.75

Fuel Oil Increment (510 Kwh/bbl. $1.80 Oil Plus 10¢/bbl. freight)

Fuel cost to furnish one Kwh to pump motors 1.11x$1.90÷510 = 4.15 mills.

Cost of Power at Generation to Furnish Pumping Requirements

	Mills per Kwh 2 per cent	3 per cent
Fixed and operating expenses (8760 Kwh/yr.)	2.62	2.71
Fuel increment	4.15	4.15
Total at generation	6.77	6.86

Cost of Power Delivered

	Mills per Kwh 2 per cent	3 per cent
Production	6.77	6.86
Transmission	.02	.02
Total	6.79	6.88

It will be noted that the Oceano Steam-electric plant and transmission system basis gives the lowest unit cost of power from the two power sources compared above. A unit cost of power for pumping, 6.3 mills per kilowatt hour has been used in the analyses presented with this report.

Bases of Annual Charges

The annual costs are set up upon 2 and 3 per cent interest rates for each analysis. The same rate is used for interest, repayment, and for sinking fund rate for replacements. Annual charges include interest, repayment, replacements, operation and maintenance, insurance and general expense. The following tabulation lists the bases for annual charges.

Interest - 2 and 3 per cent.
Repayment - 50 years on 2 and 3 per cent sinking fund basis.

Replacements - on 2 and 3 per cent sinking fund basis.

Item	Life in Years
Dam	100
Gates, valves and steel pipe	50
Canal lining and structures	50
Covered concrete conduit	100
Tunnels	100
Concrete pipe	80
Transmission lines	45
Substation	33
Pumping plant	50
Hydroelectric power plant	50

Operation and Maintenance

Dam and reservoir

First 25,000 acre-feet at $0.12 per acre-foot
Next 75,000 acre-feet at .06 per acre-foot
Next 900,000 acre-feet at .035 per acre-foot
Next 2,000,000 acre feet at .023 per acre-foot

Canals

Lined .005 times capital cost
Unlined .01 times capital cost

Covered conduit Tunnels	.0025 times capital cost

Pumping plants

#1, 2 and 3	$2.00 per Kw
#4 & 7	1.50 per Kw
#5, 9, 10, 11, 12, 13, 14, 15 and 16	.70 per Kw
#6	.95 per Kw
#8	.85 per Kw

Transmission line

230 Kv - 1 single and 1 double circuit $370 per mile

Hydroelectric power plants

440,000 Kw at $1.75
25,000 Kw at 3.50

Substations

230 Kv at 2.3 per cent of capital cost plus $15,000
115 Kv at 2.3 per cent of capital cost plus $ 9,000

Insurance

Hydroelectric plant	.0012 times capital cost
Pumping plant	.0012 " " "
Transmission lines	.0012 " " "
Substations	.0012 " " "

General Expense

Dam and reservoir Diversion conduits	.0032 times capital cost
Hydroelectric plants Pumping plants	" " " "
Other electric facilities	" " " "

Financial Analysis No. 1A.

This analysis includes the Feather River Project whose capital cost has been estimated as follows:

Oroville Dam and Reservoir	$342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line	17,124,000
Terminal Switchyard	2,610,000
Delta Cross-Channel	3,798,000
Total	$444,813,000

The assumption made in this analysis is that all the above costs would bear interest and be repaid in full. The annual charges as estimated on the bases previously set forth are as follows:

Item	Interest Rate 2 per cent	Interest Rate 3 per cent
Interest	$ 8,896,400	$13,344,300
Repayment	5,248,800	3,945,500
Replacements	1,995,700	1,299,900
Operation and Maintenance	1,469,500	1,469,500
Insurance	111,200	111,200
General Expense	1,423,400	1,423,400
Total Annual Cost	$19,145,000	$21,593,800

Revenues

2,845,000	acre-feet delivered to Delta at	$3.00	$ 8,535,000
311,000	acre-feet delivered to Feather River Service Area includes new water and amount to firm prior rights at	2.00	622,000
1,670,000,000	kilowatt hours at Terminal Substation at 7 mills		11,690,000
	Total revenue		$20,847,000

Revenues less annual charges

Analysis No. 1	Interest Rate 2 per cent	3 per cent
Revenues	$20,847,000	$20,847,000
Annual charges	19,145,000	$21,594,000
Surplus	$ 1,702,000	
Deficit		747,000

The analysis indicates that under the assumptions made all annual charges would be met, with the use of a 2 per cent interest rate, as well as a surplus of $1,702,000 and with the use of a 3 per cent interest rate an annual deficit of $747,000 occurs.

Financial Analysis No. 1B

This analysis includes the same items as included in Analysis No. 1. The assumption is made however, that $50,000,000 would be non-reimbursable in the interest of flood control and that the State would contribute to cost of the project to the extent of paying the cost of reservoir lands and improvements flooded, relocations and cost of Las Plumas Power Plant, an amount of $86,926,000. The sum of the non-reimbursable items subtracted from the total cost results in a total reimbursable cost of $307,887,000. The annual costs as estimated on the bases previously set forth are as follows:

Item	Interest Rate 2 per cent	3 per cent
Interest	$ 6,157,900	$ 9,236,500
Repayment	3,633,100	2,731,000
Replacements	1,995,700	1,299,900
Operation and Maintenance	1,469,500	1,469,500
Insurance	111,200	111,200
General expense	1,423,400	1,423,400
Total annual cost	$14,790,800	$16,271,500

Revenues

2,845,000	acre-feet delivered to Delta	at $1.00	$ 2,845,000
311,000	acre-feet delivered to Feather River Service Area, includes new water and amount to firm prior rights,	at $1.00	311,000
1,670,000,000	kilowatt hours at Terminal Station	at 7 mills	11,690,000
Total			$14,846,000

Revenues less annual charges

Analysis No. 1B

	Interest Rate	
	2 per cent	3 per cent
Revenues	$14,846,000	$14,846,000
Annual charges	14,791,000	16,272,000
Surplus	$ 55,000	
Deficit		$ 1,426,000

This analysis indicates that all annual charges could be met with a slight surplus at the 2 per cent rate and with a deficit of $1,426,000 at the 3 per cent rate. With the rate for water increased in both classifications as set forth above to $1.50 per acre-foot the surplus at the 2 per cent rate becomes $1,633,000 and at the 3 per cent rate becomes $152,000 rather than the deficit shown above.

Financial Analysis No. 2

This analysis includes the Santa Clara-Alameda Diversion charged with the unit cost of water from the Feather River Project as developed in Analyses Nos. 1A and 1B. The capital and annual charges of the Santa Clara-Alameda Diversion under a 12-month continuous pumping schedule to utilize 127,000 acre-feet of water from the Sacramento-San Joaquin Delta are as follows:

Capital Cost		$31,065,000
Annual Charges	Interest Rate	
	2 per cent	3 per cent
Interest	$ 621,300	$ 931,900
Repayment	366,600	275,500
Replacements	156,500	96,300
Operation and Maintenance	130,100	130,100
Power charges 123,200,000 kwh at $.0072	887,000	887,000
Insurance	3,500	3,500
General expense	99,400	99,400
Total annual cost	$2,264,400	$ 2,423,700
Unit cost of water		
Analysis No. 1A assumptions		
127,000 acre-feet at $3.00	$ 381,000	$ 381,000
Total cost of water	2,645,400	2,804,700
Unit cost per acre-foot	20.83	22.08
Analysis No. 1B assumptions		
127,000 acre-feet at $1.00	$ 127,000	127,000
Total cost of water	2,391,400	2,550,700
Unit cost per acre-foot	18.83	20.08
127,000 acre-feet at 1.50	190,500	190,500
Total cost of water	2,454,900	2,614,200
Unit cost per acre-foot	19.33	20.58

The analysis indicates that under the assumptions of Analysis No. 1A without any non-reimbursable funds the unit cost of water delivered to terminal storage points of the plan would be $20.83 per acre-foot with interest at 2 per cent and $22.08 per acre-foot with interest at 3 per cent. Under assumptions of Analysis No. 1B with certain non-reimbursable capital items the unit cost of water delivered to terminal storage points of the plan would be $18.83 per acre-foot at the 2 per cent interest rate and $20.08 per acre-foot at the 3 per cent rate. The unit cost would be increased 50 cents per acre-foot over the latter figures if cost of water pumped from the Delta would be $1.50 per acre-foot.

Financial Analysis No. 3

This analysis includes the Feather River Project, the Santa Clara-Alameda Diversion, and the San Joaquin Valley Diversion to mile 246.0, at Buena Vista Hills.

The capital costs are herewith recapitulated:

Oroville Dam and Reservoir	$342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line and Terminal Switchyard	19,734,000
Delta Cross Channel	3,798,000
Santa Clara-Alameda Diversion	31,065,000
San Joaquin Valley Diversion	190,561,000
Total	666,439,000
Non-reimbursable costs	136,926,000
Repayable cost	$529,513,000

In this analysis 127,000 acre-feet (on a continuous flow basis) would be furnished to Santa Clara and Alameda counties and 2,000,000 acre-feet to Fresno, Kings and Kern counties, utilizing a water supply without deficiency from the Sacramento-San Joaquin Delta on the following irrigation demand:

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.
						per cent					
5.0	3.0	3.0	4.0	4.0	8.0	11.0	12.0	14.0	14.0	12.0	10.0

The assumptions are made that $50,000,000 would be non-reimbursable in the interests of flood control and that the State would contribute to the cost of the project the cost of reservoir lands and improvements flooded and the relocation of utilities in the amount of $86,926,000.

The annual costs as estimated on the bases as previously set forth are as follows:

Item	2 per cent	3 per cent
Interest	$10,590,300	$15,885,400
Repayment	6,248,300	4,696,800
Replacements	3,398,100	2,246,400
Operation and maintenance	2,427,400	2,427,400
Power charges Santa Clara-Alameda Diversion 123,200,000 kilowatt hours at $.0072	887,000	887,000
Power charges San Joaquin Valley Diversion 1,152,500,000 kilowatt hours at $.0074	8,528,500	8,528,500
Insurance	206,500	206,500
General expense	2,132,600	2,132,600
Total annual cost	$34,418,700	$37,010,600

The annual revenues from sale of power and water would be as follows:

Revenues		
311,000	acre-feet to Feather River Service Area includes new water and amount to firm prior rights at $1.00	$311,000
127,000	acre-feet to Santa Clara-Alameda Diversion at $20.00	2,540,000
2,000,000	acre-feet to San Joaquin Valley at $11.50	23,000,000
1,670,000,000	kilowatt hours at Terminal Substation at 7 mills	11,690,000
Total		$37,541,000

Revenues less annual charges

	Interest Rate 2 per cent	3 per cent
Revenues	$37,541,000	$37,541,000
Annual charges	34,418,700	37,010,600
Surplus	$ 3,122,300	$ 530,400

The analysis indicates that under the assumptions made all annual charges would have been met with a surplus of $3,122,300 on the 2 per cent basis and with a surplus of $530,400 on the 3 per cent rate.

Financial Analysis No. 4

This analysis includes the Feather River Project, the Santa Clara-Alameda Diversion and the San Joaquin Valley - Southern California Diversion

The capital costs included are herewith recapitulated.

Oroville Dam and Reservoir	$ 342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line and Terminal Switchyard	19,734,000
Delta Cross Channel	3,798,000
Santa Clara-Alameda Diversion	31,065,000
San Joaquin Valley - Southern California Diversion	794,509,000
Total cost	1,270,387,000
Non-reimbursable costs	136,926,000
Repayable cost	$1,133,461,000

The assumption is made that $50,000,000 would be non-reimbursable in the interests of flood control and that the State would contribute towards the project to extent of the cost of reservoir lands and improvements flooded and relocation of utilities an amount of $86,926,000.

The annual costs as estimated on the bases as previously set forth are as follows:

Item	Interest rate	
	2 per cent	3 per cent
Interest	$ 22,669,400	$ 34,003,700
Repayment	13,374,900	10,053,800
Replacements	6,363,500	4,114,900
Operation and maintenance	4,531,200	4,531,200
Power charges - Santa Clara-Alameda Diversion 123,200,000 kilowatt hours at $.0072	887,000	887,000
Power charges - San Joaquin Valley - Southern California Diversion 1,566,700,000 kilowatt hours at $.0072	11,280,200	11,280,200
7,069,100,000 kilowatt hours at $.0063	44,535,300	44,535,300
Insurance	1,068,100	1,068,100
General expense	4,065,200	4,065,200
Total annual cost	$108,774,800	$114,539,400

The annual revenues from the sale of power and water would be as follows:

Revenues

311,000	acre-feet to Feather River Service Area includes new water and amount to firm prior rights at $ 1.00	$ 311,000
127,000	acre-feet to Santa Clara-Alameda Diversion at $20.00	2,540,000
945,000	acre-feet to San Joaquin Valley at $10.00	9,450,000
1,773,000	acre-feet to Southern California at $50.00	88,650,000
1,670,000,000	kilowatt hours at Terminal Substation at 7 mills	11,690,000
Total		$112,641,000

Revenues less annual charges	Interest rate	
	2 per cent	3 per cent
Revenues	$112,641,000	$112,641,000
Annual charges	108,774,800	114,539,400
Surplus	$ 3,866,200	
Deficit		$ 1,898,400

The analysis indicates that under the assumptions made all annual charges would have been met and a surplus available on the 2 per cent rate of $3,866,200 and a deficit of $1,898,400 at the 3 per cent rate.

Financial Analysis No. 5

This analysis includes the same features as analysis No. 3, Oroville Dam and Reservoir, Oroville Power Plant, Oroville Afterbay and Power Plant, Oroville Transmission Line and Terminal Switchyard, Delta Cross Channel, Santa Clara-Alameda Diversion, and San Joaquin Valley Diversion, with a total estimated cost of $666,439,000.

In this analysis, 127,000 acre-feet on a continuous flow basis would be furnished for Santa Clara-Alameda Diversion and 2,000,000 acre-feet to Fresno, Kings, and Kern counties on an irrigation demand basis previously set forth in Financial Analysis No. 3, and without deficiency in supply.

The assumptions are made that $50,000,000 would be nonreimbursable in the interests of flood control; that the State would contribute to the project to the extent of the cost of reservoir lands and improvements flooded and the relocations involved, an amount of $86,926,000, and that the excess capacity of the conduit between the inlet and its terminus would be a deferred cost assumed initially by the State until such excess capacity would become of use when it would be charged to the water users. The allocation of the canal cost to be included is based on the proportional initial use of the canal to its design capacity, a ratio of .78. A summary of the cost to be borne by the water users on the above assumptions is as follows:

Item	
Oroville Dam and Reservoir (Repayable cost)	$205,700,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line and Terminal Switchyard	19,734,000
Delta Cross Channel	3,798,000
Santa Clara-Alameda Diversion	31,065,000
San Joaquin Valley Diversion	
Pumping plants (Total cost)	76,478,000
Conduit (.78 times total cost)	88,985,000
Total cost to water users	$504,415,000

The annual costs as estimated on the bases previously set forth are as follows:

Item	Interest Rate 2 per cent	Interest Rate 3 per cent
Interest	$10,088,300	$15,132,400
Repayment	5,952,100	4,474,200
Replacements	3,398,100	2,246,400
Operation and maintenance	2,427,400	2,427,400
Power charges Santa Clara-Alameda Diversion 123,200,000 kwh. at $.0072	887,000	887,000
Power charges San Joaquin Valley Diversion 1,152,500,000 kwh. at $.0074	8,528,500	8,528,500
Insurance	206,500	206,500
General expense	2,132,600	2,132,600
Total cost	$33,620,500	$36,035,000

The annual revenues from sale of power and water would be as follows:

Revenues		
311,000	acre-feet delivered to Feather River Service Area includes new water and amount to firm prior rights at $1.00	$ 311,000
127,000	acre-feet to Santa Clara-Alameda Diversion at $20.00	2,540,000
2,000,000	acre-feet to San Joaquin Valley at $11.00	22,000,000
1,670,000,000	kilowatt hours at Terminal Substation at 7 mills	11,690,000
Total		$36,541,000

Revenues less annual charges

	Interest Rate 2 per cent	Interest Rate 3 per cent
Revenues	$36,541,000	$36,541,000
Annual charges	33,620,500	36,035,000
Surplus	$ 2,920,500	$ 506,000

The analysis indicates that under the assumption made all annual charges would have been met with a surplus of $2,920,500 on the 2 per cent interest rate basis and $506,000 on the 3 per cent interest rate basis.

In the foregoing Analyses Nos. 2, 3, 4, and 5, the assumed non-reimbursable items, totaling $136,926,000, have been deducted from the total capital cost in each instance. If these analyses were made without deducting the non-reimbursable amount, the unit cost of water in each analysis would be increased about $1.50 per acre-foot.

Financing

The agreement between the State Water Resources Board, the Department of Public Works, acting through the agency of the State Engineer, and the California Central Valleys Flood Control Association, provides for the "possibilities of financing thereof

(the project) through a contribution of Federal funds for the portion of the cost of the project properly allocated to flood control and State or local financing of the balance of the cost."

It is apparent from a study of the foregoing analyses that the Feather River Project alone (Analysis No. 1A) would be financially feasible without Federal or State contribution to the cost of the project if the water and power could be sold at the outset in the estimated amounts produced and at the respective rates assumed in the analysis. In the remaining analyses, the Feather River Project, in combination with the diversion projects from the Sacramento-San Joaquin Delta, does not appear financially feasible without substantial contributions from Federal and State Governments in the interest of flood control and water development of State-wide concern.

The Federal Government would be justified in contributing substantial sums to the Oroville Reservoir in the interest of flood control. Also, it would appear that the State of California could contribute to the Feather River Project in the interest of flood control and water development which would be of State interest and result in state-wide benefits. Contributions have been made by the State, through legislative enactments, both on Federally authorized flood control projects and locally financed water development projects.

In connection with the financing of the Feather River Project and associated Santa Clara-Alameda and San Joaquin Valley-Southern California Diversion Projects, it is believed desirable for consideration to be given by the counties or agencies therein benefited, to participate in the financing of the construction of the projects by contributing funds to the capital cost of the project in an amount which would acquire a permanent water right to a definite amount of water therefrom. Such water would be distributed and utilized by the county or agency securing a permanent right to the use of the water in such manner as may be determined by the County or agency.

In certain cases electric power could be produced economically in substantial amounts following receipt of the water by a County or agency, as for example on Piru Creek, a tributary of Santa Clara River; at Devil Canyon, a tributary of the Santa Ana River; and on the North Fork of San Jacinto River. In these cases the contributing county or agency would have the opportunity to develop and dispose of such electric power to its own financial advantage. Further, it is believed desirable to explore the possibility and feasibility of financing any or all of the projects presented herein either by revenue bonds, general obligation bonds, or a combination thereof, and by cooperative financing with counties and local agencies as discussed above.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are submitted in response to the agreement dated February 1, 1951, between the State Water Resources Board, the California Central Valleys Flood Control Association, and the Department of Public Works of the State of California, acting through the agency of the State Engineer:

Conclusions

1. There is an immediate and urgent need for flood control measures to be provided on the Feather River to adequately protect communities and highly improved lands in Butte, Sutter, Yuba, Yolo, and Sacramento counties.

2. There is an immediate need for supplemental water supplies in Santa Clara and Alameda counties; on the west side of the San Joaquin Valley in Merced, Fresno, Kings, and Kern counties; and in certain areas south of the Tehachapi mountains in Ventura, Los Angeles, Kern, San Bernardino, Orange, Riverside, and San Diego counties.

3. The Feather River Project and associated Santa Clara-Alameda, and San Joaquin Valley-Southern California Diversion Projects would meet the foregoing needs for flood control and supplemental water as set forth in this report.

4. The Feather River Project and associated Santa Clara-Alameda and San Joaquin Valley-Southern California

Diversion Projects as set forth in this report are feasible of construction from an engineering standpoint.

5. The Feather River Project and associated Santa Clara-Alameda and San Joaquin Valley-Southern California Diversion Projects constitute the most practicable and economic means of providing flood protection to areas along the Feather River and furnishing supplemental water supplies to Santa Clara, Alameda, the lands of the west side of the San Joaquin Valley in Merced, Fresno, Kings, and Kern counties, and to the counties south of the Tehachapi mountains.

6. The Feather River Project and associated Santa Clara-Alameda and San Joaquin Valley-Southern California Diversion Projects are not financially feasible on the basis of revenue derived from water charges and the sale of electric power at the rates assumed in the report unless the Federal and State Governments contribute to the cost of the projects funds in substantial amounts in the interest of flood control and water development on the basis of state-wide concern.

7. The counties and local areas benefited by the Project could participate financially in the project.

Recommendations

1. It is recommended that the Feather River Project and associated Santa Clara-Alameda and San Joaquin Valley-Southern California Diversion Projects be adopted as

features of The California Water Plan.

2. It is recommended that consideration be given to the enactment of legislation that may be necessary to implement the foregoing recommendation.

APPENDIX A

AGREEMENT BETWEEN STATE WATER RESOURCES BOARD, THE CALIFORNIA CENTRAL VALLEYS FLOOD CONTROL ASSOCIATION, AND THE DEPARTMENT OF PUBLIC WORKS

APPENDIX A

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD,
THE CALIFORNIA CENTRAL VALLEYS FLOOD CONTROL ASSOCIATION,
AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, as of February 1, 1951, by and between the State Water Resources Board, hereinafter referred to as the "Board"; the California Central Valleys Flood Control Association, hereinafter referred to as the "Association"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

W I T N E S S E T H

WHEREAS, the State Engineer, following several years of investigation, recommended in a report to the Legislature of 1931 (Bulletin No. 25), the construction of a dam and reservoir on the Feather River in the vicinity of Oroville in the County of Butte, as a unit of the State Water Plan; and

WHEREAS, in 1949 the District Engineer of the Corps of Engineers, Sacramento District, Department of the Army, the Acting Regional Director of Region II, U. S. Bureau of Reclamation, Department of Interior, and the State Engineer, agreed on the need of a proposed dam, reservoir and appurtenant works on the Feather River for the purpose of properly controlling its flood waters and conserving and utilizing such waters for beneficial purposes; and also agreed on a site approximately 5½ miles upstream from the City of Oroville as being best suited from topographical,

engineering and practicable standpoints, and recommended further studies be directed toward the formulation of plans for the construction of said dam, reservoir, and appurtenant works for flood control, irrigation, electric power production and other benefits, and recommended that studies be made of the financial feasibility of said project; and

WHEREAS, in connection with authorized studies in the formulation of The California Water Plan, the State Engineer has made limited additional investigations, studies, surveys and estimates of costs relating to the engineering and financial feasibility of said Oroville project and has accumulated certain maps, plans, information, data and records in relation thereto; and

WHEREAS, by The State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects; and

WHEREAS, the Association desires and hereby requests the Board to prepare an interim report, utilizing available data, on the nature and extent of the works required for the Oroville project on the Feather River in the County of Butte, for the storage, conservation, conveyance and utilization of waters thereof for beneficial purposes, including flood control, irrigation and other purposes, and the production and transmission of electric power; the cost of such project and of works required for the widest practicable coordinated utilization of project water and electric power; and including the engineering feasibility of

said project and the possibilities of financing thereof through a contribution of Federal funds for the portion of the cost thereof properly allocated to flood control, and State or local financing of the balance of the cost; and

WHEREAS, the Association has agreed to make funds available to meet the cost of preparing said interim report; namely, the sum of Seven Thousand Five Hundred ($7,500) Dollars;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the Association, and the State Engineer do hereby mutually agree as follows:

ARTICLE I - WORK TO BE PERFORMED

The work to be performed under this agreement shall consist of an interim report, utilizing available data, on:

(a) The nature and extent of the project works required for the Oroville project on the Feather River in the County of Butte, for the storage, conservation, conveyance and utilization of water for beneficial purposes, including flood control, irrigation and other purposes, and the production and transmission of electric power;

(b) The cost of such project works and all canals, conduits, transmission lines and other works required for the widest practicable coordinated utilization of project water and electric power available therefrom;

(c) The engineering feasibility of said project and the possibilities of financing thereof through a contribution of Federal funds for the portion of the cost of the project properly allocated to flood control, and state or local financing of the balance of the cost.

The Board by this agreement authorizes and directs the State Engineer to prepare said interim report for the Association.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the interim report on or before June 1, 1951, or as nearly thereafter as possible.

ARTICLE II - FUNDS

The Association upon execution by it of this agreement, shall transmit to the State Engineer the sum of Seven Thousand Five Hundred ($7,500) Dollars for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Seven Thousand Five Hundred ($7,500) Dollars as made available hereunder.

Upon completion of the work provided for in this agreement, the State Engineer shall furnish to the Board and to the Association a statement of all expenditures made under this agreement, together with copies of the interim report, and such compilations of data as may have been collected hereunder. Any residue of the funds deposited pursuant to this article remaining

unexpended and unobligated upon completion of the work provided for herein shall be returned to the Association.

Notwithstanding anything herein contained to the contrary, this agreement may be terminated and the provisions of this agreement may be altered, changed or amended, by mutual consent of the parties hereto.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the date first herein written.

Approved as to form and procedure:

/s/ V. L. Diepenbrock
Attorney, California Central Valleys Flood Control Association

Approved as to form and procedure:

/s/ Robert E. Reed
Attorney for Department of Public Works

Approved as to form and procedure:

/s/ Henry Holsinger
Attorney for Division of Water Resources

APPROVED:

/s/ James S. Dean
Director of Finance

CALIFORNIA CENTRAL VALLEYS FLOOD CONTROL ASSOCIATION

By /s/ John M. Luther, Mgr.

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

/s/ C. H. PURCELL (Seal)

Director of Public Works

By ______
Deputy Director

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

APPENDIX B

FEATHER RIVER PROJECT

OPERATION STUDIES, OROVILLE RESERVOIR

1921-1947 by months

FEATHER RIVER PROJECT

OPERATION STUDIES OROVILLE RESERVOIR

1921-1947 by months

		Operation in Coordination with Sacramento-San Joaquin Delta Diversion Projects							Operation primarily for power			
				Releases from reservoir-1,000 Ac. Ft.								
Year and Month	Inflow to reservoir	Reservoir storage on first of Month	Evaporation	Net requirement for Feather River Service Area	Requirement to yield a supply of 3,930 sec. ft. in Delta	Power generation and waste through flood control outlets and over spillway	Total	Electric energy output	Reservoir storage on first of Month	Evaporation	Release from reservoir	Electric energy output
	1000 Ac.Ft.	1000 Ac.Ft.	1000 Ac.Ft.					1,000,000 kilowatt hours	1000 Ac.Ft.	1000 Ac.Ft.	1000 Ac.Ft.	1,000,000 kilowatt hours
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921												
J	754.3	2,539.1				410.0	410.0	242.4	2,898.5		652.8	242.4
F	537.3	2,883.4				420.7	420.7	218.4	3,000.0		537.3	218.4
M	829.5	3,000.0		9.7		819.8	829.5	234.6	3,000.0		829.5	234.6
A	687.9	3,000.0	4.5	45.1		199.3	244.4	152.7	3,000.0	4.5	392.8	242.7
M	788.4	3,439.0	6.7	138.3		582.4	720.7	254.8	3,290.6	6.5	572.5	254.8
J	390.1	3,500.0	8.0	139.8		287.4	427.2	271.4	3,500.0	8.0	427.5	271.4
J	172.5	3,454.9	9.6	145.6	24.0	298.2	467.8	291.5	3,454.6	9.5	468.0	291.5
A	114.6	3,150.0	8.4	119.4	130.3	233.9	483.6	291.8	3,149.6	8.4	247.8	152.5
S	98.3	2,772.6	6.0	48.6	165.3	196.3	410.2	239.9	3,008.0	6.3	187.5	114.2
O	99.3	2,454.7	4.2	- 1.9	34.1	60.1	94.2	54.4	2,912.5	4.7	160.1	96.8
N	97.2	2,455.6	2.8	- 13.6		60.6	60.6	35.1	2,847.0	3.1	147.8	88.8
D	186.8	2,489.4				137.1	137.1	79.8	2,793.3		166.2	99.7
Totals	4,756.2		50.2	631.0	353.7	3,705.8	4,706.0	2,366.8		51.0	4,789.8	2,307.8
1922												
J	179.7	2,539.1				61.0	61.0	35.9	2,813.9		156.9	94.3
F	372.0	2,657.8				275.4	275.4	163.0	2,836.7		275.2	166.4
M	429.9	2,754.4		9.7		174.6	184.3	111.4	2,933.5		363.4	221.1
A	816.1	3,000.0	4.5	45.1		327.5	372.6	231.8	3,000.0	4.5	390.3	242.7
M	1,458.5	3,439.0	6.7	138.3		1,252.5	1,390.8	254.8	3,421.3	6.7	1,373.1	254.8
J	646.9	3,500.0	8.0	139.8		499.1	638.9	271.4	3,500.0	8.0	638.9	271.4
J	163.6	3,500.0	9.5	145.6		320.2	465.8	291.5	3,500.0	9.6	465.5	291.5
A	106.8	3,188.3	8.4	119.4		364.1	483.5	291.8	3,188.5	8.5	278.8	172.1
S	93.3	2,803.2	6.0	48.6	216.0	171.2	435.8	254.0	3,008.0	6.3	187.4	114.2
O	101.3	2,454.7	4.2	- 1.9		96.2	96.2	55.6	2,907.6	4.7	160.2	96.8
N	140.7	2,455.6	2.8	- 13.6		60.4	60.4	35.1	2,844.0	3.1	147.4	88.8
D	371.6	2,533.1				365.6	365.6	211.2	2,834.2		307.3	185.0
Totals	4,880.4		50.1	631.0	216.0	3,967.8	4,890.9	2,207.5		51.4	4,744.4	2,199.1

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1923												
J	300.3	2,539.1				175.7	175.7	103.2	2,898.5		270.2	163.8
F	196.1	2,663.7				105.4	105.4	62.6	2,928.6		191.2	116.0
M	294.7	2,754.4		9.7		39.4	49.1	29.8	2,933.5		228.2	139.3
A	554.3	3,000.0	4.5	45.1		65.7	110.8	69.4	3,000.0	4.5	375.3	230.8
M	374.6	3,439.0	6.7	138.3		215.4	353.7	224.7	3,174.5	6.5	208.6	130.7
J	179.2	3,453.2	7.9	139.8		219.7	359.5	226.9	3,334.0	7.8	233.8	147.0
J	116.4	3,265.0	9.2	145.6	282.3	0	427.9	263.6	3,271.6	9.2	239.7	149.4
A	105.6	2,944.3	8.0	119.4	288.5	0	407.9	243.1	3,139.1	8.4	242.8	149.2
S	94.8	2,634.0	5.8	48.6	237.1	0	285.7	165.5	2,993.5	6.3	187.5	114.2
O	104.6	2,437.3	4.2	- 1.9	106.8	0	106.8	61.1	2,894.5	4.7	160.3	95.3
N	97.1	2,430.9	2.8	- 13.6	2.8	58.0	60.8	35.1	2,834.1	3.1	148.0	88.8
D	92.7	2,464.4				73.9	73.9	42.9	2,780.1		167.5	99.7
Totals	2,510.4		49.1	631.0	917.5	953.2	2,517.2	1,527.9		50.5	2,653.1	1,625.7
1924												
J	99.1	2,483.2			28.6	33.2	61.8	35.9	2,705.3		159.3	94.3
F	230.9	2,520.5				49.2	49.2	29.0	2,645.1		138.2	81.9
M	93.0	2,702.2		9.7	108.7	0	118.4	70.2	2,737.8		143.6	85.3
A	126.1	2,676.8	4.1	45.1	278.2	0	323.3	188.3	2,687.2	4.2	163.0	96.3
M	76.1	2,475.5	5.4	138.3	241.6	0	379.9	214.2	2,646.1	5.7	177.6	104.1
J	52.3	2,166.3	5.8	139.8	233.8	0	373.6	201.7	2,538.9	6.5	228.0	131.3
J	53.4	1,839.2	6.3	145.6	241.6	0	387.2	198.0	2,356.7	7.3	266.6	149.4
A	58.7	1,499.1	5.0	119.4	261.1	0	380.5	179.5	2,136.2	6.4	274.9	149.2
S	59.3	1,172.3	3.3	48.6	289.3	0	337.9	148.8	1,913.6	4.6	216.5	114.2
O	93.0	890.4	2.1	- 1.9	136.5	0	136.5	56.0	1,751.8	3.3	187.2	96.8
N	124.9	844.8	1.3	- 13.6		85.5	85.5	35.1	1,654.3	2.1	174.0	88.8
D	134.4	882.9				103.5	103.5	42.9	1,603.1		197.5	99.7
Totals	1,201.2		33.3	631.0	1,819.4	271.4	2,737.3	1,399.6		40.1	2,326.4	1,291.3
1925												
J	145.7	913.8				84.1	84.1	35.9	1,540.0		190.8	94.3
F	649.2	975.4				61.3	61.3	29.0	1,494.9		157.8	81.9
M	299.8	1,563.3		9.7		43.3	53.0	27.4	1,986.3		156.0	85.3
A	434.0	1,810.1	3.2	45.1		23.5	68.6	37.2	2,130.1	3.5	171.3	95.3
M	331.5	2,172.3	4.9	138.3		0	138.3	78.0	2,389.3	5.3	180.5	104.1
J	161.2	2,360.6	6.2	139.8		0	139.8	79.7	2,535.0	6.5	227.0	131.3
J	109.6	2,375.8	7.5	145.6	241.6	0	387.2	216.0	2,462.7	7.6	261.9	149.4
A	102.9	2,090.7	6.4	119.4	235.3	0	354.7	190.3	2,302.8	6.7	267.0	149.2
S	101.8	1,832.5	4.5	48.6	223.1	0	271.7	141.3	2,132.0	5.0	203.5	114.2
O	104.1	1,658.1	3.2	- 1.9	79.5	1.6	81.1	41.8	2,020.3	3.6	178.8	96.8
N	115.8	1,677.9	2.1	- 13.6		67.6	67.6	35.1	1,942.0	2.4	165.8	88.8
D	132.0	1,724.0				82.1	82.1	42.9	1,889.6		187.8	99.7
Totals	2.687.6		38.0	631.0	779.5	363.5	1.789.5	954.6		40.6	2.353.2	1.291.3

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1926												
J	142.9	1,773.9				68.0	68.0	35.9	1,833.8		178.8	94.3
F	539.6	1,848.8				52.7	52.7	29.0	1,797.9		151.3	81.9
M	335.7	2,335.7		9.7		37.4	47.1	27.4	2,186.2		151.7	85.3
A	730.7	2,624.3	4.1	45.1		15.9	61.0	37.2	2,370.2	3.8	163.4	96.3
M	252.8	3,289.9	6.5	138.3	95.7	3.8	237.8	149.5	2,933.7	6.1	170.5	104.1
J	114.5	3,298.4	7.7	139.8	262.6	0	402.4	248.9	3,009.9	7.3	215.9	131.3
J	114.1	3,002.8	8.7	145.6	273.7	0	419.3	251.6	2,901.2	8.5	248.9	149.4
A	112.5	2,688.9	7.6	119.4	286.7	0	406.1	235.4	2,757.9	7.7	252.3	149.2
S	111.3	2,387.7	5.4	48.6	281.3	0	329.9	184.0	2,610.4	5.7	195.6	114.2
O	105.6	2,163.7	4.0	- 1.9	120.8	0	120.8	67.1	2,520.4	4.2	167.3	96.8
N	396.5	2,144.5	2.6	- 13.6		61.8	61.8	35.1	2,454.5	2.8	151.7	88.8
D	259.6	2,476.6				197.1	197.1	114.4	2,696.5		167.5	99.7
Totals	3,215.8		46.6	631.0	1,320.8	456.7	2,404.0	1,415.5		46.1	2,214.9	1,291.3
1927												
J	314.9	2,539.1				190.3	190.3	111.7	2,788.6		174.9	105.5
F	1,141.7	2,663.7				805.4	805.4	218.4	2,928.6		1,070.3	218.4
M	671.2	3,000.0		9.7		661.5	671.2	234.6	3,000.0		671.2	234.6
A	819.5	3,000.0	4.5	45.1		330.9	376.0	234.2	3,000.0	4.5	390.1	242.7
M	588.8	3,439.0	6.7	138.3		382.8	521.1	254.8	3,424.9	6.7	507.0	254.8
J	272.3	3,500.0	8.0	139.8		289.6	429.4	271.4	3,500.0	8.0	490.0	271.4
J	130.2	3,334.9	9.2	145.6	142.7	186.4	474.7	291.5	3,334.3	9.4	313.8	195.8
A	114.2	2,981.2	8.1	119.4	241.6	87.5	448.5	266.7	3,141.3	8.4	242.3	149.2
S	107.4	2,698.8	5.8	48.6	233.8	3.3	285.7	166.1	3,004.8	6.3	187.4	114.2
O	113.2	2,454.7	4.2	- 1.9	35.5	72.6	108.1	62.4	2,918.5	4.7	159.7	96.8
N	217.9	2,455.6	2.8	- 13.6		135.4	135.4	78.5	2,867.3	3.1	156.2	93.7
D	153.1	2,535.3				149.3	149.3	87.0	2,925.9		180.5	109.4
Totals	4,644.4		49.3	631.0	653.6	3,295.0	4,595.1	2,277.3		51.1	4,483.4	2,086.5
1928												
J	190.7	2,539.1				66.1	66.1	38.9	2,898.5		160.6	97.5
F	321.2	2,663.7				230.5	230.5	136.6	2,928.6		316.3	191.5
M	1,263.1	2,754.4		9.7		1,007.8	1,017.5	234.6	2,933.5		1,196.6	234.6
A	604.6	3,000.0	4.5	45.1		116.0	161.1	100.7	3,000.0	4.5	394.2	242.7
M	301.9	3,439.0	6.7	138.3		142.7	281.0	179.1	3,205.9	6.4	165.9	104.1
J	127.2	3,453.2	7.9	139.8	257.0	0	396.8	249.2	3,335.5	7.8	208.9	131.3
J	124.5	3,175.7	9.1	145.6	254.5	0	400.1	244.8	3,246.0	9.2	240.0	149.4
A	105.3	2,891.0	8.0	119.4	275.4	0	394.8	234.4	3,121.3	8.4	243.0	149.2
S	86.8	2,593.5	5.7	48.6	267.9	0	316.5	182.5	2,975.2	6.3	188.0	114.2
O	96.9	2,358.1	4.0	- 1.9	155.8	0	155.8	88.4	2,867.7	4.6	160.7	96.8
N	100.1	2,295.2	2.7	- 13.6		61.8	61.8	35.1	2,799.3	3.1	148.5	88.8
D	114.6	2,390.8				75.2	75.2	42.9	2,747.8		167.7	99.7
Totals	3,436.9		48.6	631.0	1,210.6	1,700.1	3,557.2	1,767.2		50.3	3,590.4	1,699.8

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1929												
J	120.2	2,370.2			59.2	3.3	62.5	35.9	2,694.7		159.4	94.3
F	190.1	2,427.9				49.9	49.9	29.0	2,655.5		138.2	81.9
M	274.0	2,568.1		9.7		36.5	46.2	27.4	2,707.4		142.5	85.3
A	249.3	2,795.9	4.3	45.1	142.6	0	187.7	112.9	2,838.9	4.3	159.3	96.3
M	294.8	2,853.2	6.0	138.3	191.7	0	330.0	197.8	2,924.6	6.1	170.4	104.1
J	146.7	2,812.0	7.1	139.8	215.1	0	354.9	209.7	3,042.9	7.4	214.9	131.3
J	120.0	2,596.7	7.9	145.6	282.5	0	428.1	244.8	2,967.3	8.7	247.1	149.5
A	136.1	2,280.7	6.7	119.4	317.1	0	436.5	239.2	2,831.5	7.9	250.2	149.3
S	129.5	1,973.6	4.7	48.6	275.5	0	324.1	171.6	2,709.5	5.9	193.1	114.2
O	132.2	1,774.3	3.3	-1.9	162.8	0	162.8	85.0	2,640.0	4.4	164.5	96.8
N	103.4	1,740.4	2.2	-13.6	129.5	0	129.5	67.4	2,603.3	2.9	151.7	88.8
D	764.5	1,712.1				78.4	78.4	42.9	2,552.1		408.0	241.6
Totals	2,660.8		42.2	631.0	1,776.0	168.1	2,590.6	1,463.6		47.6	2,399.3	1,433.4
1930												
J	278.9	2,398.2				61.8	61.8	35.9	2,908.6		258.9	157.0
F	343.3	2,615.3				204.2	204.2	120.8	2,928.6		338.4	204.9
M	524.3	2,754.4		9.7		269.0	278.7	168.3	2,933.5		457.8	234.6
A	502.8	3,000.0	4.5	45.1		14.2	59.3	37.2	3,000.0	4.5	323.8	196.6
M	333.5	3,439.0	6.7	138.3	174.3	0	312.6	199.0	3,174.5	6.5	167.5	104.1
J	154.3	3,453.2	7.9	139.8	194.8	0	334.6	211.3	3,334.0	7.8	208.9	131.3
J	118.3	3,265.0	9.2	145.6	280.6	0	426.2	262.7	3,271.6	9.2	239.4	149.4
A	117.8	2,947.9	8.1	119.4	299.4	0	418.8	249.8	3,141.3	8.4	242.7	149.2
S	131.6	2,638.8	5.8	48.6	261.3	0	309.9	180.1	3,008.0	6.3	187.0	114.2
O	145.5	2,454.7	4.2	-1.9	140.4	0	140.4	81.1	2,946.3	4.7	159.2	96.8
N	147.5	2,455.6	2.8	-13.6	65.0	0	65.0	37.7	2,927.9	3.2	146.3	88.8
D	136.9	2,535.3			133.1	0	133.1	77.6	2,925.9		164.3	99.7
Totals	2,934.7		49.2	631.0	1,548.9	549.2	2,744.6	1,661.5		50.6	2,894.2	1,726.6
1931												
J	185.6	2,539.1				61.0	61.0	35.9	2,898.5		155.5	94.3
F	139.5	2,663.7				48.8	48.8	29.0	2,928.6		134.6	81.9
M	206.0	2,754.4		9.7	12.3	23.4	45.4	27.4	2,933.5		139.5	85.3
A	123.6	2,915.0	4.4	45.1	256.1	0	301.2	180.6	3,000.0	4.5	157.5	96.3
M	102.5	2,733.0	5.8	138.3	245.0	0	383.3	223.6	2,961.6	6.2	171.4	104.1
J	76.9	2,446.4	6.8	139.8	237.0	0	376.8	212.0	2,886.5	7.2	218.9	131.3
J	77.8	2,139.7	7.0	145.6	259.7	0	405.3	217.8	2,737.3	8.1	253.8	149.4
A	73.5	1,805.2	5.7	119.4	295.3	0	414.7	210.4	2,553.2	7.4	259.0	149.2
S	67.5	1,458.3	3.8	48.6	289.7	0	338.3	159.2	2,360.3	5.3	202.3	114.2
O.	73.5	1,183.7	2.5	-1.9	205.1	0	205.1	91.1	2,220.2	3.9	174.0	96.8
N	83.4	1,051.6	1.6	-13.6	92.3	0	92.3	41.2	2,117.8	2.5	161.6	88.8
D	233.7	1,041.1				96.2	96.2	42.9	2,037.1		180.2	99.7
Totals	1,445.5		37.6	631.0	1,892.5	229.4	2,768.4	1,471.1		45.1	2,208.3	1,291.3

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1932												
J	197.8	1,178.6				77.0	77.0	35.9	2,090.6		171.0	94.3
F	164.7	1,299.4				60.6	60.6	29.0	2,117.4		148.2	81.9
M	451.9	1,403.5		9.7		44.2	53.9	27.4	2,133.9		151.2	85.3
A	479.6	1,801.5	3.2	45.1		23.3	68.4	37.2	2,434.6	3.9	164.4	96.3
M	509.0	2,209.5	5.0	138.3		0	138.3	79.3	2,745.9	5.9	171.6	104.1
J	230.1	2,575.2	6.6	139.8		0	139.8	82.2	3,077.4	7.4	213.0	131.3
J	123.8	2,658.9	8.0	145.6	291.2	0	436.8	251.3	3,087.1	8.9	243.9	149.4
A	102.6	2,337.9	6.6	119.4	288.1	0	407.5	225.7	2,958.1	8.1	247.2	149.2
S	64.4	2,026.4	4.8	48.6	250.8	0	299.4	159.6	2,805.4	6.0	191.7	114.2
O	47.0	1,786.6	3.4	-1.9	156.3	0	156.3	81.3	2,672.1	4.4	164.9	96.8
N	51.7	1,673.9	2.1	-13.6	60.0	8.1	68.1	35.1	2,549.8	2.9	153.4	88.8
D	82.3	1,655.4			46.9	96.5	83.4	42.9	2,445.2		174.1	99.7
Totals	2,504.9		39.7	631.0	1,093.3	249.7	1,989.5	1,086.9		47.5	2,194.6	1,291.3
1933												
J	119.3	1,654.3				69.5	69.5	35.9	2,353.4		166.0	94.3
F	95.0	1,704.1			16.6	39.1	55.7	29.0	2,306.7		145.1	81.9
M	206.8	1,743.4		9.7		42.1	51.8	27.4	2,256.6		150.9	85.3
A	259.1	1,898.4	3.3	45.1	106.2	0	151.3	81.5	2,312.5	3.8	169.0	96.3
M	288.8	2,002.9	4.7	138.3		0	138.3	76.0	2,398.8	5.3	180.5	104.1
J	195.2	2,148.7	5.8	139.8		0	139.8	77.7	2,501.8	6.5	227.1	131.3
J	98.8	2,198.3	7.1	145.6	267.0	0	412.6	224.1	2,463.4	7.6	262.0	149.4
A	87.6	1,877.4	5.9	119.4	273.2	0	392.6	202.7	2,292.6	6.7	267.9	149.2
S	70.7	1,566.5	4.0	48.6	269.5	0	318.1	154.0	2,105.6	5.0	209.9	114.2
O	95.6	1,315.1	2.7	-1.9	145.8	0	145.8	68.6	1,961.4	3.6	180.6	96.8
N	95.1	1,262.2	1.8	-13.6	105.7	0	105.7	49.4	1,872.8	2.3	168.0	88.8
D	159.5	1,249.8				91.3	91.3	42.9	1,797.6		190.4	99.7
Totals	1,771.5		35.3	631.0	1,184.0	242.0	2,072.5	1,069.2		40.8	2,317.4	1,291.3
1934												
J	233.0	1,318.0				74.4	74.4	35.9	1,766.7		179.6	94.3
F	246.7	1,466.6				58.1	58.1	29.0	1,810.1		154.4	81.9
M	283.7	1,654.9		9.7		42.6	52.3	27.4	1,902.1		158.1	85.3
A	203.8	1,886.3	3.3	28.1	236.7	0	264.8	140.3	2,027.7	3.4	176.6	96.3
M	137.9	1,822.0	4.3	90.0	299.9	0	389.9	200.3	2,051.5	4.7	191.4	104.1
J	96.8	1,565.7	4.7	90.9	258.0	0	348.9	168.5	1,993.3	5.5	245.2	131.3
J	94.5	1,308.9	4.9	94.6	263.3	0	357.9	160.9	1,839.4	6.3	288.0	149.4
A	89.7	1,040.6	3.9	77.6	276.3	0	353.9	145.7	1,639.6	5.3	302.6	149.2
S	80.5	772.5	2.5	31.6	276.8	0	308.4	114.2	1,421.4	3.8	240.5	114.2
O	86.6	542.1	1.5	-1.3	189.3	0	189.3	64.0	1,257.6	2.7	213.0	96.8
N	122.6	437.9	0.9	-8.8		106.1	106.1	35.1	1,128.5	1.7	201.0	88.8
D	122.1	453.5				129.3	129.3	42.9	1,048.4		232.1	99.7
Totals	1,787.6		26.0	412.4	1,800.3	410.5	2,639.3	1,164.2		33.4	2,582.5	1,291.3

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1935												
J	237.6	446.3				104.5	104.5	35.9	938.0		222.3	94.3
F	190.6	579.4				78.2	29.0	29.0	953.7		192.6	81.8
M	291.5	691.8		9.7		58.7	68.4	27.4	951.7		198.0	85.4
A	1,228.3	914.9	1.9	45.1		30.8	75.9	37.2	1,045.2	2.2	195.5	96.3
M	782.3	2,065.4	4.8	138.3		0	138.3	79.1	2,075.8	4.8	182.5	104.1
J	342.3	2,705.1	6.8	139.8		0	139.8	83.8	2,671.3	6.7	220.9	131.3
J	127.2	2,900.8	8.5	145.6	296.3	0	441.9	261.2	2,786.0	8.3	251.8	149.5
A	128.6	2,577.6	7.4	119.4	315.3	0	434.7	248.0	2,653.1	7.5	255.3	149.2
S	98.7	2,264.1	5.2	48.6	267.3	0	315.9	174.7	2,518.9	5.6	198.0	114.2
O	105.8	2,041.7	3.7	-1.9	113.2	0	113.2	61.9	2,414.0	4.1	169.5	96.8
N	91.2	2,030.6	2.4	-13.6	46.4	17.7	64.1	35.1	2,346.2	2.7	156.7	88.8
D	135.2	2,055.3			6.4	71.5	77.9	42.9	2,278.0		177.1	99.7
Totals	3,759.8		40.7	631.0	1,044.9	961.4	2,052.8	1,116.2		41.9	2,420.2	1,291.4
1936												
J	569.9	2,112.6				62.9	62.9	35.9	2,236.1		163.8	94.3
F	839.9	2,619.6				459.5	459.5	218.4	2,642.2		482.1	218.4
M	588.0	3,000.0		9.7		578.3	588.0	234.6	3,000.0		588.0	234.6
A	602.8	3,000.0	4.5	45.1		114.2	159.3	99.6	3,000.0	4.5	394.2	242.7
M	431.9	3,439.0	6.7	138.3		262.3	400.6	254.8	3,204.7	6.4	295.6	185.1
J	246.8	3,463.6	7.9	139.8		297.7	437.5	275.1	3,334.0	7.8	301.4	189.4
J	138.6	3,265.0	9.2	145.6	259.1	41.8	446.5	274.4	3,271.6	9.2	259.7	161.7
A	132.5	2,947.9	8.1	119.4	319.7	0	439.1	261.1	3,141.3	8.4	257.4	158.4
S	124.3	2,633.2	5.8	48.6	265.6	0	314.2	182.4	3,008.0	6.3	187.2	114.2
O	107.1	2,437.5	4.2	-1.9	123.3	0	123.3	71.0	2,938.8	4.7	159.5	96.8
N	80.9	2,417.1	2.8	-13.6	78.1	0	78.1	45.0	2,881.7	3.2	147.4	88.8
D	79.5	2,417.1			3.8	70.7	74.5	42.9	2,812.0		166.9	99.7
Totals	3,942.2		49.2	631.0	1,049.6	1,887.4	3,583.5	1,995.2		50.5	3,409.2	1,884.1
1937												
J	84.4	2,422.1				62.2	62.2	35.9	2,724.6		159.4	94.3
F	211.5	2,444.3				49.7	49.7	29.0	2,649.6		138.2	81.9
M	426.4	2,606.1		9.7		35.9	45.6	27.4	2,722.9		149.3	90.2
A	597.4	2,986.9	4.5	45.1		95.7	140.8	88.0	3,000.0	4.5	394.3	242.7
M	617.9	3,439.0	6.7	138.3		411.9	550.2	254.8	3,198.6	6.4	310.1	195.2
J	239.2	3,500.0	8.0	139.8		290.5	430.3	271.4	3,500.0	8.0	231.2	148.1
J	131.3	3,300.9	9.2	145.6	252.7	76.8	475.1	290.7	3,500.0	9.6	466.7	291.5
A	97.7	2,947.9	8.1	119.4	284.0	0	403.4	240.7	3,155.0	8.4	242.2	149.2
S	93.6	2,634.1	5.8	48.6	258.5	0	307.1	178.0	3,002.1	6.3	187.4	114.2
O	125.8	2,414.8	4.1	-1.9	108.0	0	108.0	62.1	2,902.0	4.7	160.0	96.8
N	306.4	2,428.5	2.8	-13.6		196.8	196.8	113.9	2,863.1	3.1	240.5	145.4
D	1,052.8	2,535.3				588.1	588.1	241.6	2,925.9		978.7	241.6
Totals	3,984.4		49.2	631.0	903.2	1,807.6	3,357.3	1,833.5		51.0	3,658.0	1,891.1

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1938												
J	310.3	3,000.0				399.5	399.5	242.4	3,000.0		381.7	231.8
F	829.4	2,910.8				740.2	740.2	218.4	2,928.6		758.0	218.4
M	1,331.9	3,000.0		9.7		1,322.2	1,331.9	234.6	3,000.0		1,331.9	234.6
A	1,450.8	3,000.0	4.5	45.1		901.2	946.3	242.7	3,000.0	4.5	946.3	242.7
M	1,534.0	3,500.0	6.7	198.3		1,389.0	1,527.3	254.8	3,500.0	6.8	1,527.2	254.8
J	670.7	3,500.0	7.9	139.8		523.0	662.8	271.4	3,500.0	8.0	662.7	271.4
J	202.2	3,500.0	9.5	145.6		319.5	465.1	291.5	3,500.0	9.6	465.0	291.5
A	146.2	3,227.6	8.5	119.4	47.3	313.9	480.6	291.8	3,227.6	8.5	357.3	220.2
S	137.4	2,884.7	6.2	48.6		387.4	496.0	257.1	3,008.0	6.3	192.8	117.8
O	128.5	2,579.9	4.3	- 1.9		248.5	248.5	144.2	2,946.3	4.7	159.3	96.8
N	140.2	2,455.6	2.8	- 13.6		60.4	60.4	35.1	2,910.8	3.2	164.5	99.7
D	183.4	2,532.6				176.9	176.9	103.1	2,833.3		168.2	101.9
Totals	7,065.0		50.4	631.0	47.3	6,781.7	7,475.5	2,587.1		51.6	7,114.9	2,381.6
1939												
J	143.6	2,539.1				61.2	61.2	35.9	2,898.5		155.6	94.3
F	136.7	2,621.5				48.9	48.9	29.0	2,886.5		135.4	81.9
M	255.1	2,709.3		9.7		35.8	45.5	27.4	2,887.8		142.9	87.1
A	263.1	2,918.9	4.4	45.1		15.4	60.5	37.2	3,000.0	4.5	156.3	96.3
M	127.0	3,117.1	6.3	198.3	288.8	0	427.1	254.8	3,102.3	6.3	168.7	104.1
J	87.2	2,810.7	6.0	139.8	248.8	0	388.6	228.5	3,054.3	7.4	215.0	131.3
J	90.3	2,503.3	6.5	145.6	259.0	0	404.6	229.1	2,919.1	8.5	248.5	149.4
A	99.1	2,182.5	6.5	119.4	285.6	0	405.0	219.7	2,752.4	7.7	252.7	149.2
S	87.9	1,870.1	4.6	48.6	271.8	0	320.4	166.5	2,591.1	5.7	196.0	114.2
O	86.4	1,633.0	3.2	- 1.9	183.2	0	183.2	92.9	2,477.3	4.2	168.3	96.8
N	69.4	1,533.0	2.0	- 13.6	123.3	0	123.3	60.9	2,391.2	2.8	156.0	88.8
D	105.0	1,477.1			49.0	37.0	86.0	42.9	2,301.8		177.0	99.7
Totals	1,550.8		39.5	631.0	1,709.5	198.3	2,554.3	1,424.8		47.1	2,172.4	1,293.1
1940												
J	557.5	1,496.1				68.9	68.9	35.9	2,229.8		164.0	94.3
F	1,055.2	1,984.7				285.5	285.5	162.0	2,623.3		678.5	218.4
M	1,424.4	2,754.4		9.7		1,169.1	1,178.8	234.6	3,000.0		1,424.4	234.6
A	958.5	3,000.0	4.5	45.1		408.9	454.0	242.7	3,000.0	4.5	454.0	242.7
M	413.5	3,500.0	6.7	138.3		268.5	406.8	254.8	3,500.0	6.8	406.7	254.8
J	176.9	3,500.0	8.0	139.8		264.1	403.9	255.8	3,500.0	8.0	397.3	251.1
J	117.2	3,265.0	9.2	145.6	241.6	37.9	425.1	262.1	3,271.6	9.2	239.8	149.4
A	112.0	2,947.9	8.1	119.4	266.6	27.0	413.0	246.4	3,139.8	8.4	242.5	149.2
S	130.2	2,638.8	5.8	48.6	251.1	8.8	308.5	179.3	3,000.9	6.3	187.1	114.2
O	146.3	2,454.7	4.2	- 1.9	56.1	85.1	141.2	81.6	2,937.7	4.7	159.3	96.8
N	146.0	2,455.6	2.8	- 13.6		63.5	63.5	36.9	2,920.0	3.2	146.3	88.8
D	577.5	2,535.3				413.1	413.1	241.6	2,916.5		494.0	241.6
Totals	5,815.2		49.3	631.0	815.4	3,100.4	4,562.3	2,239.7		51.1	4,993.9	2,135.9

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1941												
J	679.8	2,699.7				406.0	406.0	242.4	3,000.0		679.8	242.4
F	1,056.0	2,973.5				1,029.5	1,029.5	218.4	3,000.0		1,056.0	218.4
M	909.8	3,000.0		9.7		900.1	909.8	234.6	3,000.0		909.8	234.6
A	807.4	3,000.0	4.5	45.1		318.8	363.9	226.7	3,000.0	4.5	302.9	189.4
M	951.7	3,439.0	6.7	138.3		745.7	884.0	254.8	3,500.0	6.8	944.9	254.8
J	964.6	3,500.0	8.0	139.8		287.7	427.5	271.4	3,500.0	8.0	428.3	271.4
J	168.1	3,429.1	9.4	145.6		323.6	469.2	291.5	3,428.3	9.5	445.6	277.9
A	125.7	3,118.6	8.2	119.4	19.9	347.5	486.8	291.8	3,141.3	8.4	250.6	154.2
S	112.1	2,749.3	6.0	48.6	170.0	182.1	400.7	234.1	3,008.0	6.3	187.3	114.2
O	116.7	2,454.7	4.2	-1.9		111.6	111.6	64.5	2,926.5	4.7	159.6	96.8
N	140.7	2,455.6	2.8	-13.6		60.4	60.4	35.1	2,878.9	3.2	146.8	88.8
D	723.4	2,533.1				410.0	410.0	241.6	2,869.6		593.0	241.6
Totals	6,156.0		49.8	631.0	189.9	5,123.0	5,959.4	2,606.9		51.4	6,104.6	2,384.5
1942												
J	840.8	2,846.5				687.3	687.3	242.4	3,000.0		840.8	242.4
F	1,079.6	3,000.0				1,079.6	1,079.6	218.4	3,000.0		1,079.6	218.4
M	492.1	3,000.0		9.7		482.4	492.1	234.6	3,000.0		492.1	234.6
A	987.4	3,000.0	4.5	45.1		437.8	482.9	242.7	3,000.0	4.5	482.9	242.7
M	841.3	3,500.0	6.8	138.3		696.2	834.5	254.8	3,500.0	6.8	834.5	254.8
J	514.9	3,500.0	8.0	139.8		367.1	506.9	271.4	3,500.0	8.0	506.9	271.4
J	193.5	3,500.0	9.6	145.6		319.5	465.1	291.5	3,500.0	9.6	465.0	291.5
A	135.5	3,218.8	8.5	119.4		361.6	481.0	291.8	3,218.9	8.5	337.9	208.2
S	136.3	2,864.8	6.1	48.6	59.5	328.9	437.0	257.1	3,008.0	6.3	191.7	117.2
O	142.8	2,558.0	4.3	-1.9		240.9	240.9	199.6	2,946.3	4.7	159.2	96.8
N	206.2	2,455.6	2.8	-13.6		123.7	123.7	71.8	2,925.2	3.2	202.3	122.8
D	372.7	2,535.3				368.9	368.9	213.9	2,925.9		400.1	241.6
Totals	5,943.1		50.6	631.0	59.5	5,493.9	6,199.9	2,790.0		51.6	5,993.0	2,542.4
1943												
J	917.3	2,539.1				456.4	456.4	242.4	2,898.5		815.8	242.4
F	572.0	3,000.0				572.0	572.0	218.4	3,000.0		572.0	218.4
M	1,143.9	3,000.0		9.7		1,134.2	1,143.9	234.6	3,000.0		1,143.9	234.6
A	829.0	3,000.0	4.5	45.1		340.4	385.5	240.2	3,000.0	4.5	324.5	202.6
M	434.3	3,439.0	6.7	138.3		262.3	400.6	254.8	3,500.0	6.8	427.5	254.8
J	280.2	3,466.0	7.9	139.8		291.1	430.9	271.4	3,500.0	8.0	429.8	271.4
J	137.4	3,307.4	9.2	145.6	210.2	120.0	475.8	291.5	3,342.4	9.4	329.1	205.2
A	121.9	2,959.8	8.1	119.4	233.7	81.7	434.8	258.9	3,141.3	8.4	246.8	151.8
S	99.0	2,638.8	5.8	48.6	196.5	32.2	277.3	161.2	3,008.0	6.3	187.4	114.2
O	107.5	2,454.7	4.2	-1.9	30.1	72.3	102.4	59.2	2,913.3	4.7	160.0	96.8
N	121.0	2,455.6	2.8	-13.6		60.6	60.6	35.1	2,856.1	3.1	147.3	88.8
D	123.3	2,513.2				97.4	97.4	56.7	2,826.7		165.9	99.7
Totals	4,886.8		49.2	631.0	670.5	3,520.6	4,837.6	2,324.4		51.2	4,950.0	2,180.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1944												
J	194.5	2,539.1				61.2	61.2	35.9	2,784.1		157.6	94.3
F	227.6	2,612.4				85.6	85.6	50.8	2,761.0		136.4	81.9
M	385.2	2,754.4		9.7		129.9	139.6	84.5	2,852.2		237.4	144.1
A	436.4	3,000.0	4.5	45.1	9.6	4.9	59.6	37.2	3,000.0	4.5	257.4	159.0
M	490.3	3,372.3	6.5	138.3		263.8	402.1	254.8	3,174.5	6.5	324.3	202.9
J	186.4	3,454.0	7.9	139.8	73.8	153.9	367.5	232.1	3,334.0	7.8	241.0	151.6
J	137.5	3,265.0	9.2	145.6	306.8	0	452.4	277.5	3,271.6	9.2	258.6	161.2
A	128.6	2,940.9	8.0	119.4	315.2	0	434.6	258.4	3,141.3	8.4	253.5	156.1
S	98.8	2,626.9	5.8	48.6	262.5	0	311.1	180.3	3,008.0	6.3	187.4	114.2
O	91.5	2,408.8	4.1	-1.9	107.4	0	107.4	61.6	2,913.1	4.7	160.2	96.8
N	184.7	2,388.9	2.8	-13.6		60.8	60.8	35.1	2,839.7	3.1	147.1	88.8
D	261.3	2,509.9				232.0	232.0	134.8	2,874.2		237.0	143.3
Totals	2,762.8		48.8	631.0	1,075.3	992.1	2,713.9	1,643.0		50.5	2,597.9	1,594.2
1945												
J	210.1	2,539.2				85.6	85.6	50.3	2,898.5		180.0	109.2
F	711.9	2,663.7				375.6	375.6	218.4	2,928.6		640.5	218.4
M	340.1	3,000.0		9.7		330.4	340.1	204.5	3,000.0		340.1	207.5
A	444.2	3,000.0	4.5	45.1		14.4	59.5	37.2	3,000.0	4.5	265.2	163.8
M	494.0	3,380.2	6.6	138.3		263.3	401.6	254.8	3,174.5	6.5	328.0	205.3
J	232.3	3,466.0	7.9	139.8		285.6	425.4	268.0	3,334.0	7.8	286.9	180.3
J	145.0	3,265.0	9.2	145.6	247.5	59.8	452.9	277.6	3,271.6	9.2	266.1	168.0
A	132.9	2,947.9	8.1	119.4	279.3	35.2	433.9	255.6	3,141.3	8.4	257.8	158.5
S	127.1	2,638.8	5.8	48.6	239.2	17.6	305.4	176.2	3,008.0	6.3	187.0	114.2
O	138.8	2,454.7	4.2	-1.9		133.7	133.7	77.3	2,941.8	4.7	159.4	96.8
N	210.5	2,455.6	2.8	-13.6		128.0	128.0	74.3	2,916.5	3.2	197.9	120.0
D	839.9	2,535.3				407.1	407.1	241.6	2,925.9		765.8	241.6
Totals	4,026.8		49.1	631.0	766.0	2,136.3	3,548.8	2,135.8		50.6	3,874.7	1,983.6
1946												
J	575.2	2,968.1				543.3	543.3	242.4	3,000.0		575.2	242.4
F	267.5	3,000.0				360.0	360.0	218.4	3,000.0		334.0	203.0
M	389.1	2,907.5		9.7		286.9	296.6	180.2	2,933.5		322.6	196.5
A	543.3	3,000.0	4.5	45.1		54.7	99.8	62.5	3,000.0	4.5	364.3	224.3
M	430.9	3,439.0	6.7	138.3		262.3	400.6	254.8	3,174.5	6.5	264.9	165.9
J	184.1	3,462.6	7.9	139.8		234.0	373.8	235.3	3,334.0	7.8	238.7	150.1
J	150.2	3,265.0	9.2	145.6	242.3	70.2	458.1	280.9	3,271.6	9.2	271.3	169.1
A	145.5	2,947.9	8.1	119.4	275.7	51.4	446.5	265.2	3,141.3	8.4	270.4	166.4
S	119.2	2,638.8	5.8	48.6	233.8	15.1	297.5	172.9	3,008.0	6.3	187.2	114.2
O	102.9	2,454.7	4.2	-1.9	91.8	6.0	97.8	56.5	2,933.7	4.7	159.5	96.8
N	164.7	2,455.6	2.8	-13.6		82.2	82.2	47.8	2,872.4	3.1	146.8	88.8
D	162.8	2,535.3				159.0	159.0	92.6	2,887.2		164.8	99.7
Totals	3,235.4		49.2	631.0	843.6	2,125.1	3,615.2	2,109.5		50.5	3,299.7	1,917.2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1947												
J	87.6	2,539.1				61.4	61.4	35.9	2,885.2		156.5	94.3
F	296.8	2,565.3				107.7	107.7	63.7	2,816.3		179.6	108.6
M	428.2	2,754.4		9.7		172.9	182.6	110.4	2,933.5		361.7	219.8
A	332.9	3,000.0	4.5	45.1		14.7	59.8	37.2	3,000.0	4.5	155.8	96.3
M	179.7	3,268.6	6.5	138.3	216.8	0	355.1	220.5	3,172.6	6.4	167.1	104.1
J	146.3	3,086.7	7.5	139.8	305.2	0	445.0	267.7	3,178.8	7.6	212.0	131.3
J	140.3	2,780.5	8.3	145.6	305.0	0	450.6	262.0	3,105.5	8.9	243.2	149.4
A	137.6	2,461.9	7.1	119.4	319.4	0	438.8	246.3	2,993.7	8.1	245.5	149.2
S	106.0	2,153.6	5.0	48.6	267.5	0	316.1	172.3	2,877.7	6.2	189.6	114.2
O	124.2	1,938.5	3.6	-1.9		77.3	77.3	41.	2,787.9	4.5	161.8	96.8
N	116.7	1,981.8	2.4	-13.6		64.5	64.5	35.1	2,745.8	3.1	149.2	88.8
D	112.3	2,031.6			47.2	31.0	78.2	42.9	2,710.2		168.2	99.7
Totals	2,208.6		44.9	631.0	1,461.1	529.5	2,637.1	1,535.8		49.3	2,390.2	1,452.5
27 Year Mean	3,547.2		45.0	622.9	1,007.5	1,874.1	3,519.7	1,781.8		47.9	3,508.3	1,742.6

APPENDIX C

FEATHER RIVER PROJECT

WATER USES AND DIVERSIONS FROM

SACRAMENTO-SAN JOAQUIN DELTA,

1921-1947 by months

APPENDIX C

FEATHER RIVER PROJECT

Water Uses and Diversions from Sacramento-San Joaquin Delta

1921-1947 by months
Quantities in 1,000 acre-feet

Year and Month	Water Supply				Requirements of the Central Valley Project					Irrigation supply reserved for the area adjacent to Delta-Mendota Canal when a surplus above Central Valley Project requirements exists in the Delta	Inflow to Delta in excess of Central Valley Project requirements 5-(10+11)	Continuous water supply without deficiency of 3930 Sec. Ft. for diversion to Santa Clara Valley, San Joaquin Valley and Southern California
	Uncontrolled inflow to Delta from Sacramento-San Joaquin River basin modified by present developments and operation of Folsom and Oroville reservoirs	Water released from Oroville Reservoir to supplement surplus water in Delta so as to provide a continuous diversion of 3930 Sec. Ft. therefrom	Water released from Oroville Reservoir specifically for power generation and water wasted over spillway and through flood control outlets	Total	Required flow into Suisun Bay to prevent encroachment of saline waters into the Delta (4500 Sec.Ft.)	Estimated water requirements of the Contra Costa Conduit in 1960 and the present requirements of the Delta Uplands	Consumptive irrigation requirements and evaporation losses in Delta	Water diverted to meet requirements of Exchange Agreement, dated July 27,1939, between United States and San Joaquin and Kings River Canal Company, San Luis Canal Company, and Firebaugh Canal Company	Total			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921												
J	4,832.5		410.0	5,242.5	276.7	3.1	23.6	22.9	326.3		4,916.2	241.6
F	3,314.1		420.7	3,734.8	249.9	2.5	28.7	27.5	308.6		3,426.2	218.3
M	2,573.8		819.8	3,393.6	276.7	5.5	40.9	76.3	399.4	5.6	2,988.6	241.6
A	1,854.9		199.3	2,054.2	267.8	21.4	123.7	109.3	522.2	7.9	1,524.1	233.8
M	2,234.1		582.4	2,816.5	276.7	11.8	181.0	131.8	601.3	21.5	2,193.7	241.6
J	1,840.4		287.4	2,127.8	267.8	25.1	143.7	136.3	572.9	21.5	1,533.4	233.8
J	859.1	24.0	298.2	1,181.3	276.7	24.0	194.5	124.8	620.0	21.5	539.8	241.6
A	741.8	130.3	233.9	1,106.0	276.7	20.1	222.7	92.9	612.4	18.1	475.5	241.6
S	584.2	165.3	196.3	945.8	267.8	11.0	162.8	61.7	503.3	12.4	430.1	233.8
O	629.8	34.1	62.0	725.9	276.7	4.9	100.1	38.0	419.7	4.5	301.7	241.6
N	651.1		74.2	725.3	267.8	3.5	44.0	26.5	341.8		383.5	233.8
D	1,371.0		137.1	1,508.1	276.7	2.9	31.2	22.9	333.7		1,174.4	241.6
Totals	21,486.8	353.7	3,721.3	25,561.8	3,258.0	135.8	1,296.9	870.9	5,561.6	113.0	19,887.2	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1922												
J	987.7		61.0	1,048.7	276.7	3.1	23.6	22.9	326.3		722.4	241.6
F	2,887.0		275.4	3,162.4	249.9	2.5	28.7	27.5	308.6		2,853.8	218.3
M	1,839.1		174.6	2,013.7	276.7	5.5	40.9	68.6	391.7	5.6	1,616.4	241.6
A	2,038.1		327.5	2,365.6	267.8	21.4	123.7	105.8	518.7	7.9	1,839.0	233.8
M	3,952.4		1,252.5	5,204.9	276.7	11.8	181.0	131.8	601.3	21.5	4,582.1	241.6
J	3,192.1		499.1	3,691.2	267.8	25.1	143.7	136.3	572.9	21.5	3,096.8	233.8
J	979.1		320.2	1,299.3	276.7	24.0	194.5	135.2	630.4	21.5	647.4	241.6
A	902.4		364.1	1,266.5	276.7	20.1	222.7	96.3	615.8	18.1	632.6	241.6
S	544.3	216.0	171.2	931.5	267.8	11.0	162.8	72.5	514.1	12.4	405.0	233.8
O	688.4		98.1	736.5	276.7	4.9	100.1	38.1	419.8	4.5	312.2	241.6
N	911.7		74.0	985.7	267.8	3.5	44.0	26.5	341.8		643.9	233.8
D	2,715.1		365.6	3,080.7	276.7	2.9	31.2	22.9	333.7		2,747.0	241.6
Totals	21,637.4	216.0	3,983.3	25,786.7	3,258.0	135.8	1,296.9	884.4	5,575.1	113.0	20,098.6	2,844.7
1923												
J	1,807.7		175.7	1,983.4	276.7	3.1	23.6	22.9	326.3		1,657.1	241.6
F	1,034.0		105.4	1,139.4	249.9	2.5	28.7	27.5	308.6		830.8	218.3
M	896.4		39.4	935.8	276.7	5.5	40.9	67.8	390.9	5.6	539.3	241.6
A	1,919.8		65.7	1,985.5	267.8	21.4	123.7	109.3	522.2	7.9	1,455.4	233.8
M	1,817.6		215.4	2,033.0	276.7	11.8	181.0	131.8	601.3	21.5	1,410.2	241.6
J	1,089.1		219.7	1,308.8	267.8	25.1	143.7	136.3	572.9	21.5	714.4	233.8
J	582.2	282.3	0	864.5	276.7	24.0	194.5	127.7	622.9		241.6	241.6
A	565.8	288.5	0	854.3	276.7	20.1	222.7	93.2	612.7		241.6	241.6
S	507.1	237.1	0	744.2	267.8	11.0	162.8	68.8	510.4		233.8	233.8
O	557.2	106.8	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	559.2	2.8	71.6	633.6	267.8	3.5	44.0	26.5	341.8		291.8	233.8
D	577.6		73.9	651.5	276.7	2.9	31.2	22.9	333.7		317.8	241.6
Totals	11,913.7	917.5	968.7	13,799.9	3,258.0	135.8	1,296.9	872.8	5,563.5	61.0	8,175.4	2,844.7
1924												
J	539.3	28.6	33.2	601.1	276.7	3.1	23.6	22.9	326.3		274.8	241.6
F	684.3		49.2	733.5	258.8	2.5	28.7	28.5	318.5		415.0	226.1
M	516.5	108.7	0	625.2	276.7	5.5	40.9	54.9	378.0	5.6	241.6	241.6
A	458.1	278.2	0	736.3	267.8	21.4	123.7	89.6	502.5		233.8	233.8
M	590.5	241.6	0	832.1	276.7	11.8	181.0	120.9	590.4		241.7	241.6
J	534.9	233.8	0	768.7	267.8	25.1	143.7	98.2	534.8		233.9	233.8
J	597.9	241.6	0	839.5	276.7	24.0	194.5	102.6	597.8		241.7	241.6
A	592.7	261.1	0	853.8	276.7	20.1	222.7	92.7	612.2		241.6	241.6
S	440.4	289.3	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	517.2	136.5	1.9	655.6	276.7	4.9	100.1	27.8	409.5	4.5	241.6	241.6
N	621.9		99.1	721.0	267.8	3.5	44.0	22.6	337.9		383.1	233.8
D	828.0		103.5	931.5	276.7	2.9	31.2	22.1	332.9		598.6	241.6
Totals	6,921.7	1,819.4	286.9	9,028.0	3,266.9	135.8	1,296.9	737.1	5,436.7	10.1	3,581.2	2,852.5

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1925												
J	700.6		84.1	784.7	276.7	3.1	23.6	21.7	325.1		459.6	241.6
F	3,449.6		61.3	3,510.9	249.9	2.5	28.7	27.4	308.5		3,202.4	218.3
M	1,484.6		43.3	1,527.9	276.7	5.5	40.9	69.3	392.4	5.6	1,129.9	241.6
A	2,091.8		23.5	2,115.3	267.8	21.4	123.7	109.3	522.2	7.9	1,585.2	233.8
M	1,829.4		0	1,829.4	276.7	11.8	181.0	131.8	601.3	21.5	1,206.6	241.6
J	1,026.6		0	1,026.6	267.8	25.1	143.7	136.3	572.9	21.5	432.2	233.8
J	639.3	241.6	0	880.9	276.7	24.0	194.5	127.5	622.7	16.6	241.6	241.6
A	638.3	235.3	0	873.6	276.7	20.1	222.7	94.4	613.9	18.1	241.6	241.6
S	527.0	223.1	0	750.1	267.8	11.0	162.8	62.3	503.9	12.4	233.8	233.8
O	584.5	79.5	3.5	667.5	276.7	4.9	100.1	38.1	419.8	4.5	243.2	241.6
N	633.7		81.2	714.9	267.8	3.5	44.0	26.5	341.8		373.1	233.8
D	706.5		82.1	788.6	276.7	2.9	31.2	22.9	333.7		454.9	241.6
Totals	14,311.9	779.5	379.0	15,470.4	3,258.0	135.8	1,296.9	867.5	5,558.2	108.1	9,804.1	2,844.7
1926												
J	833.6		68.0	901.6	276.7	3.1	23.6	22.9	326.3		575.3	241.6
F	2,900.7		52.7	2,953.4	249.9	2.5	28.7	27.5	308.6		2,644.8	218.3
M	1,073.9		37.4	1,111.3	276.7	5.5	40.9	69.6	392.7	5.6	713.0	241.6
A	2,108.3		15.9	2,124.2	267.8	21.4	123.7	108.7	521.6	7.9	1,594.7	233.8
M	764.9	95.7	3.8	864.4	276.7	11.8	181.0	131.8	601.3	21.5	241.6	241.6
J	524.7	262.6	0	787.3	267.8	25.1	143.7	116.9	553.5		233.8	233.8
J	565.7	273.7	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	567.3	286.7	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	448.4	281.3	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	543.1	120.8	1.9	665.8	276.7	4.9	100.1	38.0	419.7	4.5	241.6	241.6
N	1,580.8		75.4	1,656.2	267.8	3.5	44.0	26.5	341.8		1,314.4	233.8
D	1,919.4		197.1	2,116.5	276.7	2.9	31.2	22.9	333.7		1,782.8	241.6
Totals	13,830.8	1,320.8	452.2	15,603.8	3,258.0	135.8	1,296.9	814.6	5,505.3	39.5	10,059.0	2,844.7
1927												
J	2,024.9		190.3	2,215.2	276.7	3.1	23.6	22.9	326.3		1,888.9	241.6
F	6,709.1		805.4	7,514.5	249.9	2.5	28.7	27.5	308.6		7,205.9	218.3
M	2,623.7		661.5	3,285.2	276.7	5.5	40.9	76.2	399.3	5.6	2,880.3	241.6
A	3,384.5		330.9	3,715.4	267.8	21.4	123.7	109.3	522.2	7.9	3,185.3	233.8
M	2,366.8		382.8	2,749.6	276.7	11.8	181.0	131.8	601.3	21.5	2,126.8	241.6
J	1,884.4		289.6	2,174.0	267.8	25.1	143.7	136.3	572.9	21.5	1,579.6	233.8
J	753.2	142.7	186.4	1,082.3	276.7	24.0	194.5	137.6	632.8	21.5	428.0	241.6
A	624.9	241.6	87.5	954.0	276.7	20.1	222.7	92.9	612.4	12.5	329.1	241.6
S	515.5	233.8	3.3	752.6	267.8	11.0	162.8	65.3	506.9	8.6	237.1	233.8
O	628.5	35.5	74.5	738.5	276.7	4.9	100.1	38.1	419.8	4.5	314.2	241.6
N	1,409.2		149.0	1,558.2	267.8	3.5	44.0	26.5	341.8		1,216.4	233.8
D	1,216.3		149.3	1,365.6	276.7	2.9	31.2	22.9	333.7		1,031.9	241.6
Totals	24,141.0	653.6	3,310.5	28,105.1	3,258.0	135.8	1,296.9	887.3	5,578.0	103.6	22,423.5	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1928												
J	1,239.2		66.1	1,305.3	276.7	3.1	23.6	22.9	326.3		979.0	241.6
F	1,738.0		230.5	1,968.5	258.8	2.5	28.7	28.5	318.5		1,650.0	226.1
M	4,821.9		1,007.8	5,829.7	276.7	5.5	40.9	64.0	387.1	5.6	5,437.0	241.6
A	2,613.0		116.0	2,729.0	267.8	21.4	123.7	109.3	522.2	7.9	2,198.9	233.8
M	1,394.9		142.7	1,537.6	276.7	11.8	181.0	131.8	601.3	21.5	914.8	241.6
J	532.5	257.0	0	789.5	267.8	25.1	143.7	119.1	555.7		233.8	233.8
J	584.9	254.5	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	578.6	275.4	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	463.3	267.9	0	731.2	267.8	11.0	162.8	55.8	497.4		233.8	233.8
O	508.2	155.8	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	696.1		75.4	771.5	267.8	3.5	44.0	26.5	341.8		429.7	233.8
D	757.2		75.2	832.4	276.7	2.9	31.2	22.9	333.7		498.7	241.6
Totals	15,927.8	1,210.6	1,715.6	18,854.0	3,266.9	135.8	1,296.9	814.4	5,514.0	39.5	13,300.5	2,852.5
1929												
J	508.4	59.2	3.3	570.9	276.7	3.1	23.6	22.6	326.0		244.9	241.6
F	821.9		49.9	871.8	249.9	2.5	28.7	27.4	308.5		563.3	218.3
M	649.7		36.5	686.2	276.7	5.5	40.9	59.6	382.7	5.6	297.9	241.6
A	604.8	142.6	0	747.4	267.8	21.4	123.7	92.8	505.7	7.9	233.8	233.8
M	672.7	191.7	0	864.4	276.7	11.8	181.0	131.8	601.3	21.5	241.6	241.6
J	611.7	215.1	0	826.8	267.8	25.1	143.7	134.9	571.5	21.5	233.8	233.8
J	563.3	282.5	0	845.8	276.7	24.0	194.5	109.0	604.2		241.6	241.6
A	536.9	317.1	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	454.2	275.5	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	493.5	162.8	1.9	658.2	276.7	4.9	100.1	30.4	412.1	4.5	241.6	241.6
N	431.8	129.5	13.6	574.9	267.8	3.5	44.0	25.8	341.1		233.8	233.8
D	1,345.7		78.4	1,424.1	276.7	2.9	31.2	22.0	332.8		1,091.3	241.6
Totals	7,694.6	1,776.0	183.6	9,654.2	3,258.0	135.8	1,296.9	803.5	5,494.2	61.0	4,099.0	2,844.7
1930												
J	1,174.9		61.8	1,236.7	276.7	3.1	23.6	22.9	326.3		910.4	241.6
F	1,229.4		204.2	1,433.6	249.9	2.5	28.7	27.4	308.5		1,125.1	218.3
M	1,912.4		269.0	2,181.4	276.7	5.5	40.9	62.5	385.6	5.6	1,790.2	241.6
A	1,057.4		14.2	1,071.6	267.8	21.4	123.7	107.3	520.2	7.9	543.5	233.8
M	684.6	174.3	0	858.9	276.7	11.8	181.0	126.3	595.8	21.5	241.6	241.6
J	629.3	194.8	0	824.1	267.8	25.1	143.7	132.2	568.8	21.5	233.8	233.8
J	560.3	280.6	0	840.9	276.7	24.0	194.5	104.1	599.3		241.6	241.6
A	554.6	299.4	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	468.4	261.3	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	514.1	140.4	1.9	656.4	276.7	4.9	100.1	28.6	410.3	4.5	241.6	241.6
N	493.7	65.0	13.6	572.3	267.8	3.5	44.0	23.2	338.5		233.8	233.8
D	440.7	133.1	0	573.8	276.7	2.9	31.2	21.4	332.2		241.6	241.6
Totals	9,719.8	1,548.9	564.7	11,833.4	3,258.0	135.8	1,296.9	803.1	5,493.8	61.0	6,278.6	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1931												
J	697.6		61.0	758.6	276.7	3.1	23.6	22.2	325.6		433.0	241.6
F	559.4		48.8	608.2	249.9	2.5	28.7	27.0	308.1		300.1	218.3
M	613.7	12.3	23.4	649.4	276.7	5.5	40.9	55.7	378.8	5.6	265.0	241.6
A	482.7	256.1	0	738.8	267.8	21.4	123.7	92.1	505.0		233.8	233.8
M	590.3	245.0	0	835.3	276.7	11.8	181.0	124.2	593.7		241.6	241.6
J	531.9	237.0	0	768.9	267.8	25.1	143.7	98.5	535.1		233.8	233.8
J	579.7	259.7	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	558.7	295.3	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	440.0	289.7	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	448.2	205.1	1.9	655.2	276.7	4.9	100.1	27.4	409.1	4.5	241.6	241.6
N	462.7	92.3	13.6	568.6	267.8	3.5	44.0	19.5	334.8		233.8	233.8
D	1,449.5		96.2	1,545.7	276.7	2.9	31.2	19.0	329.8		1,215.9	241.6
Totals	7,414.4	1,892.5	244.9	9,551.8	3,258.0	135.8	1,296.9	735.4	5,426.1	10.1	4,115.6	2,844.7
1932												
J	897.6		77.0	974.6	276.7	3.1	23.6	22.9	326.3		648.3	241.6
F	1,504.1		60.6	1,564.7	258.8	2.5	28.7	28.5	318.5		1,246.2	226.1
M	1,259.7		44.2	1,303.9	276.7	5.5	40.9	76.3	399.4	5.6	898.9	241.6
A	1,080.9		23.3	1,104.2	267.8	21.4	123.7	109.3	522.2	7.9	574.1	233.8
M	1,938.3		0	1,938.3	276.7	11.8	181.0	131.8	601.3	21.5	1,315.5	241.6
J	1,612.9		0	1,612.9	267.8	25.1	143.7	136.3	572.9	21.5	1,018.5	233.8
J	578.5	291.2	0	869.7	276.7	24.0	194.5	132.9	628.1		241.6	241.6
A	566.5	288.1	0	854.6	276.7	20.1	222.7	93.5	613.0		241.6	241.6
S	489.2	250.8	0	740.0	267.8	11.0	162.8	64.6	506.2		233.8	233.8
O	507.7	156.3	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	500.6	60.0	21.7	582.3	267.8	3.5	44.0	25.1	340.4		241.9	233.8
D	528.0	46.9	36.5	611.4	276.7	2.9	31.2	22.5	333.3		278.1	241.6
Totals	11,464.0	1,093.3	265.2	12,822.5	3,266.9	135.8	1,296.9	881.8	5,581.4	61.0	7,180.1	2,852.5
1933												
J	708.7		69.5	778.2	276.7	3.1	23.6	22.9	326.3		451.9	241.6
F	510.3	16.6	39.1	566.0	249.9	2.5	28.7	27.5	308.6		257.4	218.3
M	969.4		42.1	1,011.5	276.7	5.5	40.9	74.4	397.5	5.6	608.4	241.6
A	656.5	106.2	0	762.7	267.8	21.4	123.7	108.1	521.0	7.9	233.8	233.8
M	872.9		0	872.9	276.7	11.8	181.0	123.1	592.6	21.5	258.8	241.6
J	1,031.0		0	1,031.0	267.8	25.1	143.7	135.1	571.7	21.5	437.8	233.8
J	590.7	267.0	0	857.7	276.7	24.0	194.5	120.9	616.1		241.6	241.6
A	580.8	273.2	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	460.2	269.5	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	514.6	145.8	1.9	662.3	276.7	4.9	100.1	34.5	416.2	4.5	241.6	241.6
N	456.3	105.7	13.6	575.6	267.8	3.5	44.0	26.5	341.8		233.8	233.8
D	944.1		91.3	1,035.4	276.7	2.9	31.2	22.9	333.7		701.7	241.6
Totals	8,295.5	1,184.0	257.5	9,737.0	3,258.0	135.8	1,296.9	843.1	5,533.8	61.0	4,142.2	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1934												
J	1,046.4		74.4	1,120.8	276.7	3.1	23.6	22.9	326.3		794.5	241.6
F	1,156.3		58.1	1,214.4	249.9	2.5	28.7	27.5	308.6		905.8	218.3
M	1,031.8		42.6	1,074.4	276.7	5.5	40.9	74.4	397.5	5.6	671.3	241.6
A	517.3	236.7	0	754.0	267.8	21.4	123.7	107.3	520.2		233.8	233.8
M	529.4	299.9	0	829.3	276.7	11.8	181.0	118.2	587.7		241.6	241.6
J	510.6	258.0	0	768.6	267.8	25.1	143.7	98.2	534.8		233.8	233.8
J	576.1	263.3	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	577.7	276.3	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	452.9	276.8	0	729.7	267.8	11.0	162.8	54.3	495.9		233.8	233.8
O	467.3	189.3	1.9	657.9	276.7	4.9	100.1	30.1	411.8	4.5	241.6	241.6
N	730.1		114.9	845.0	267.8	3.5	44.0	24.8	340.1		504.9	233.8
D	657.4		129.3	786.7	276.7	2.9	31.2	22.4	333.2		453.5	241.6
Totals	8,253.3	1,800.3	421.2	10,474.2	3,258.0	135.8	1,296.9	775.6	5,466.3	10.1	4,997.8	2,844.7
1935												
J	1,537.7		104.5	1,642.2	276.7	3.1	23.6	22.9	326.3		1,315.9	241.6
F	1,001.1		78.2	1,079.3	249.9	2.5	28.7	27.5	308.6		770.7	218.3
M	1,570.7		58.7	1,629.4	276.7	5.5	40.9	74.3	397.4	5.6	1,226.4	214.6
A	3,657.5		30.8	3,688.3	267.8	21.4	123.7	109.3	522.2	7.9	3,158.2	233.8
M	2,009.7		0	2,009.7	276.7	11.8	181.0	131.8	601.3	21.5	1,386.9	241.6
J	1,622.6		0	1,622.6	267.8	25.1	143.7	136.3	572.9	21.5	1,028.2	233.8
J	569.2	296.3	0	865.5	276.7	24.0	194.5	128.7	623.9		241.6	241.6
A	541.2	315.3	0	856.5	276.7	20.1	222.7	95.4	614.9		241.6	241.6
S	477.9	267.3	0	745.2	267.8	11.0	162.8	69.8	511.4		233.8	233.8
O	550.6	113.2	1.9	665.7	276.7	4.9	100.1	37.9	419.6	4.5	241.6	241.6
N	515.6	46.4	31.3	593.3	267.8	3.5	44.0	26.5	341.8		251.5	233.8
D	568.6	6.4	71.5	646.5	276.7	2.9	31.2	22.6	333.4		313.1	241.6
Totals	14,622.4	1,044.9	376.9	16,044.2	3,258.0	135.8	1,296.9	883.0	5,573.7	61.0	10,409.5	2,844.7
1936												
J	2,327.6		62.9	2,390.5	276.7	3.1	23.6	22.9	326.3		2,064.2	241.6
F	4,989.7		459.5	5,449.2	258.8	2.5	28.7	28.5	318.5		5,133.7	226.1
M	1,965.6		578.3	2,543.9	276.7	5.5	40.9	76.3	399.4	5.6	2,138.9	241.6
A	2,321.0		114.2	2,435.2	267.8	21.4	123.7	109.3	522.2	7.9	1,905.1	233.8
M	2,090.2		262.3	2,352.5	276.7	11.8	181.0	131.8	601.3	21.5	1,729.7	241.6
J	1,460.1		297.7	1,757.8	267.8	25.1	143.7	136.3	572.9	21.5	1,16[illegible].4	233.8
J	604.6	259.1	41.8	905.5	276.7	24.0	194.5	126.9	622.1		283.4	241.6
A	535.8	319.7	0	855.5	276.7	20.1	222.7	94.4	613.9		241.6	241.6
S	480.7	265.6	0	746.3	267.8	11.0	162.8	70.9	512.5		233.8	233.8
O	540.3	123.3	1.9	665.5	276.7	4.9	100.1	37.7	419.4	4.5	241.6	241.6
N	483.9	78.1	13.6	575.6	267.8	3.5	44.0	26.5	341.8		233.8	233.8
D	571.5	3.8	70.7	646.0	276.7	2.9	31.2	22.9	333.7		312.3	241.6
Totals	18,371.0	1,049.6	1,902.9	21,323.5	3,266.9	135.8	1,296.9	884.4	5,584.0	61.0	15,678.5	2,852.5

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1937												
J	711.3		62.2	773.5	276.7	3.1	23.6	22.9	326.3		447.2	241.6
F	2,301.6		49.7	2,351.3	249.9	2.5	28.7	27.5	308.6		2,042.7	218.3
M	2,720.9		35.9	2,756.8	276.7	5.5	40.9	76.3	399.4	5.6	2,351.8	241.6
A	2,235.7		95.7	2,331.4	267.8	21.4	123.7	109.3	522.2	7.9	1,801.3	233.8
M	2,715.2		411.9	3,127.1	276.7	11.8	181.0	131.8	601.3	21.5	2,504.3	241.6
J	1,324.5		290.5	1,615.0	267.8	25.1	143.7	136.3	572.9	21.5	1,020.6	233.8
J	609.0	252.7	76.8	938.5	276.7	24.0	194.5	124.9	620.1		318.4	241.6
A	570.1	284.0	0	854.1	276.7	20.1	222.7	93.0	612.5		241.6	241.6
S	484.9	258.5	0	743.4	267.8	11.0	162.8	68.0	509.6		233.8	233.8
O	556.0	108.0	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	1,942.2		210.4	2,152.6	267.8	3.5	44.0	26.5	341.8		1,810.8	233.8
D	4,237.1		588.1	4,825.2	276.7	2.9	31.0	22.9	333.7		4,491.5	241.6
Totals	20,408.5	903.2	1,823.1	23,134.8	3,258.0	135.8	1,296.9	877.5	5,568.2	61.0	17,505.6	2,844.7
1938												
J	2,117.8		399.5	2,517.3	276.7	3.1	23.6	22.9	326.3		2,191.0	241.6
F	6,913.5		740.2	7,653.7	249.9	2.5	28.7	0	281.1		7,372.6	218.3
M	7,578.4		1,322.2	8,900.6	276.7	5.5	40.9	0	323.1	5.6	8,571.9	241.6
A	4,422.9		901.2	5,324.1	267.8	21.4	123.7	109.3	522.2	7.9	4,794.0	233.8
M	4,849.8		1,389.0	6,238.8	276.7	11.8	181.0	59.4	528.9	21.5	5,688.4	241.6
J	3,388.3		523.0	3,911.3	267.8	25.1	143.7	0	436.6	21.5	3,453.2	233.8
J	1,051.3		319.5	1,370.8	276.7	24.0	194.5	105.9	601.1	21.5	748.2	241.6
A	842.1	47.3	313.9	1,203.3	276.7	20.1	222.7	110.2	629.7	18.1	555.5	241.6
S	808.5		387.4	1,195.9	267.8	11.0	162.8	70.5	512.1	12.4	671.4	233.8
O	774.0		250.4	1,024.4	276.7	4.9	100.1	38.1	419.8	4.5	600.1	241.6
N	758.1		74.0	832.1	267.8	3.5	44.0	26.5	341.8		490.3	233.8
D	843.5		176.9	1,020.4	276.7	2.9	31.2	22.9	333.7		686.7	241.6
Totals	34,348.2	47.3	6,797.2	41,192.7	3,258.0	135.8	1,296.9	565.7	5,256.4	113.0	35,823.3	2,844.7
1939												
J	628.6		61.2	689.8	276.7	3.1	23.6	22.9	326.3		363.5	241.6
F	622.3		48.9	671.2	249.9	2.5	28.7	27.5	308.6		362.6	218.3
M	1,164.2		35.8	1,200.0	276.7	5.5	40.9	69.6	392.7	5.6	801.7	241.6
A	924.1		15.4	939.5	267.8	21.4	123.7	109.3	522.2	7.9	409.4	233.8
M	552.9	288.8	0	841.7	276.7	11.8	181.0	130.6	600.1		241.6	241.6
J	532.9	248.8	0	781.7	267.8	25.1	143.7	111.3	547.9		233.8	233.8
J	580.4	259.0	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	568.4	285.6	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	458.0	271.8	0	729.8	267.8	11.0	162.8	54.4	496.0		233.8	233.8
O	479.4	183.2	1.9	664.5	276.7	4.9	100.1	36.7	418.4	4.5	241.6	241.6
N	436.2	123.3	13.6	573.1	267.8	3.5	44.0	24.0	339.3		233.8	233.8
D	524.6	49.0	37.0	610.6	276.7	2.9	31.2	21.2	332.0		278.6	241.6
Totals	7,472.0	1,709.5	213.8	9,395.3	3,258.0	135.8	1,296.9	803.0	5,493.7	18.0	3,883.6	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1937												
J	711.3		62.2	773.5	276.7	3.1	23.6	22.9	326.3		447.2	241.6
F	2,301.6		49.7	2,351.3	249.9	2.5	28.7	27.5	308.6		2,042.7	218.3
M	2,720.9		35.9	2,756.8	276.7	5.5	40.9	76.3	399.4	5.6	2,351.8	241.6
A	2,235.7		95.7	2,331.4	267.8	21.4	123.7	109.3	522.2	7.9	1,801.3	233.8
M	2,715.2		411.9	3,127.1	276.7	11.8	181.0	131.8	601.3	21.5	2,504.3	241.6
J	1,324.5		290.5	1,615.0	267.8	25.1	143.7	136.3	572.9	21.5	1,020.6	233.8
J	609.0	252.7	76.8	938.5	276.7	24.0	194.5	124.9	620.1		318.4	241.6
A	570.1	284.0	0	854.1	276.7	20.1	222.7	93.0	612.5		241.6	241.6
S	484.9	258.5	0	743.4	267.8	11.0	162.8	68.0	509.6		233.8	233.8
O	556.0	108.0	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	1,942.2		210.4	2,152.6	267.8	3.5	44.0	26.5	341.8		1,810.8	233.8
D	4,237.1		588.1	4,825.2	276.7	2.9	31.0	22.9	333.7		4,491.5	241.6
Totals	20,408.5	903.2	1,823.1	23,134.8	3,258.0	135.8	1,296.9	877.5	5,568.2	61.0	17,505.6	2,844.7
1938												
J	2,117.8		399.5	2,517.3	276.7	3.1	23.6	22.9	326.3		2,191.0	241.6
F	6,913.5		740.2	7,653.7	249.9	2.5	28.7	0	281.1		7,372.6	218.3
M	7,578.4		1,322.2	8,900.6	276.7	5.5	40.9	0	323.1	5.6	8,571.9	241.6
A	4,422.9		901.2	5,324.1	267.8	21.4	123.7	109.3	522.2	7.9	4,794.0	233.8
M	4,849.8		1,389.0	6,238.8	276.7	11.8	181.0	59.4	528.9	21.5	5,688.4	241.6
J	3,388.3		523.0	3,911.3	267.8	25.1	143.7	0	436.6	21.5	3,453.2	233.8
J	1,051.3		319.5	1,370.8	276.7	24.0	194.5	105.9	601.1	21.5	748.2	241.6
A	842.1	47.3	313.9	1,203.3	276.7	20.1	222.7	110.2	629.7	18.1	555.5	241.6
S	808.5		387.4	1,195.9	267.8	11.0	162.8	70.5	512.1	12.4	671.4	233.8
O	774.0		250.4	1,024.4	276.7	4.9	100.1	38.1	419.8	4.5	600.1	241.6
N	758.1		74.0	832.1	267.8	3.5	44.0	26.5	341.8		490.3	233.8
D	843.5		176.9	1,020.4	276.7	2.9	31.2	22.9	333.7		686.7	241.6
Totals	34,348.2	47.3	6,797.2	41,192.7	3,258.0	135.8	1,296.9	565.7	5,256.4	113.0	35,823.3	2,844.7
1939												
J	628.6		61.2	689.8	276.7	3.1	23.6	22.9	326.3		363.5	241.6
F	622.3		48.9	671.2	249.9	2.5	28.7	27.5	308.6		362.6	218.3
M	1,164.2		35.8	1,200.0	276.7	5.5	40.9	69.6	392.7	5.6	801.7	241.6
A	924.1		15.4	939.5	267.8	21.4	123.7	109.3	522.2	7.9	409.4	233.8
M	552.9	288.8	0	841.7	276.7	11.8	181.0	130.6	600.1		241.6	241.6
J	532.9	248.8	0	781.7	267.8	25.1	143.7	111.3	547.9		233.8	233.8
J	580.4	259.0	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	568.4	285.6	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	458.0	271.8	0	729.8	267.8	11.0	162.8	54.4	496.0		233.8	233.8
O	479.4	183.2	1.9	664.5	276.7	4.9	100.1	36.7	418.4	4.5	241.6	241.6
N	436.2	123.3	13.6	573.1	267.8	3.5	44.0	24.0	339.3		233.8	233.8
D	524.6	49.0	37.0	610.6	276.7	2.9	31.2	21.2	332.0		278.6	241.6
Totals	7,472.0	1,709.5	213.8	9,395.3	3,258.0	135.8	1,296.9	803.0	5,493.7	18.0	3,883.6	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1940												
J	2,662.3		68.9	2,731.2	276.7	3.1	23.6	22.6	326.0		2,405.2	241.6
F	6,248.9		285.5	6,534.4	258.8	2.5	28.7	28.5	318.5		6,215.9	226.1
M	5,044.1		1,169.1	6,213.2	276.7	5.5	40.9	76.3	399.4	5.6	5,808.2	241.6
A	3,215.3		408.9	3,624.2	267.8	21.4	123.7	109.3	522.2	7.9	3,094.1	233.8
M	2,083.3		268.5	2,351.8	276.7	11.8	181.0	131.8	601.3	21.5	1,729.0	241.6
J	962.7		264.1	1,226.8	267.8	25.1	143.7	136.3	572.9	21.5	632.4	233.8
J	610.9	241.6	37.9	890.4	276.7	24.0	194.5	114.9	610.1		280.3	241.6
A	587.4	266.6	27.0	881.0	276.7	20.1	222.7	92.9	612.4		268.6	241.6
S	486.9	251.1	8.8	746.8	267.8	11.0	162.8	62.6	504.2		242.6	233.8
O	605.6	56.1	87.0	748.7	276.7	4.9	100.1	35.8	417.5	4.5	326.7	241.6
N	672.9		77.1	750.0	267.8	3.5	44.0	25.2	340.5		409.5	233.9
D	3,491.7		413.1	3,904.8	276.7	2.9	31.2	22.9	333.7		3,571.1	241.6
Totals	26,672.0	815.4	3,115.9	30,603.3	3,266.9	135.8	1,296.9	859.1	5,558.7	61.0	24,983.6	2,852.5
1941												
J	5,426.8		406.0	5,832.8	276.7	3.1	23.6	22.9	326.3		5,506.5	241.6
F	6,086.8		1,029.5	7,116.3	249.9	2.5	28.7	27.5	308.6		6,807.7	218.3
M	4,420.1		900.1	5,320.2	276.7	5.5	40.9	76.3	399.4	5.6	4,915.2	241.6
A	4,401.1		318.8	4,719.9	267.8	21.4	123.7	109.3	522.2	7.9	4,189.8	233.8
M	3,620.5		745.7	4,366.2	276.7	11.8	181.0	131.8	601.3	21.5	3,743.4	241.6
J	1,946.2		287.7	2,233.9	267.8	25.1	143.7	136.3	572.9	21.5	1,639.5	233.8
J	959.9		326.6	1,283.5	276.7	24.0	194.5	140.9	636.1	21.5	625.9	241.6
A	861.8	19.9	347.5	1,229.2	276.7	20.1	222.7	102.5	622.0	18.1	589.1	241.6
S	588.6	170.0	182.1	940.7	267.8	11.0	162.8	70.8	512.4	12.4	415.9	233.8
O	696.0		113.5	809.5	276.7	4.9	100.1	38.1	419.8	4.5	385.2	241.6
N	726.3		74.0	800.3	267.8	3.5	44.0	26.5	341.8		458.5	233.8
D	3,668.9		410.0	4,078.9	276.7	2.9	31.2	22.9	333.7		3,745.2	241.6
Totals	33,403.0	189.9	5,138.5	38,731.4	3,258.0	135.8	1,296.9	905.8	5,596.5	113.0	33,021.9	2,844.7
1942												
J	4,775.8		687.3	5,463.1	276.7	3.1	23.6	22.9	326.3		5,136.8	241.6
F	5,970.6		1,079.6	7,050.2	249.9	2.5	28.7	27.5	308.6		6,741.6	218.3
M	1,739.7		482.4	2,222.1	276.7	5.5	40.9	76.3	399.4	5.6	1,817.1	241.6
A	2,921.5		437.8	3,359.3	267.8	21.4	123.7	109.3	522.2	7.9	2,829.2	233.8
M	3,090.0		696.2	3,786.2	276.7	11.8	181.0	131.8	601.3	21.5	3,163.4	241.6
J	2,610.3		367.1	2,977.4	267.8	25.1	143.7	136.3	572.9	21.5	2,383.0	233.8
J	1,002.3		319.5	1,321.8	276.7	24.0	194.5	141.6	636.8	21.5	663.5	241.6
A	882.9		361.6	1,244.5	276.7	20.1	222.7	98.2	617.7	18.1	608.7	241.6
S	701.1	59.5	328.9	1,089.5	267.8	11.0	162.8	72.8	514.4	12.4	562.7	233.8
O	679.5		242.8	922.3	276.7	4.9	100.1	38.1	419.8	4.5	498.0	241.6
N	1,182.2		137.3	1,319.5	267.8	3.5	44.0	26.5	341.8		977.7	233.8
D	1,927.1		368.9	2,296.0	276.7	2.9	31.2	22.9	333.7		1,962.3	241.6
Totals	27,483.0	59.5	5,509.4	33,051.9	3,258.0	135.8	1,296.9	904.2	5,594.9	113.0	27,344.0	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1943												
J	4,665.2		456.4	5,121.6	276.7	3.1	23.6	22.9	326.3		4,795.3	241.6
F	2,925.5		572.0	3,497.5	249.9	2.5	28.7	27.5	308.6		3,188.9	218.3
M	4,578.1		1,134.2	5,712.3	276.7	5.5	40.9	76.3	399.4	5.6	5,307.3	241.6
A	2,757.1		340.4	3,097.5	267.8	21.4	123.7	109.3	522.2	7.9	2,567.4	233.8
M	1,982.3		262.3	2,244.6	276.7	11.8	181.0	131.8	601.3	21.5	1,621.8	241.6
J	1,309.3		291.1	1,600.4	267.8	25.1	143.7	136.3	572.9	21.5	1,006.9	233.8
J	677.4	210.2	120.0	1,007.6	276.7	24.0	194.5	129.3	624.5	21.5	361.6	241.6
A	640.5	233.7	81.7	955.9	276.7	20.1	222.7	95.0	614.5	18.1	323.3	241.6
S	556.7	196.5	32.2	785.4	267.8	11.0	162.8	65.4	507.0	12.4	266.0	233.8
O	633.7	30.1	74.2	738.0	276.7	4.9	100.1	37.9	419.6	4.5	313.9	241.6
N	608.4		74.2	682.6	267.8	3.5	44.0	26.5	341.8		340.8	233.8
D	616.7		97.4	714.1	276.7	2.9	31.2	22.5	333.3		380.8	241.6
Totals	21,950.9	670.5	3,536.1	26,157.5	3,258.0	135.8	1,296.9	880.7	5,571.4	113.0	20,473.1	2,844.7
1944												
J	638.6		62.2	690.8	276.7	3.1	23.6	22.8	326.2		373.6	241.6
F	1,241.1		85.6	1,326.7	258.8	2.5	28.7	28.5	318.5		1,008.2	226.1
M	1,433.9		129.9	1,563.8	276.7	5.5	40.9	76.1	399.2	5.6	1,159.0	241.6
A	753.5	9.6	4.9	768.0	267.8	21.4	123.7	108.5	521.4	7.9	238.7	233.8
M	1,216.9		263.8	1,480.7	276.7	11.8	181.0	131.8	601.3	21.5	857.9	241.6
J	754.4	73.8	153.9	982.1	267.8	25.1	143.7	136.3	572.9	21.5	387.7	233.8
J	553.2	306.8	0	860.0	276.7	24.0	194.5	123.2	618.4		241.6	241.6
A	538.8	315.2	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	484.3	262.5	0	746.8	267.8	11.0	162.8	71.4	513.0		233.8	233.8
O	556.6	107.4	1.9	665.9	276.7	4.9	100.1	38.1	419.8	4.5	241.6	241.6
N	1,095.4		74.4	1,169.8	267.8	3.5	44.0	26.5	341.8		828.0	233.8
D	1,472.3		232.0	1,704.3	276.7	2.9	31.2	22.9	333.7		1,370.6	241.6
Totals	10,739.0	1,075.3	1,007.6	12,821.9	3,266.9	135.8	1,296.9	879.0	5,578.6	61.0	7,182.3	2,852.5
1945												
J	820.9		85.6	906.5	276.7	3.1	23.6	22.9	326.3		580.2	241.6
F	3,849.7		375.6	4,225.3	249.9	2.5	28.7	27.5	308.6		3,916.7	218.3
M	1,814.4		330.4	2,144.8	276.7	5.5	40.9	76.3	399.4	5.6	1,739.8	241.6
A	1,287.1		14.4	1,301.5	267.8	21.4	123.7	109.3	522.2	7.9	771.4	233.8
M	1,753.6		263.3	2,016.9	276.7	11.8	181.0	131.8	601.3	21.5	1,394.1	241.6
J	1,398.1		285.6	1,683.7	267.8	25.1	143.7	136.3	572.9	21.5	1,089.3	233.8
J	630.2	247.5	59.8	937.5	276.7	24.0	194.5	140.9	636.1		301.4	241.6
A	588.3	279.3	35.2	902.8	276.7	20.1	222.7	106.5	626.0		276.8	241.6
S	510.3	239.2	17.6	767.1	267.8	11.0	162.8	74.1	515.7		251.4	233.8
O	768.1		135.6	903.7	276.7	4.9	100.1	38.1	419.8	4.5	479.4	241.6
N	1,346.7		141.6	1,488.3	267.8	3.5	44.0	26.5	341.8		1,146.5	233.8
D	4,832.6		407.1	5,239.7	276.7	2.9	31.2	22.9	333.7		4,906.0	241.6
Totals	19,600.0	766.0	2,151.8	22,517.8	3,258.0	135.8	1,296.9	913.1	5,603.8	61.0	16,853.0	2,844.7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1946												
J	2,579.5		543.3	3,122.8	276.7	3.1	23.6	22.9	326.3		2,796.5	241.6
F	986.2		360.0	1,346.2	249.9	2.5	28.7	27.5	308.6		1,037.6	218.3
M	1,693.2		286.9	1,980.1	276.7	5.5	40.9	75.9	399.0	5.6	1,575.5	241.6
A	1,748.0		54.7	1,802.7	267.8	21.4	123.7	109.3	522.2	7.9	1,272.6	233.8
M	1,998.0		262.3	2,260.3	276.7	11.8	181.0	131.8	601.3	21.5	1,637.5	241.6
J	856.9		234.0	1,090.9	267.8	25.1	143.7	136.3	572.9	21.5	496.5	233.8
J	614.5	242.3	70.2	927.0	276.7	24.0	194.5	120.0	615.2		311.8	241.6
A	578.6	275.7	51.4	905.7	276.7	20.1	222.7	93.2	612.7		293.0	241.6
S	513.4	233.8	15.1	762.3	267.8	11.0	162.8	68.8	510.4	3.0	248.9	233.8
O	571.6	91.8	7.9	671.3	276.7	4.9	100.1	37.5	419.2	4.5	247.6	241.6
N	766.4		95.8	862.2	267.8	3.5	44.0	26.5	341.8		520.4	233.8
D	965.2		159.0	1,124.2	276.7	2.9	31.2	22.9	333.7		790.5	241.6
Totals	13,871.5	843.6	2,140.6	16,855.7	3,258.0	135.8	1,296.9	872.6	5,563.3	64.0	11,228.4	2,844.7
1947												
J	572.9		61.4	634.3	276.7	3.1	23.6	22.9	326.3		308.0	241.6
F	1,051.7		107.7	1,159.4	249.9	2.5	28.7	27.5	308.6		350.8	218.3
M	1,718.5		172.9	1,891.4	276.7	5.5	40.9	76.3	399.4	5.6	1,486.4	241.6
A	803.5		14.7	818.2	267.8	21.4	123.7	103.7	516.6	7.9	293.7	233.8
M	647.6	216.8	0	864.4	276.7	11.8	181.0	131.8	601.3	21.5	241.6	241.6
J	491.8	305.2	0	797.0	267.8	25.1	143.7	126.9	563.2		233.8	233.8
J	534.4	305.0	0	839.4	276.7	24.0	194.5	102.6	597.8		241.6	241.6
A	534.6	319.4	0	854.0	276.7	20.1	222.7	92.9	612.4		241.6	241.6
S	464.2	267.5	0	731.7	267.8	11.0	162.8	56.3	497.9		233.8	233.8
O	665.2		79.2	744.4	276.7	4.9	100.1	37.9	419.6	4.5	320.3	241.6
N	601.2		28.1	679.3	267.8	3.5	44.0	25.7	341.0		338.3	233.8
D	528.0	47.2	31.0	606.2	276.7	2.9	31.2	22.3	333.1		273.1	241.6
Totals	8,613.6	1,461.1	545.0	10,619.7	3,258.0	135.8	1,296.9	826.5	5,517.2	39.5	5,063.0	2,844.7
27 Yr. Mean	16,317.3	1,007.5	1,889.4	19,212.3	3,260.0	135.8	1,296.9	838.7	5,531.4	66.4	13,614.5	2,846.4

APPENDIX D

ESTIMATED COST, SANTA CLARA-ALAMEDA DIVERSION

APPENDIX D

ESTIMATED COST
SANTA CLARA-ALAMEDA DIVERSION

April 1951 Prices

Italian Slough		
Excavation, 121,500 cu.yds. at $0.25	$30,400	
Right of way	2,000	$ 32,400
Intake Canal		
Excavation, 554,000 cu.yds. at $0.25	138,500	
Railroad and highway bridges	107,500	
Right of way	11,200	257,200
Canal at Pumping Plant No. 2		
Excavation, 79,200 cu.yds. at $0.40	31,700	
Compacting embankment, 16,000 cu.yds. at $0.18	2,900	
Concrete lining, 3,880 cu.yds. at $35.00	135,800	
Reinforcing steel, 267,000 lbs. at $0.15	40,000	
Right of way	1,800	212,200
Tunnel, Brushy Peak (8.7' dia.)		
7,550 lin.ft. at $187		1,411,900
Tunnel, San Ramon (6.5' dia.)		
3,200 lin.ft. at $168		537,600
Pipe Conduit		
84" Diameter Pipe		
6.4 miles of pipe at $313,000 to $431,500	2,175,400	
Air valves, blowoffs, etc.	79,500	
Special structures	55,000	
78" Diameter Pipe		
6.4 miles of pipe at $265,000 to $284,600	1,701,900	
Air valves, blowoffs, etc.	38,400	
Road crossings	20,000	
Special structures	70,000	

60" Diameter Pipe		
46.9 miles of pipe at $168,000 to $216,600	$8,737,200	
Air valves, blowoffs, etc.	495,600	
Road crossings	100,000	
Railroad crossings	20,000	
Special structures	80,000	
Major drainage crossings	100,000	
Right of way	152,100	$13,825,100
Pumping Plants (2 plants, 3 units each)		
Pumps, valves and hydraulic controls	790,000	
Motors and electrical controls	800,000	
Buildings, including cranes and utilities	500,000	
House, grounds and roads	200,000	2,290,000
Air Point Dam and Reservoir		
Excavation for foundation 843,000 cu.yds. at $0.50 to $0.75	590,100	
Embankment, 3,233,000 cu.yds. at $0.25 to $0.85	2,037,300	
Grouting foundation	120,000	
Spillway	4,500	
Outlet works	226,500	
Reservoir, lands and improvements	290,000	
Clearing	10,000	
Relocating roads, 2 miles at $75,000	150,000	3,428,400
Crow Canyon Dam and Reservoir		
Excavation for foundation 185,400 cu.yds. at $0.50 to $0.75	111,200	
Embankment, 975,000 cu.yds. at $0.25 to $0.80	485,000	
Grouting foundation	100,000	
Spillway	190,000	
Outlet works	232,400	
Reservoir, lands and improvements	200,000	
Clearing	10,000	
Relocating roads, 4 miles at $75,000	300,000	1,628,600
Terminal storage at Evergreen Reservoir		504,900
Subtotal		$24,128,300
Engineering and Administration, 10%		2,412,800
Contingencies, 15%		3,619,200
Interest during construction		904,800
Total estimated cost		$31,065,100

APPENDIX E

ESTIMATED COST,

SAN JOAQUIN VALLEY-SOUTHERN CALIFORNIA DIVERSION

APPENDIX E

ESTIMATED COST
SAN JOAQUIN VALLEY-SOUTHERN CALIFORNIA DIVERSION

Section I. Delta to Fresno-Kings County Line
Mile 0.0 to mile 157.6 Length, 157.6 miles Capacity, 6,000 c.f.s.
April 1951 prices

Item		Unit	Quantity	Unit Cost	Item Cost
Canal excavation	-earth	c.y.	37,548,000	$ 0.18	$ 6,759,000
	-rock	c.y.	1,195,000	1.50	1,793,000
Canal embankment		c.y.	13,187,000	0.20	2,637,000
Canal trimming	-earth	sq.y.	12,019,000	0.25	3,005,000
	-rock	sq.y.	269,000	1.50	404,000
Canal lining	-concrete	c.y.	1,361,400	20.00	27,228,000
Siphons					
Railroad and Highway					546,000
Railroad					137,000
Corral Hollow Creek and Railroad					982,000
Hetch Hetchy Aqueduct					276,000
Puerto Creek					345,000
Orestimba Creek					273,000
Garzas Creek					273,000
San Luis Creek					410,000
Los Banos Creek					410,000
Little Panoche Creek					414,000
Panoche Creek					683,000
Cantua Creek					410,000
Inlet structure and fish control structure					1,000,000
Drainage structures					610,000
Farm bridges		ea.	80	7,925	634,000
County road bridges		ea.	65	28,150	1,830,000
Canal checks		ea.	16	105,000	1,680,000
Turnouts					72,000
Pumping plants					
#1 3755 c.f.s.	- 50.5 feet				5,741,000
#2 3755 c.f.s.	- 50.3 feet				5,712,000
#3 3755 c.f.s.	- 50.3 feet				5,712,000
#4 3755 c.f.s.	- 75.2 feet				6,748,000
#5 3755 c.f.s.	-197.2 feet				14,698,000
Wasteways		ea.	8	161,750	1,294,000
Fencing and cattle guards		mi.	316	1,650	521,000
Right of way					3,759,000
Sub-total					96,996,000
Engineering, administration and contingencies, 25%					24,249,000
Interest during construction					7,275,000
Total estimated cost					$ 128,520,000

Section II. Fresno-Kings County Line to Kings-Kern County Line

Mile 157.6 to mile 183.5 Length, 25.9 miles Capacity, 4,200 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Canal excavation - earth	cu. yd.	6,583,000	$ 0.18	$ 1,185,000
Canal embankment	cu. yd.	1,963,000	0.20	393,000
Canal trimming - earth	sq. yd.	1,656,000	0.25	414,000
Canal lining - concrete	cu. yd.	184,300	20.00	3,686,000
Siphons				
Pino Arroyo				398,000
Estrecho Creek				499,000
La Salida Creek				1,050,000
Avenal Gap				277,000
Minor				649,000
Drainage structures				146,000
Farm bridges	ea.	7	6,470	45,000
County road bridges	ea.	12	23,925	287,000
Canal checks	ea.	3	83,000	249,000
Turnouts				8,000
Fencing and cattle guards	Mi.	52	1,650	86,000
Right of way				374,000
Wasteways	ea.	1	108,000	108,000
Sub-total				9,854,000
Engineering, administration and contingencies, 25%				2,464,000
Interest during construction				739,000
Total estimated cost				$13,057,000

Section IV. Buena Vista Hills to Pastoria Creek

Mile 246.0 to mile 290.6 Length, 44.6 miles Capacity, 3,500 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Canal excavation - earth	cu. yd.	9,730,000	$ 0.18	$ 1,751,000
Canal excavation - rock	cu. yd.	129,000	1.50	194,000
Canal embenkment	cu. yd.	3,223,000	0.20	645,000
Canal trimming - earth	sq. yd.	2,525,000	0.25	631,000
Canal trimming - rock	sq. yd.	42,000	1.50	63,000
Canal Lining - concrete	cu. yd.	285,500	20.00	5,710,000
Siphons				
Railroad				38,000
Highway				151,000
Salt Creek				302,000
Tecuya Creek				151,000
Grapevine Creek				151,000
Live Oak Canyon				378,000
Minor				645,000
Drainage structures				521,000
Farm bridges	ea.	31	6,290	195,000
County road bridges	ea.	7	22,845	160,000
Canal checks	ea.	4	75,000	300,000
Turnouts				40,000
Pumping Plants				
#6 2940 c.f.s. - 149.6 feet				9,095,000
#7 2550 c.f.s. - 106.8 feet				6,361,000
#8 2550 c.f.s. - 200.2 feet				8,412,000
#9 2550 c.f.s. - 350.4 feet				12,204,000
#10 2550 c.f.s. - 350.0 feet				12,180,000
Fencing and cattle guards	mi.	86	1,650	142,000
Right of way				451,000
Wasteways	ea.	2	91,000	182,000
Sub-total				61,053,000
Engineering, administration and contingencies 25%				15,263,000
Interest during construction				4,579,000
Total estimated cost				$80,895,000

Section V. Pastoria Creek to Quail Lake

Mile 290.6 to mile 302.4 Length, 11.8 miles Capacity 2,500 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnel excavation	cu. yd.	1,523,500	$ 18.00	$ 27,423,000
Tunnel timbering	M.B.M.	33,670	300.00	10,101,000
Tunnel lining - concrete	cu.yd.	389,200	35.00	13,622,000
Quail Lake siphon				2,021,000
Pumping Plant				
#11 2450 c.f.s. 313.6 feet				11,040,000
#12 2450 c.f.s. 313.6 feet				11,384,000
#13 2450 c.f.s. 313.6 feet				11,305,000
#14 2450 c.f.s. 313.6 feet				11,140,000
#15 2450 c.f.s. 313.6 feet				11,544,000
#16 2450 c.f.s. 313.6 feet				12,509,000
Turnout				20,000
Right of Way				22,000
Drainage structure				14,000
Sub-total				122,145,000
Engineering, administration and contingencies 25%				30,536,000
Interest during construction				9,161,000
Total estimated cost				$161,842,000

Section VI. Quail Lake to Fairmont

Mile 302.4 to mile 327.0 — Length, 24.6 miles — Capacity, 2000 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Canal excavation -earth	c.y.	544,000	$ 0.25	$ 136,000
Canal embankment	c.y.	264,000	0.20	53,000
Canal trimming -earth	sq.y.	150,000	0.25	38,000
Canal lining -concrete	c.y.	16,600	20.00	332,000
Covered conduit excavation -earth	c.y.	4,209,000	0.30	1,263,000
Covered conduit excavation -rock	c.y.	3,729,000	1.50	5,594,000
Covered conduit backfill	c.y.	2,949,000	0.25	737,000
Covered conduit -concrete	c.y.	931,200	30.00	27,936,000
Tunnel excavation -19'	c.y.	51,300	20.00	1,026,000
Tunnel timber	MBM	1,450	300.00	435,000
Tunnel lining -concrete	c.y.	14,500	35.00	473,000
Siphons				
Horse Camp Canyon				461,000
Spencer Canyon				308,000
Burnside Canyon				504,000
Adams Canyon				308,000
Baldwin Canyon				160,000
Kings Canyon				154,000
Bly Canyon				168,000
Broad Canyon				160,000
Minor				782,000
Drainage structures				53,000
Farm bridges	ea.	2	5,540	11,000
County road bridges	ea.	2	21,520	43,000
Canal check and turnout				66,000
Fencing and cattle guards	mi.	49	1,650	81,000
Right of way				47,000
Wasteways	ea.	1	51,000	51,000
Sub-total				41,380,000
Engineering, administration and contingencies, 25%				10,345,000
Interest during construction				3,104,000
Total estimated cost				$ 54,829,000

Section VII. Fairmont to Little Rock Creek

Mile 327.0 to mile 369.6 | Length, 42.6 miles | Capacity 1,500 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Covered conduit excavation - earth	cu.yd.	8,021,000	$ 0.30	$ 2,406,000
Covered conduit excavation - rock	cu.yd.	6,734,000	1.50	10,101,000
Covered conduit backfill	cu.yd.	4,886,000	0.25	1,222,000
Covered conduit concrete	cu.yd.	1,256,000	30.00	37,680,000
Tunnel excavation	cu.yd.	72,000	20.00	1,440,000
Tunnel timbering	M.B.M.	1,820	300.00	546,000
Tunnel lining - concrete	cu.yd.	19,200	35.00	672,000
Siphons				
Price Creek				150,000
Amaragosa Creek				466,000
Anaverde Creek				485,000
Soledad Pass				1,009,000
Minor				173,000
Drainage structures				154,000
Turnout				20,000
Fencing and cattle guards	mi.	84	1,650	139,000
Right of way				70,000
Sub-total				56,733,000
Engineering, administration and contingencies 25%				14,183,000
Interest during construction				4,255,000
Total estimated cost				$75,171,000

Section VIII. Little Rock Creek to Devil Canyon

Mile 369.6 to mile 428.4 | Length, 58.8 miles | Capacity, 1,200 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Covered conduit excavation - earth	c. y.	766,000	$ 0.30	$ 230,000
Covered conduit excavation - rock	c. y.	598,000	1.50	897,000
Covered conduit backfill	c. y.	494,000	0.25	124.000
Covered conduit-concrete	c. y.	133,500	30.00	4,005,000
Canal excavation - earth	c. y.	6,358,000	0.18	1,144,000
Canal embankment	c. y.	2,812,000	0.20	562,000
Canal trimming - earth	s. y.	2,430,000	0.25	608,000
Canal lining - concrete	c. y.	269,600	20.00	5,392,000
Tunnel excavation	c. y.	374,500	20.00	7,490,000
Tunnel timbering	M.B.M.	9,460	300.00	2,838,000
Tunnel lining - concrete	c. y.	99,700	35.00	3,490,000
Siphons				
A.T. & S.P.R.R.				87,000
Little Rock Wash				3,002,000
Oro Grande Wash				174,000
Horsethief Canyon				1,280,000
Minor (4)				686,000
Mojave				174,000
Drainage structures				136,000
Farm bridges	ea.	34	5,390.00	183,000
County road bridges	ea.	9	20,500.00	185,000
Canal checks	ea.	6	58,000	348,000
Canal Turnouts				20,000
Highway bridges	ea.	2	25,500	51,000
Fencing and cattle guards	mi.	101	1,650	167,000
Right of way				130,000
Wasteways	ea.	3	43,000	129,000
Sub-total				33,532,000
Engineering, administration and contingencies 25%				8,383,000
Interest during construction				2,515,000
Total estimated cost				$44,430,000

Section IX. Devil Canyon to Alder Creek

Mile 428.4 to mile 444.3 Length, 15.9 miles Capacity, 1100 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
Excavation	c.y.	940,700	$ 20.00	$ 18,814,000
Timbering	MBM	23,770	300.00	7,131,000
Concrete lining	c.y.	250,500	35.00	8,768,000
Turnouts				20,000
Right of Way				5,000
Sub-total				34,738,000
Engineering, administration and contingencies, 25%				8,685,000
Interest during construction				2,605,000
Total estimated cost				$ 46,028,000

Section X. Alder Creek to Beaumont

Mile 444.3 to mile 461.3 | Length, 17.0 miles | Capacity, 850 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
Excavation	c.y.	796,500	$ 20.00	$ 15,930,000
Timbering	MBM	23,290	300.00	6,987,000
Concrete lining	c.y.	198,500	35.00	6,948,000
Santa Ana River siphon				124,000
Turnout				10,000
Right of way				5,000
Sub-total				30,004,000
Engineering, administration and contingencies, 25%				7,501,000
Interest during construction				2,250,000
Total estimated cost				$ 39,755,000

Section XI. Beaumont to North Fork San Jacinto River

Mile 461.3 to mile 480.3 Length, 19.0 miles Capacity, 800 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
excavation	c. y.	512,400	20.00	$ 10,248,000
timbering	M.B.M.	15,000	300.00	4,500,000
concrete lining	c. y.	127,800	35.00	4,473,000
San Gorgonio Pass siphon				13,938,000
Turnouts				10,000
Right of way				14,000

Sub-total	33,183,000
Engineering, administration and contingencies 25%	8,296,000
Interest during construction	2,489,000
Total estimated cost	$ 43,968,000

Section XII. North Fork San Jacinto River to Lake Henshaw

Mile 480.3 to mile 539.8 | Length, 59.5 miles | Capacity, 500 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
Excavation	c.y.	859,000	$ 30.00	$ 25,770,000
Timbering	MBM	13,820	300.00	4,146,000
Concrete lining	c.y.	228,600	35.00	8,001,000
Canal excavation	c.y.	996,000	0.25	249,000
Canal embankment	c.y.	939,000	0.20	188,000
Canal trimming	sq.y.	968,000	0.25	242,000
Canal lining	c.y.	106,900	20.00	2,138,000
San Luis Rey River siphon				532,000
Drainage structures				152,000
Farm bridges	ea.	7	3,270	23,000
County road bridges	ea.	5	14,430	72,000
Turnouts				10,000
Fencing	mi.	60	1,650	99,000
Right of way				30,000
Sub-total				41,652,000
Engineering, administration and contingencies, 25%				10,413,000
Interest during construction				3,124,000
Total estimated cost				$ 55,189,000

Section XIII. Lake Henshaw to San Diego River

Mile 539.8 to mile 546.2 Length, 6.4 miles Capacity, 300 c.f.s.

April 1951 prices

Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
excavation	c. y.	93,400	$ 30.00	$ 2,802,000
timbering	M.B.M.	1,540	300.00	462,000
concrete lining	c. y.	25,100	35.00	879,000
Canal excavation	c. y.	46,000	0.30	14,000
Canal embankment	c. y.	48,000	0.25	12,000
Canal trimming	s. y.	50,000	0.30	15,000
Canal lining	c. y.	5,600	30.00	168,000
Drainage structures				21,000
Farm bridge				3,000
County road bridge				13,000
Turnout				10,000
Fencing	mi.	4	1,650	7,000
Right of way				3,000
Sub-total				4,409,000
Engineering, administration and contingencies 25 %				1,102,000
Interest during construction				331,000
Total estimated cost				$ 5,842,000

Section XIV. San Diego River to Horse Thief Canyon

Mile 546.2 to mile 566.6 Length, 20.4 miles Capacity, 200 c.f.s.

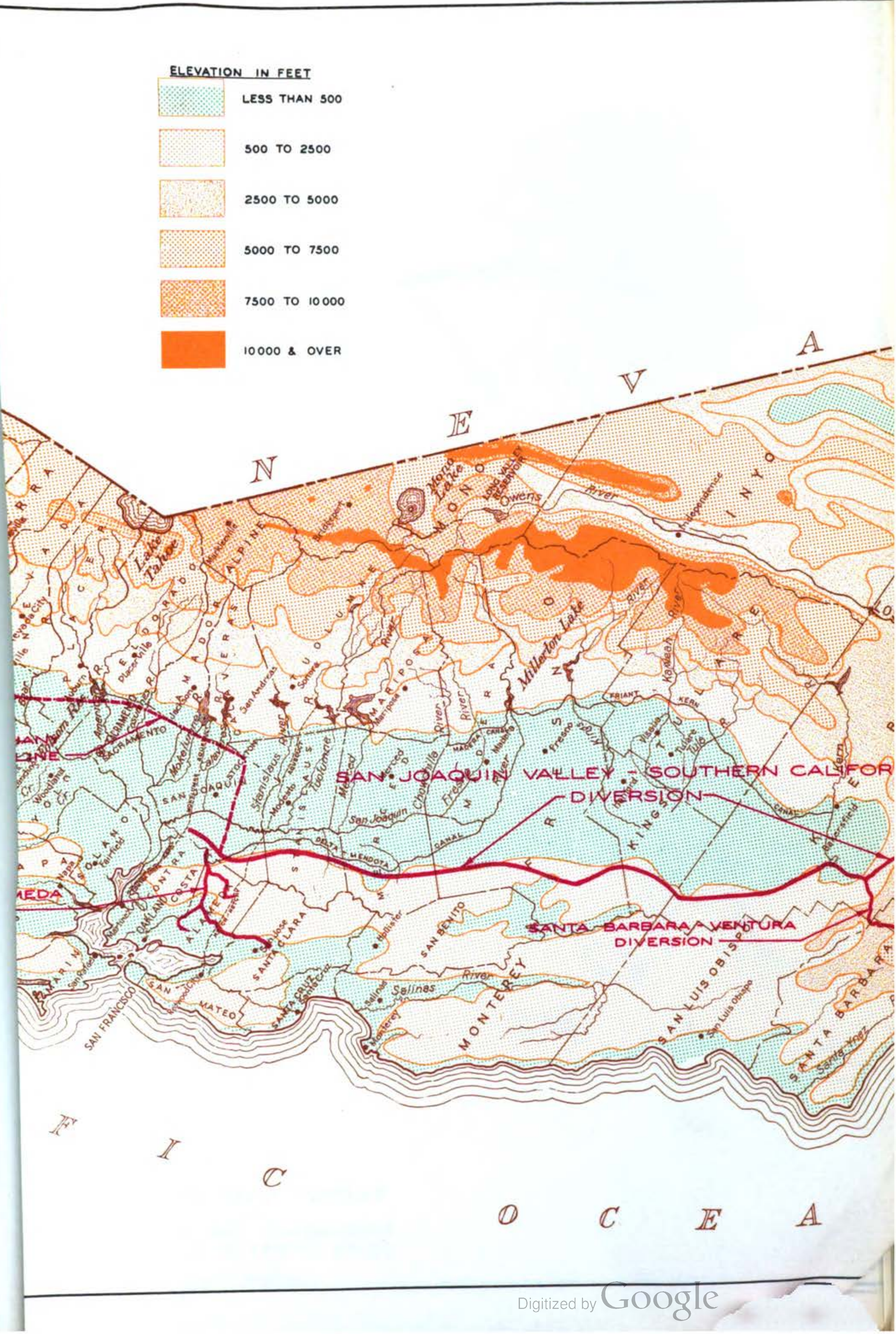
April 1951 prices

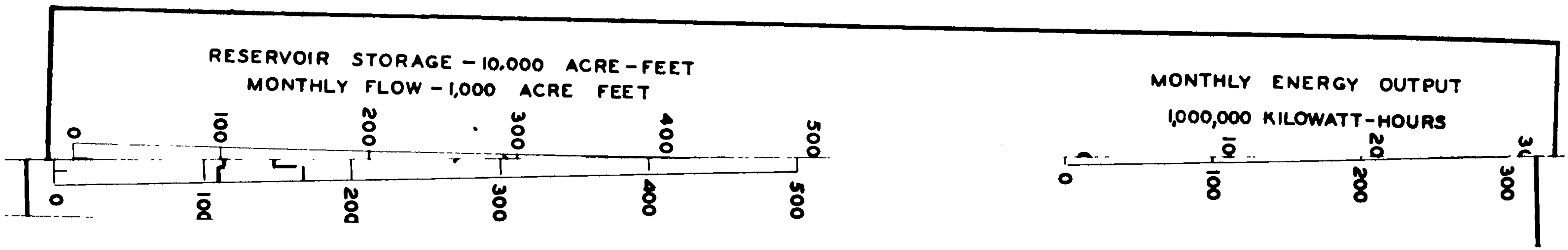
Item	Unit	Quantity	Unit Cost	Item Cost
Tunnels				
Excavation	c.y.	332,500	$ 35.00	$ 11,638,000
Timbering	MBM	5,960	300.00	1,788,000
Concrete lining	c.y.	75,300	35.00	2,636,000
Turnouts				20,000
Right of way				6,000
Sub-total				16,088,000
Engineering, administration and contingencies, 25%				4,022,000
Interest during construction				1,207,000
Total estimated cost				$ 21,317,000

APPENDIX F

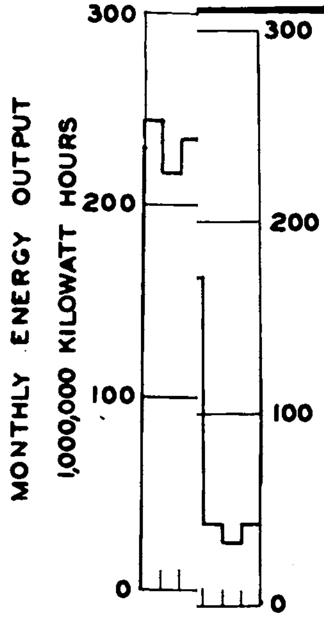
PLATES FOR FEATHER RIVER PROJECT REPORT

Plate	
1	Feather River Project and Sacramento-San Joaquin Delta Diversion Projects
2	Feather River Project Water and Power Developments above Oroville Reservoir on Feather River
3	Feather River Project Flood Plain and Water Service Area
4	Feather River Project Oroville Reservoir Operating Primarily for Power
5	Feather River Project Oroville Reservoir Operating in Coordination with Sacramento-San Joaquin Delta Diversion Projects
6	Feather River Project Water Uses and Diversions from Sacramento-San Joaquin Delta
7	Feather River Project Relocation of Existing Facilities at Oroville Reservoir
8	Feather River Project Oroville Dam and Afterbay
9	Santa Clara-Alameda Diversion
10	San Joaquin Valley-Southern California Diversion
11	Santa Barbara-Ventura Diversion
12	Typical Sections of Works for Santa Clara-Alameda Diversion Project
13	Typical Sections of Conduit for San Joaquin Valley-Southern California Diversion Project
14	Feather River Project Power Transmission Line Oroville Dam to Bethany Substation
15	Oceano Steam-Electric Plant and Transmission Line to Pumping Plants on San Joaquin Valley-Southern California Canal


ELEVATION IN FEET
LESS THAN 500
500 TO 2500
2500 TO 5000
5000 TO 7500
7500 TO 10 000
10 000 & OVER
N E V A
Mono Lake
Lake Tahoe
Millerton Lake
Owens River
Independence
SAN JOAQUIN VALLEY - SOUTHERN CALIFOR
DIVERSION
SANTA BARBARA - VENTURA
DIVERSION
SACRAMENTO
SAN JOAQUIN
STANISLAUS
MERCED
MARIPOSA
MADERA
FRESNO
KINGS
TULARE
INYO
MONO
ALPINE
AMADOR
CALAVERAS
TUOLUMNE
PLACER
NEVADA
EL DORADO
SOLANO
NAPA
MARIN
CONTRA COSTA
ALAMEDA
SANTA CLARA
SAN MATEO
SANTA CRUZ
SAN BENITO
MONTEREY
SAN LUIS OBISPO
SANTA BARBARA
SAN FRANCISCO
Oakland
San Jose
Salinas River
San Joaquin River
Kings River
Kaweah River
Fresno
Modesto
Merced
Stockton
Bakersfield
San Luis Obispo
Santa Ynez
Monterey
Salinas
Hollister
FRIANT
KERN
CANAL
DELTA - MENDOTA
F I C
O C E A

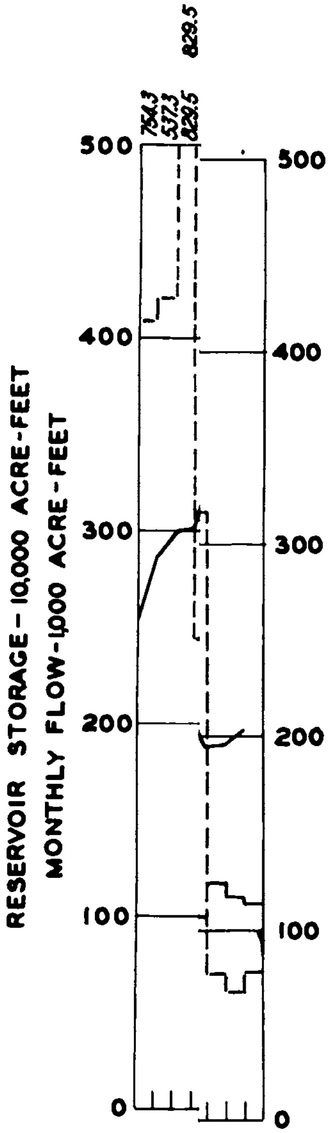


RESERVOIR STORAGE - 10,000 ACRE-FEET
MONTHLY FLOW - 1,000 ACRE FEET
0
100
200
300
400
500
MONTHLY ENERGY OUTPUT
1,000,000 KILOWATT-HOURS
0
100
200
300



LEGEND

ENERGY OUTPUT



LEGEND

INFLOW TO RESERVOIR

CONTROLLED RELEASE AND SPILL

RESERVOIR STORAGE ON FIRST DAY OF MONTH

653.1 *Inflow*
653.1 1102.6 *Outflow*
FLOWS IN EXCESS OF 500,000 ACRE-FEET PER MONTH

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

FEATHER RIVER PROJECT

OROVILLE RESERVOIR
OPERATING IN COORDINATION WITH
SACRAMENTO - SAN JOAQUIN
DELTA DIVERSION PROJECTS

LEGEND

INFLOW

- WATER RELEASED FROM OROVILLE RESERVOIR SPECIFICALLY FOR POWER GENERATION AND WATER WASTED OVER SPILLWAY AND THROUGH FLOOD CONTROL OUTLETS.
- WATER RELEASED FROM OROVILLE RESERVOIR TO SUPPLEMENT SURPLUS WATER IN SACRAMENTO - SAN JOAQUIN DELTA SO AS TO PROVIDE A CONTINUOUS DIVERSION OF 3,930 SECOND-FEET THEREFROM.
- UNCONTROLLED INFLOW TO DELTA FROM SACRAMENTO - SAN JOAQUIN RIVER BASIN MODIFIED BY PRESENT DEVELOPMENTS AND OPERATION OF FOLSOM AND OROVILLE RESERVOIRS.

USES

- IRRIGATION SUPPLY RESERVED FOR THE AREA ADJACENT TO DELTA - MENDOTA CANAL WHEN A SURPLUS ABOVE CENTRAL VALLEY PROJECT REQUIREMENTS EXISTS IN THE SACRAMENTO-SAN JOAQUIN DELTA.
- CONTINUOUS WATER SUPPLY WITHOUT DEFICIENCY OF 3,930 SECOND-FEET FOR DIVERSION TO SANTA CLARA VALLEY, SAN JOAQUIN VALLEY, AND SOUTHERN CALIFORNIA.
- WATER DIVERTED TO MEET REQUIREMENTS OF EXCHANGE AGREEMENT DATED JULY 27, 1939, BETWEEN UNITED STATES AND SAN JOAQUIN & KINGS RIVER CANAL AND IRRIGATION COMPANY, COLUMBIA CANAL COMPANY, SAN LUIS CANAL COMPANY, AND FIREBAUGH CANAL COMPANY.
- CONSUMPTIVE IRRIGATION REQUIREMENTS AND EVAPORATION LOSSES IN SACRAMENTO - SAN JOAQUIN DELTA.
- ESTIMATED WATER REQUIREMENTS OF THE CONTRA COSTA CONDUIT IN 1960 AND PRESENT USES IN THE DELTA UPLANDS.
- REQUIRED FLOW INTO SUISUN BAY TO PREVENT THE ENCROACHMENT OF SALINE WATERS INTO THE SACRAMENTO - SAN JOAQUIN DELTA. (4500 SECOND-FEET)

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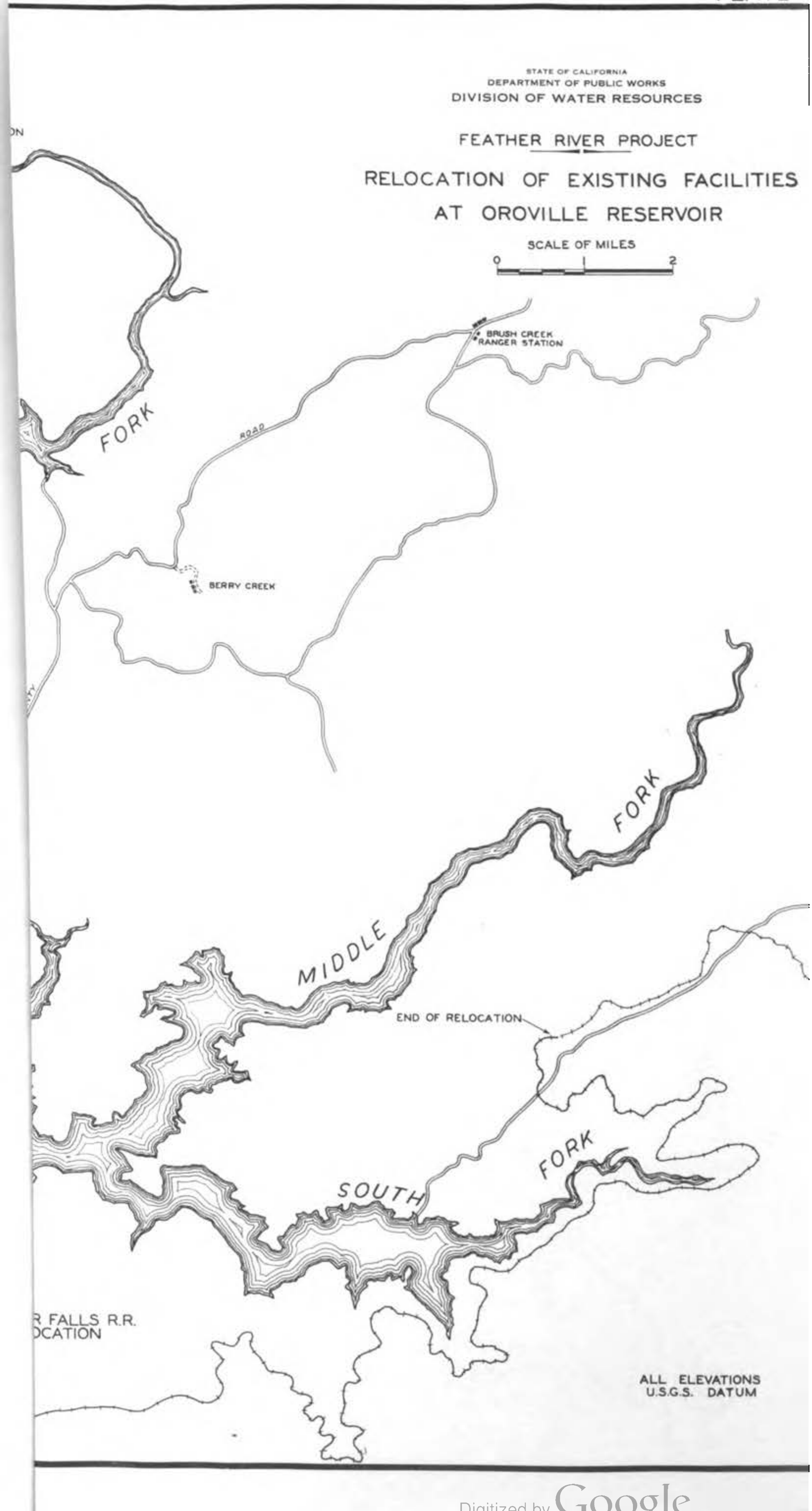
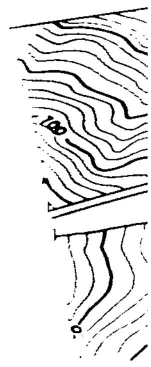
DIVISION OF WATER RESOURCES

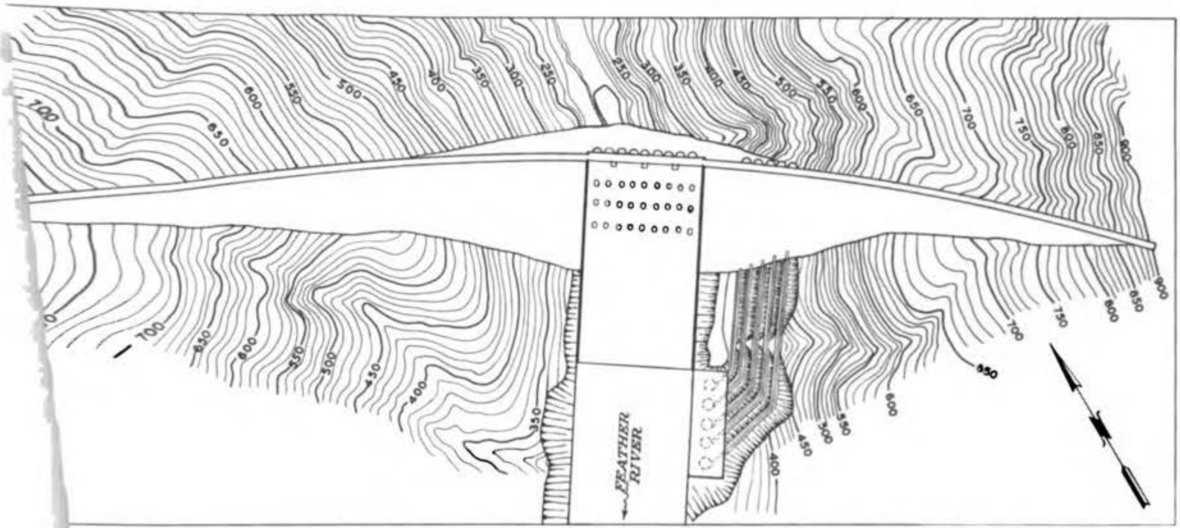
FEATHER RIVER PROJECT

WATER USES AND DIVERSIONS FROM SACRAMENTO — SAN JOAQUIN DELTA


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
FEATHER RIVER PROJECT
RELOCATION OF EXISTING FACILITIES
AT OROVILLE RESERVOIR
SCALE OF MILES
0
1
2
BRUSH CREEK RANGER STATION
FORK
ROAD
BERRY CREEK
MIDDLE FORK
END OF RELOCATION
SOUTH FORK
R FALLS R.R.
OCATION
ALL ELEVATIONS
U.S.G.S. DATUM


100

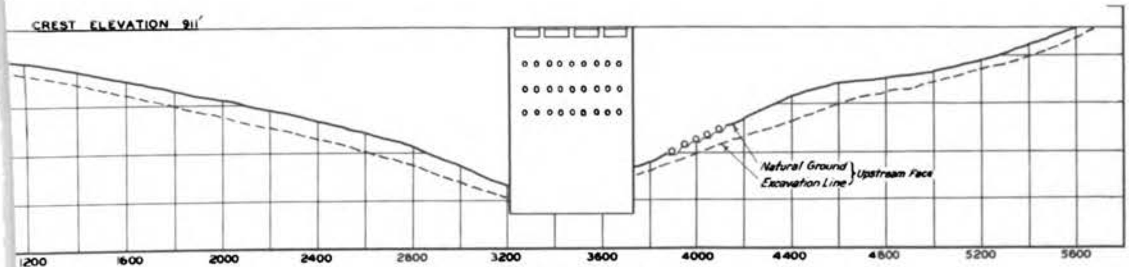
OROVILLE DAM



GENERAL PLAN

SCALE OF FEET

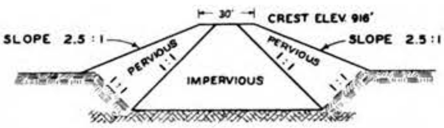
0 400 800



LENGTH IN FEET

PROFILE OF DAM

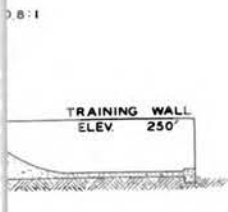
LOOKING UPSTREAM



SECTION AUXILIARY EARTH FILL DAM

SCALE OF FEET

0 50 100



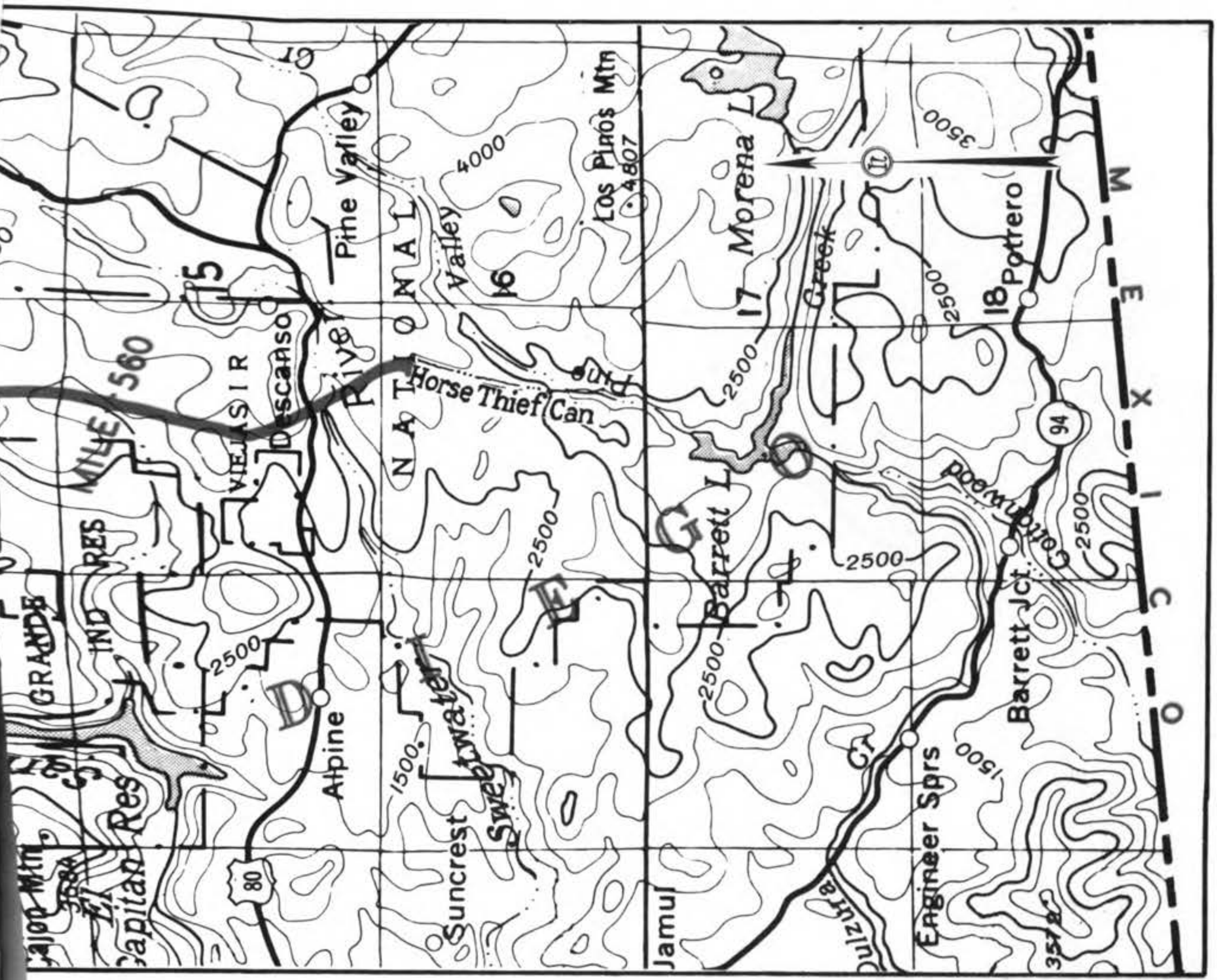
DAM

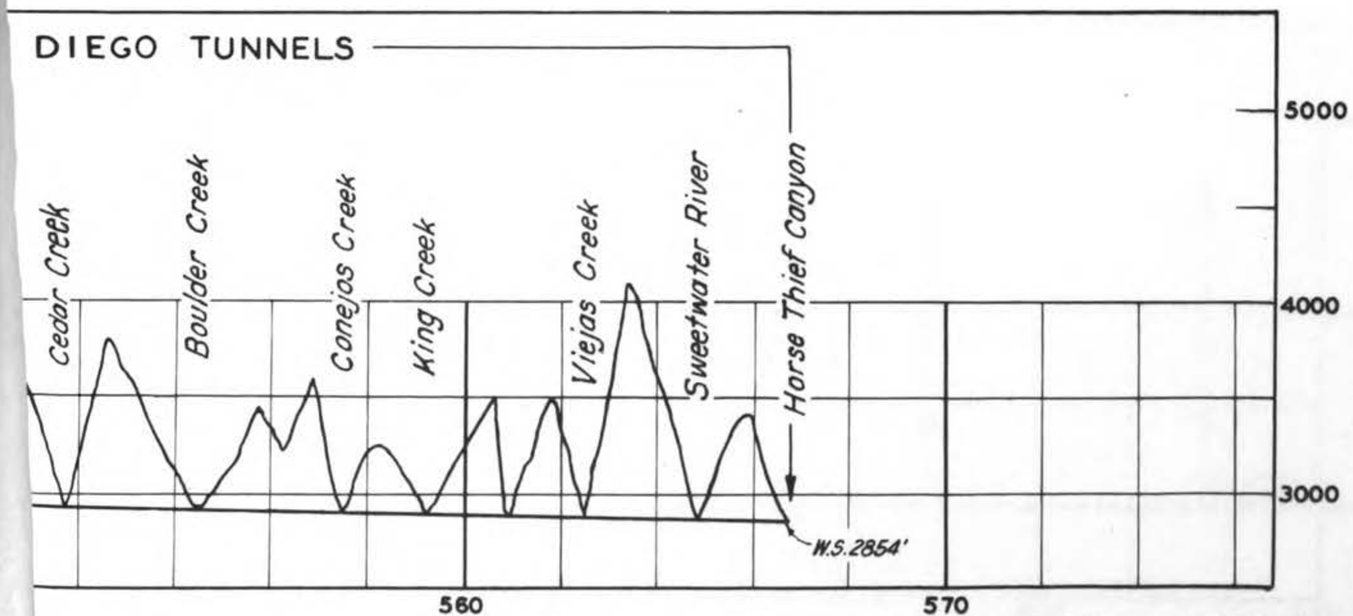
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

FEATHER RIVER PROJECT

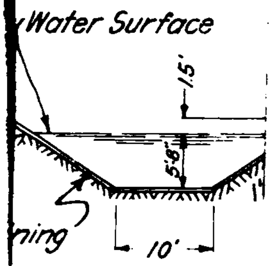
OROVILLE DAM AND AFTERBAY


GRANDE
Cedar Creek



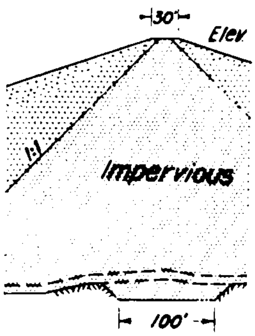


SAN JOAQUIN VALLEY
SOUTHERN CALIFORNIA DIVERSION
SHEET 6 OF 6 SHEETS



RETE LINED CAN

2 TO MILE 4.7 ~ CAP

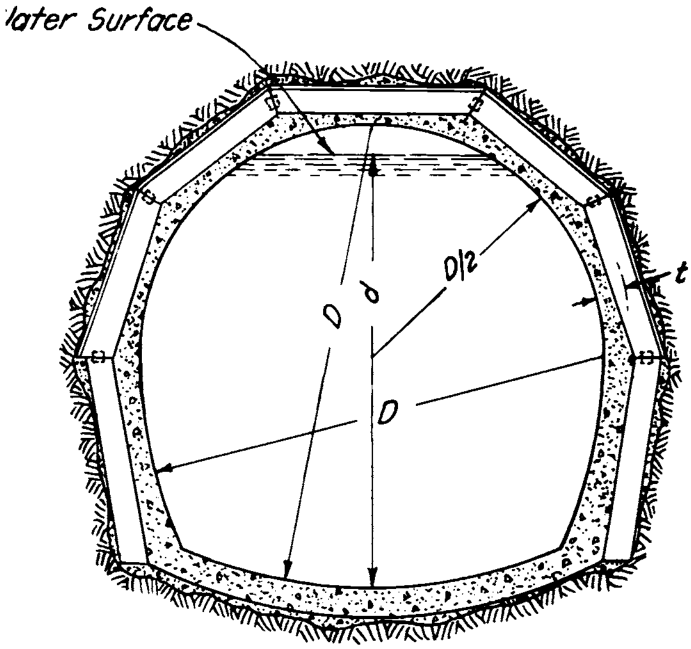


TYPICAL CROSS SEC

AIR POINT D

T

SANT



CAPACITY	D	d	t	Slope
2500 c.f.s.	24'	22.6'	18"	.00019
2000 "	19'	17.9'	16"	.00042
1500 "	15'	14.1'	12"	.00084
1200 "	15'	14.1'	12"	.00054
1100 "	15'	14.1'	12"	.00045
850 "	13'	12.2'	10"	.00058
800 "	13'	12.2'	10"	.00051
500 "	10'	9.4'	9"	.00081
300 "	8'	7.5'	8"	.00096
200 "	7'	6.6'	6"	.00087

CONCRETE LINED TUNNEL SECTION

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

TYPICAL SECTIONS OF CONDUITS
FOR
SAN JOAQUIN VALLEY - SOUTHERN CALIFORNIA
DIVERSION PROJECTS